U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

FINAL

RADIOLOGICAL REMOVAL ACTION WORK PLAN

July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION
AT FORMER NAVAL STATION PUGET SOUND
SEATTLE, WASHINGTON

U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

FINAL
RADIOLOGICAL REMOVAL ACTION WORK PLAN
July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION AT FORMER NAVAL STATION PUGET SOUND SEATTLE, WASHINGTON

Prepared by:

TETRA TECH EC, INC.
1230 Columbia Street, Suite 750
San Diego, California 92101-8536

Erik J. Abkemeier

Erik Abkemeier, CHP, PE, CSP, CHMM
TtEC Radiation Safety Officer

07/10/2013
Date

Lee Boreen
TtEC Project Manager

07/10/2013
Date

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

TABLES

FIGURES

ATTACHMENTS

This page intentionally left blank.

ABBREVIATIONS AND ACRONYMS

μR	microroentgen
μR/hr	microroentgens per hour
ACM	asbestos-containing material
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
APP	Accident Prevention Plan
Argus	Argus Pacific, Inc.
ASTM	American Society for Testing and Materials
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeter
cpm	counts per minute
Cs-137	cesium-137
DAC	derived air concentration
DCGL	derived concentration guideline level
$DCGL_{EMC}$	DCGL for elevated measurement comparison
$DCGL_W$	wide-area DCGL
dpm	disintegrations per minute
DQO	data quality objective
EBS	Environmental Baseline Survey
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
EPP	Environmental Protection Plan
FSS	Final Status Survey
GPS	Global Positioning System
ISO	International Organization for Standardization
LBGR	lower boundary of the gray region
m	meter
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual

ABBREVIATIONS AND ACRONYMS
(Continued)

MDC	minimum detectable concentration
MDCR	minimum detectable count rate
$MDCR_{Surveyor}$	MDCR calculated assuming a surveyor efficiency
MDER	minimum detectable exposure rate
MeV	megaelectron volt
min	minute
NaI	sodium iodide
NAS	Naval Air Station
NAVFAC NW	Naval Facilities Engineering Command Northwest
NAVSTA PS	Naval Station Puget Sound
Navy	Department of the Navy
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NTR	Navy Technical Representative
pCi/g	picocuries per gram
PCQC	Project Contractor Quality Control (Plan)
PjM	Project Manager
PPE	personal protective equipment
QC	quality control
R	roentgen
Ra-226	radium-226
RASO	Radiological Affairs Support Office
RCA	Radiologically Controlled Area
RCT	Radiological Control Technician
RML	Radioactive Materials License
RPM	Remedial Project Manager
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
RSOR	Radiation Safety Officer Representative

ABBREVIATIONS AND ACRONYMS
(Continued)

RSSI	Radiation Survey and Site Investigation
RTS	Radiological Task Supervisor
RWP	Radiation Work Permit
SAP	Sampling and Analysis Plan
Shaw	Shaw Environmental & Infrastructure, Inc.
SOP	Standard Operating Procedure
Sr-90	strontium-90
SSHP	Site Safety and Health Plan
TCRA	time-critical removal action
TSP	Task-specific Plan
TtEC	Tetra Tech EC, Inc.
VOC	volatile organic compound
WMP	Waste Management Plan
WRS	Wilcoxon Rank-Sum (test)

This page intentionally left blank.

1.0 INTRODUCTION

This Radiological Removal Action Work Plan (Work Plan) establishes survey, removal, and decontamination procedures and methodologies that will be implemented for the radiological release of buildings, structures, areas, materials and equipment, and personnel in support of a radiological materials time-critical removal action (TCRA) at former Naval Station Puget Sound (NAVSTA PS), Seattle, Washington. The areas of focus for this TCRA are the central portion of Building 2, the "South Shed" of Building 27, and the piping, catch basins, and soil adjacent to these areas of the buildings as outlined in Section 2.0 of this document. Both the Building 27 South Shed and portions of Building 2 have been vacant for many years, and portions of both buildings have deteriorated significantly (e.g., broken windows and leaking roofs).

Tetra Tech EC, Inc. (TtEC) was contracted by the Department of the Navy (Navy) to prepare this Work Plan under Contract Task Order 0011, Contract No. N62473-10-D-0809 for the Base Realignment and Closure (BRAC) Program Management Office West under Naval Facilities Engineering Command Northwest (NAVFAC NW). The methodologies and processes described in this Work Plan apply to operational radiological activities performed by TtEC in relation to its projects at former NAVSTA PS.

A basic concept in radiation protection specifies that exposures to ionizing radiation and releases of radioactive material should be managed to reduce collective doses to workers and the public and ensure that exposure is as low as reasonably achievable (ALARA) in accordance with Title 10, Section 20.1003 of the *Code of Federal Regulations*. The ALARA principle will be considered during the course of the radiological work carried out under this Work Plan for survey activities.

The primary objective of this Work Plan is to provide the radiological procedures and methodologies for:

- Evaluating and identifying impacted buildings, structures, areas, material and equipment, and other items that may contain radioactivity above the release criteria as a result of past activities at the former NAVSTA PS
- Removing and containerizing for disposal by the government-designated waste contractor the material with radioactive contamination above release criteria as identified in the Radiological Remedial Investigation Report (Shaw 2011)
- Confirming that the release criteria have been met

The radiological activities that support the objective of this Work Plan include:

- Reference (background) surveys
- Scoping surveys
- Characterization surveys
- Remedial action support surveys
- Final Status Surveys (FSSs)
- Personnel surveys
- Equipment and material surveys
- Decontamination and dismantling
- Low-level radioactive waste storage
- Low-level radioactive waste transport and disposal (by the Navy)

Where applicable, radiological survey activities will be conducted in accordance with the guidelines in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Nuclear Regulatory Commission (NRC) NUREG-1575 (DoD et al. 2000), as incorporated into this Work Plan. Activities not addressed by MARSSIM will be performed in accordance with this Work Plan and the Standard Operating Procedures (SOPs). Table 1-1 lists the TtEC field SOPs developed for performing radiological work at former NAVSTA PS. The SOPs are included as Attachment 4.

This Work Plan is organized as follows:

- **Section 1.0 Introduction** – Section 1.0 provides an overview of the project scope, work objectives, and organization of this Work Plan.
- **Section 2.0 Background** – Section 2.0 describes former NAVSTA PS and provides a historical summary of the station and an overview of the radiological history of former NAVSTA PS, including impacted sites, the regulatory framework, and the removal action objectives.
- **Section 3.0 Removal Action Scope** – Section 3.0 describes the removal action scope of work that will be implemented and to which this plan applies.
- **Section 4.0 Key Radiological Personnel and Work Control Procedures** – Section 4.0 discusses the project organization, roles and responsibilities of key project personnel, personnel qualifications, and work control activities.
- **Section 5.0 Radiological Survey Types, Area Classification, and Selection** – Section 5.0 identifies the types of surveys that will be conducted, and discusses survey area classification and survey type selection.

- **Section 6.0 Survey Overview** – Section 6.0 presents an overview of survey planning, survey implementation, and data assessment.
- **Section 7.0 Release Criteria and Investigation Levels** – Section 7.0 identifies the criteria for radiological release for unrestricted use.
- **Section 8.0 Instrumentation** – Section 8.0 identifies field instrumentation that will be used to perform surveys.
- **Section 9.0 Survey Implementation** – Section 9.0 presents the approach to implementing surveys that will be conducted as well as associated sampling activities.
- **Section 10.0 Decontamination, Dismantling, and Disposition** – Section 10.0 discusses the survey and construction activities that will be implemented to perform remedial action at sites contaminated by radiation above release limits.
- **Section 11.0 Documentation and Records Management** – Section 11.0 presents procedures that will be used to manage records/documentation, as well as to assess, interpret, and report data.
- **Section 12.0 Removal Action Fieldwork Implementation** – Section 12.0 discusses the construction-related activities associated with the removal of radiologically contaminated soil, storm drains, and building components.
- **Section 13.0 References** – Section 13.0 presents references cited in this Work Plan.
- **Attachments 1 through 8** – The attachments include procedures and supporting plans that will be implemented in conjunction with this Work Plan.
  - Attachment 1 – Sampling and Analysis Plan (SAP)
  - Attachment 2 – Project Contractor Quality Control (PCQC) Plan
  - Attachment 3 – Environmental Protection Plan (EPP)/Waste Management Plan (WMP)
  - Attachment 4 – Standard Operating Procedures
  - Attachment 5 – Air Emissions Plan
  - Attachment 6 – Task-specific Plan for Buildings 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys
  - Attachment 7 – Task-specific Plan for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys
  - Attachment 8 – Radiation Protection Plan

The following additional plans prepared under separate cover will be implemented in conjunction with this Work Plan:

- Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) (TtEC 2013)

This page intentionally left blank.

2.0 BACKGROUND

The following sections provide the location and description, a general site history, and a brief radiological history of former NAVSTA PS.

2.1 FORMER NAVAL STATION PUGET SOUND LOCATION

Former NAVSTA PS is located approximately 6 miles northeast of downtown Seattle in the Sand Point neighborhood on the western shore of Lake Washington (Figures 2-1 and 2-2). It is bounded by residential areas to the west and south, Lake Washington to the north, and National Oceanic and Atmospheric Administration (NOAA) facilities and Warren G. Magnuson Park to the east. The project site is situated in the northwest part of the former NAVSTA PS property and encompasses a portion of Building 2, the Building 27 South Shed and adjacent south stair towers, and portions of land area surrounding Buildings 2, 12, and 27.

2.2 GENERAL SITE HISTORY

Former NAVSTA PS was initially named Naval Air Station (NAS) Seattle. Portions of the facility were built in 1925 on land donated by King County. Many of the major buildings were built in the late 1930s prior to World War II, including Building 27 (1937) and Building 2 (1929). Further building construction and remodeling took place in later years, including addition of the South Shed to Building 27 in 1944 and expansion of the instrument shop in Building 2 in 1943 (1943 Instrument Shop).

During World War II, NAS Seattle supported air transport and ship outfitting personnel for the Alaskan and Western Pacific theaters of operation. After the war, NAS Seattle was designated a Naval Reserve Air Station. From 1945 to 1970, the station maintained naval reserve squadrons for supplementing active duty forces, both in the continental United States and abroad. Aviation activities officially ceased on June 30, 1970, and NAS Seattle was decommissioned.

In subsequent years, the station was redesignated Naval Support Activity Seattle, before being officially closed in September 1995.

Subsequent to closure, the Navy conducted environmental investigations and cleanup of portions of former NAVSTA PS. The condition of the property was described in the Environmental Baseline Survey (EBS) Report (URS 1996). The EBS described the significant operations and existing conditions at specific buildings and areas at former NAVSTA PS that were addressed in past environmental investigations. The EBS identified areas of potential environmental concern where storage or release of hazardous substances had occurred. No radiological contamination was identified in the EBS report. This EBS report was used by the Navy to generate the Finding of Suitability to Transfer for the property. After completion of these actions as well as the appropriate National Environmental Policy Act actions, the Navy initiated transfer of former

NAVSTA PS property to several government agencies in accordance with the BRAC closure plan.

The Navy transferred portions of the facility to the city of Seattle for recreational development. Because of the facility's long history of use by the Navy, and because of the potential that the environmental investigations conducted did not identify all environmental hazards that pose a threat to human health and the environment, the transfer deed between the Navy and the city included an environmental covenant that allowed the city to seek action by the Navy to address contamination that was not identified in the EBS.

2.3 RADIOLOGICAL HISTORY

During planning of proposed renovations of Building 27, the city of Seattle reviewed historical drawings and identified room labeled "Radium Room." Following this discovery, Seattle Parks and Recreation reviewed drawings for Building 2 and identified a space labeled "Instrument Shop." From the late 1930s through the 1960s, it was common practice at Naval Air Stations to perform maintenance on radioluminescent aircraft dials and gauges, and wrist watches. The aircraft components "glowed in the dark" due to the application radioluminescent paint, which contained radium-226 (Ra-226). Historical Navy records confirm that the former NAVSTA PS received routine shipments of Ra-226 used for the maintenance of the radioluminescent devices. These operations were commonly conducted in aircraft hangars, i.e., Buildings 2 and 27, implying that radioactive materials may have been used or stored in both Buildings 2 and 27.

Dose rate radiation surveys were performed in April (Argus 2009a) and May 2009 (Argus 2009b) by Argus Pacific, Inc. (Argus) under contract with Seattle Parks and Recreation. The surveys were conducted within Building 27, three pump houses (Pump House A, B, and 116) near Building 27, and within Building 2.

The 2009 surveys identified two locations in Building 27 South Shed with radiation levels above background levels. The two locations were associated with a former sink drainpipe located on the second floor of Building 27 (former Radium Room) and where the pipe extended to the first floor.

Following the 2009 surveys, Shaw Environmental & Infrastructure, Inc. (Shaw), under contract with the Navy, completed a radiological remedial investigation at former NAVSTA PS, the results of which are presented in the Radiological Remedial Investigation Report (Shaw 2011). Release criteria developed by Shaw for the investigation are listed in Tables 6 and 7 of the report. The radiological remedial investigation project release criteria for equipment and structures (surfaces) were taken from U.S. Atomic Energy Commission (AEC) Regulatory Guide 1.86 (1974). The dose-based calculations were performed using the most current version of RESRAD (for outdoor areas) software package. The dose-based calculations implement an all pathways resident farmer scenario using default parameter values except for the area and

thickness of the contaminated zone, the depth of clean cover material, and the indoor/outdoor time fractions. The values for parameters that do not use default values are specified in the Radiological Remedial Investigation Report. The Washington State Department of Health (WAC 246-246.20) and NRC (10 CFR 20.1402) regulations specify a dose limit of 25 millirems per year, and the residual radioactivity has been reduced to levels that are ALARA In promulgating CERCLA regulations, the U.S. Environmental Protection Agency (EPA) has specified a dose limit of 15 millirems per year. To take a more conservative approach, the dose limit of 15 millirems per year was used in the development of the soil and sludge radiological remedial investigation project release criteria, using the resident farmer exposure scenario (the most conservative scenario in RESRAD).

Radiological contamination above the radiological remedial investigation project release criteria was found in and around the 1939 and 1941 Instrument Shops in Building 2 and within the Building 27 South Shed (an addition onto the south face of the original Building 27 hangar structure) and two adjoining Building 27 stair towers. Radiological contamination above the radiological remedial investigation project release criteria was also found in piping associated with these buildings and in catch basins and soil adjacent to these buildings and nearby Building 12. The areas within Buildings 2 and 27 and the outside area south and west of Building 27 containing radiological contamination above radiological remedial investigation project release criteria were immediately secured with fencing and locks and signs were posted to prevent unauthorized access. Soil in other areas adjacent to Buildings 2, 12, and 27 with elevated activity is under asphalt or concrete pavement or at depth beneath grass cover and vegetation. The security measures taken at the site are described in greater detail in Section 2.4. The results of the remedial investigation are summarized in the following subsections.

Building 2

MARSSIM Class 1 surveys of portions of the floors and Class 2 surveys of the walls found radiological contamination above the radiological remedial investigation project release criteria (Shaw 2011) with contamination levels up to 7,161 disintegrations per minute (dpm) per 100 square centimeters (cm^2) α and 16,580 dpm/100 cm^2 β noted on both the floors and the walls. Radiological contamination above radiological remedial investigation project release criteria within Building 2 was limited to the 1939 Instrument Shop, the 1941 Instrument Shop, the area immediately adjacent to (south and east) the 1941 Instrument Shop, and the 1941 Instrument Shop ventilation system.

The area of radiological contamination above radiological remedial investigation project release criteria was limited to three
1-meter squares and a small area of the south wall in the 1939 Instrument Shop. The extent of radiological contamination above radiological remedial investigation project release criteria on the 1941 Instrument Shop floor was more substantial than the 1939 Instrument Shop and extends up to 6 meters laterally south and 5 meters to the east of the 1941

Instrument Shop footprint. Only one measurement on the northern brick wall of the 1941 Instrument Shop exceeded radiological remedial investigation project release criteria. It appears that this was the location of a former sink. A drain pipe from the former sink was found to contain sludge with radiological contamination exceeding radiological remedial investigation project release criteria. The aboveground portion of the sink drain pipe was removed, while the balance of the drain pipe remains intact below the ground floor slab.

With the exception of the 1941 Instrument Shop ventilation system, no radiological contamination above radiological remedial investigation project release criteria was found on the ceiling or ceiling vents in areas surveyed. The ventilation system exhaust ducts (accessed from the attic) are contaminated with levels exceeding radiological remedial investigation project release criteria. Given that the 1941 Instrument Shop ventilation is a closed-loop system, there is a potential that contamination exceeding radiological remedial investigation project release criteria extends to other areas of the ventilation system.

According to the Radiological Remedial Investigation Report (Shaw 2011), the source of radiological contamination likely originated from activities within the 1939 and 1941 Instrument Shops, and in the case of the 1941 Instrument Shop, may have been spread to an area south during cleanup activities (mopping). Currently, Building 2 is mainly vacant, with the exception of the hangar portion that is used for storage by Seattle Parks and Recreation and a north wing that houses offices and workshops for the job training program, Seattle Conservation Corps.

Building 27

MARSSIM Class 1 surveys of portions of the floors and Class 2 surveys of the walls were performed, and contamination was found above the radiological remedial investigation project release criteria (Shaw 2011); contamination levels up to 21,844 dpm/100 cm^2 α and 634,000 dpm/100 cm^2 β were noted on both the floors and the walls, primarily on the second floor of Building 27. Radiological contamination above radiological remedial investigation project release criteria within Building 27 was found to be limited to the South Shed and the two adjoining towers (southwest and southeast towers). No radiological contamination above radiological remedial investigation project release criteria was found in the public areas surveyed within the hangar.

Radiological contamination above radiological remedial investigation project release criteria was found in the wood flooring that was exposed upon removal of the remodeled flooring in nearly all the rooms on the second floor of the South Shed. The migration of radiological contamination into the wood subfloor below the tongue and groove wood flooring appears to have been impeded by a layer of roofing-type tar paper found between the wood floor and subfloor. Exceptions would be areas with floor penetrations (i.e., former steam piping) or areas where former walls had been removed and the roofing paper did not originally exist.

At penetrations and former wall locations (where the walls were removed), radiological contamination appears to have migrated to the subfloor and in the three locations where the subfloor was removed (Radium Room and two locations in the Safety Chief Room), radiological contamination had migrated to the floor joists. Radiological contamination above radiological remedial investigation project release criteria on the first floor was limited to the concrete floor of the Welding Shop near where a drain pipe from a former Radium Room sink penetrated the concrete floor and one other site consistent with dripping from a ceiling penetration. The aboveground portion of the sink drain pipe was removed, while the balance of the drain pipe remains intact below the ground floor slab. Radiological contamination above radiological remedial investigation project release criteria was found on the second floor and the metal stairs of the southwest tower and on the first floor and the metal stairs of the southeast tower.

A small penthouse structure is located on the roof of the Building 27 South Shed that contains heating and air conditioning equipment. This equipment was abandoned (not operational) but did appear to provide air flow into and out of the Radium Room. This structure was investigated, and a radiological scoping survey was performed for removable contamination and gamma dose rate. The interior of the air handling unit was accessed and surveyed. Radiological contamination above radiological remedial investigation project release criteria was found on one ceiling vent.

Abandoned floor exhaust vents are located along the north and south perimeter walls of the Former Instrument Shop. The screen grates and exhaust ducts were surveyed. Each of these floor vents had contamination in excess of the project cleanup criteria. To investigate the extent of the exhaust duct contamination, the floor was cut at three locations, exposing the exhaust ducts. In all cases, it was determined that the ducts had been cut approximately 3 feet from the floor vent, and the remainder of the exhaust ducting had been removed. The floor vent and attached exhaust duct were removed. Two of the three exposed joist space locations indicated contamination in excess of the project cleanup criteria.

A single run of the exhaust duct from this abandoned system was attached to the ceiling in the first floor Tech and Library Parts area. A survey was performed on the exhaust duct, including the accessible interior. Contamination in excess of the project cleanup criteria was detected.

According to the Radiological Remedial Investigation Report (Shaw 2011), the source of radiological contamination likely originated from activities within the instrument shop and appears to have been spread throughout the South Shed, primarily on the second floor, during cleaning activities (mopping).

No radiological contamination above radiological remedial investigation project release criteria was found on the ceiling or roof of the South Shed. Archive drawings document that

the roof had been replaced at least two times since past radium activities occurred in the building.

No radiological contamination above radiological remedial investigation project release criteria was found in the public areas surveyed within the Building 27 hangar area. In May 2010, a tenant of Seattle Parks and Recreation began renovation of the northern hangar area of Building 27 into an indoor sports facility. That facility is now open to the public.

Storm Drains

The former Radium Room sink piping that penetrated the concrete floor of the Welding Shop on the first floor of the Building 27 South Shed is connected to the storm drain line that runs south out of the building and west to catch basin CB-3. The aboveground portion of the drain pipe was removed. The line from catch basin CB-3 connects to manhole MH-141 and continues through manholes MH-137 and MH-160 to discharge into Lake Washington. Of the sludge samples collected within this storm drain line, only samples collected from catch basin CB-3 were found to contain radiological contamination (Ra-226) exceeding radiological remedial investigation project release criteria. Drain pipes from former sinks located near the center of the South Shed are connected to the storm drain line that traverses south to catch basin CB-1. Catch basin CB-1 connects to an adjacent 24-inch storm line that runs north to manhole MH-136 and through MH-160 to Lake Washington. Of the sludge samples collected within this storm line, only samples collected from catch basin CB-1 were found to exceed the project release criterion for Ra-226.

Based on the sediment results for the sewers and catch basins, it was determined that catch basins CB-1, CB-3, and CB-5 had elevated levels of Ra-226 in the sediment. As a precaution to prevent contaminated sediment from migrating to larger downgradient storm drain pipes, the three catch basins were remediated during the radiological remedial investigation in 2010. The catch basin inlet and outlet pipes were plugged, and the water pumped off the top of the sediment and containerized for disposition. The remaining sediment was scraped out and containerized in 55-gallon drums for disposition. After all the sediment was removed, a quick-drying concrete was added to each catch basin and troweled over the bottom and sides of the catch basin to cover any residual sediment and seal it in place. After the concrete dried, the plugs were removed and the catch basin resumed its normal function. These catch basins will require removal and replacement.

A drain pipe from a former sink in the Building 2 1941 Former Instrument Shop was found to contain sludge with contamination exceeding radiological remedial investigation project release criteria. This drain discharged to the storm line that parallels the west side of Building 2 at manhole MH-134. The aboveground portion of the drain pipe was removed and the pipe opening was sealed with grout. None of the sludge samples collected within accessible locations in Building 2, in manholes east of Building 2 (manholes MH-162, MH-134, and

MH-135), or in manholes located under and north of Building 27 (manholes MH-136, MH-1005, and MH-160) had contamination exceeding radiological remedial investigation project release criteria. None of the three samples of sludge from a sediment pit located near manhole MH-134 had contamination exceeding the project release criterion for Ra-226. However, the three samples had reported cesium-137 (Cs-137) (ranging from 3.0 picocuries per gram [pCi/g] to 6.03 pCi/g) and will require further investigation and remediation. There was no release criterion for Cs-137 during the radiological remedial investigation.

Soil

Results of gamma walkover surveys and soil sampling indicate that soil containing Ra-226 concentrations exceeding radiological remedial investigation project release criteria is present in historically unpaved (nontarmac) areas south and west of Building 27. The vertical extent of this soil appears to be limited to a layer of soil typically 1 to 2 feet thick within the 3 to 5 feet of soil above groundwater depending on elevation and whether the area received fill from past construction of the NOAA overpass. Results of gamma walkover surveys and soil sampling indicate that soil with Ra-226 concentrations exceeding radiological remedial investigation project release criteria is present in limited areas along the north side of Building 12 and the south and east sides of Building 2. The vertical extent of this soil appears to be limited to a thin layer of soil typically less than 2 feet below ground surface. The source of the Ra-226 concentrations in soil appears to be a result of historical release of mop water containing Ra-226 from past cleaning activities. However, a single discrete item (radioactive button) was found and removed from the soil along the east side of Building 2.

Based on the findings of the radiological remedial investigation, an Engineering Evaluation/Cost Analysis (EE/CA) was initiated to develop and evaluate removal action alternatives, with the intent that the selected alternative would be implemented as a non-time-critical removal action. However, due to continued deterioration of the buildings and the discovery of trespassers breaking into Building 2, the lead agency (NAVFAC NW) decided to forego further development of the EE/CA and perform a TCRA in order to expedite the removal actions.

An Action Memorandum (Shaw 2013) was prepared to present the written decision, where the appropriate removal action was documented based on regulatory and public comments.

2.4 SITE SECURITY

At the conclusion of the radiological remedial investigation fieldwork, Shaw implemented a Building 27 and Building 2 Security Plan to ensure that there would be no unauthorized access to the radiologically controlled areas at the site. The plan is included as Attachment 10 to the Radiological Remedial Investigation Report (Shaw 2011). A temporary fence surrounds the contaminated soils on the west and south sides of Building 27. The fence gate is locked along with all the exterior doors of the South Shed. Padlocked doors and plywood barriers have been

installed to prevent access to all areas of the South Shed. The only exception is a small room in the Southeast Tower that is open to Building 27 tenants for access to the hangar water main shutoff valve. This area has been thoroughly surveyed and poses no radiological concerns for the public. Building 2 access doors and stairwells are secured by either plywood barriers or padlocks. The Building 27 fencing and all access points to Buildings 2 and 27 are posted "Controlled Area." Shielding (steel plates) that covers hot spots at Building 27 are posted with "Do Not Remove or Disturb" signs, and below the shielding are appropriate radiological postings. Radiological postings are in place inside both buildings, where necessary. Fencing also was installed to enclose areas of potential soil contamination at the south end of Building 2 and adjacent to Building 12. These locations are also posted as "Controlled Areas."

Buildings 2 and 27 are inspected on a weekly basis to ensure that all points of access are secured and to look for evidence of trespassing. Fencing, locks, plywood barriers, postings, and shielding are all inspected for integrity. A security checklist is completed, signed, and forwarded to the Navy and Seattle Parks and Recreation personnel. On a monthly basis, a dose rate survey is performed along the Building 27 perimeter fence, along the south and west exterior face of the South Shed, and at select South Shed interior locations. Dose rates are also measured at the Building 2 second floor Radiologically Controlled Area (RCA) entrances. Once each month, a smear survey is also conducted at the boundaries of RCAs and other locations to ensure that contamination has not migrated beyond the posted radiological areas. This is done to ensure that radiological conditions have not changed at the boundaries of the controlled areas. Surveys are documented, reviewed, and placed in the project files, with copies to the Navy and the Washington State Department of Health.

2.5 REGULATORY FRAMEWORK

This TCRA is being conducted in accordance with the Navy's Environmental Restoration Program using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. The Washington State Department of Ecology is the lead regulatory agency for the radiological cleanup at former NAVSTA PS. The TCRA will follow the substantive requirements of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan. Per Title 40, *Code of Federal Regulations* Section 300.415(3)(b)(1), for any release, regardless of whether the site is included on the National Priorities List, where the lead agency (NAVFAC NW) makes the determination that there is a threat to public health or welfare or the environment, the lead agency may take any appropriate removal action to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release. The threat to public health or welfare or the environment is appropriate based on the following factors:

- Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants
- Presence of hazardous substances or pollutants or contaminants in soils largely at or near the surface

2.6 REMOVAL ACTION OBJECTIVES

The removal action objectives for the former NAVSTA PS site are to:

- Provide short-term and long-term protection of human health and the environment through the removal of known soil contamination with concentrations of Ra-226 and/or possibly Cs-137 and possibly strontium-90 (Sr-90) exceeding project release criteria.
- Provide short-term and long-term protection of human health and the environment through the removal/replacement of storm drain lines or catch basins containing known sludge contamination with concentrations of Ra-226 and/or possibly Cs-137 and Sr-90 exceeding the project release criteria.
- Provide short-term and long-term protection of human health through the removal of impacted building materials and equipment with known radiological contamination exceeding project release criteria.

This page intentional left blank.

3.0 REMOVAL ACTION SCOPE

The radiological materials TCRA at former NAVSTA PS will focus on the tasks listed below. Figure 3-1 provides the locations of the following planned activities:

- Removal of radiologically contaminated Building 27 components, including associated radiological surveys and waste management, and subsequent demolition of the Building 27 South Shed and restoration of the south face of the original Building 27 hangar structure.
- Removal of radiologically contaminated Building 2 components, including associated radiological surveys, restoration, and waste management. The ventilation system will be removed if contamination is found above TCRA project release criteria. Sections with contamination that is not above project release criteria may be left in place.
- Removal of radiologically contaminated soil surrounding Buildings 2, 12, and 27, including characterization, associated radiological surveys, restoration, and waste management.
- Removal and replacement of radiologically contaminated storm drain system components (e.g., catch basins, pipe, and appurtenances) associated with Buildings 2 and 27, including additional assessments, associated radiological surveys, restoration, and waste management.
- Disposal of non-low-level radioactive waste in a permitted landfill and low-level radioactive waste in a licensed low-level radioactive waste disposal facility.

This page intentionally left blank.

4.0 KEY RADIOLOGICAL PERSONNEL AND WORK CONTROL PROCEDURES

This section describes the responsibilities of key personnel necessary for management of radiological activities at former NAVSTA PS. It also identifies the minimum training requirements for workers at former NAVSTA PS and work control procedures, including Task-specific Plans (TSPs) (Section 4.3.1), Radiation Work Permits (RWPs), and radiological notifications.

4.1 KEY RADIOLOGICAL PERSONNEL

Specific personnel are essential in performing radiological activities at former NAVSTA PS. Qualified and experienced personnel will fulfill the necessary functions to ensure consistent and successful implementation of radiological work activities. Key radiological personnel are expected to have the requisite skills necessary to perform these functions. The key radiological personnel and their responsibilities are listed below.

4.1.1 Radiation Safety Officer

The Radiation Safety Officer (RSO) is responsible for implementing, directing, and supervising all radiological project-related activities. The RSO has the responsibility and authority to perform the following:

- Provide oversight of implementation and ensure compliance with the applicable NRC (or Agreement State, if applicable) Service Provider Radioactive Materials License (RML).
- Serve as the contact for NRC and the state of Washington.
- Perform site inspections.
- Assist Navy representatives during site audits.
- Control exposure conditions for site workers.
- Implement a dosimetry program for all site workers entering RCAs.
- Enforce radiological controls.
- Coordinate radiological activities with other NRC or Agreement State licensed contractors.
- Ensure all radiological work activities comply with RML requirements.
- Identify radiological analysis needs.
- Provide health physics guidance on an as-needed basis.
- Provide radiological control protection services, if required.
- Direct and assist radiological personnel in proper completion of radiological records.

- Assist the on-site Radiation Safety Officer Representative (RSOR) to determine whether an external dose is to be assigned to an individual who reported lost or damaged dosimetry devices.
- Review all changes to the SAP (Attachment 1 to this Work Plan) to ensure that radiological requirements are met.
- Ensure that the required radiological safety training is provided.
- Review and approve project field procedures associated with the handling of radioactive materials or access to radiological areas.
- Ensure timely and thorough review of records, in accordance with corporate procedure NLP-07, Radiological Protection Records, prior to approval.
- Approve records with verifiable signature and date once records meet the quality standards as described in NLP-07, Radiological Protection Records.
- Conduct radiation incident investigations.
- Conduct radiological inspections.
- Conduct data assessments and evaluations.

4.1.2 Radiation Safety Officer Representative

The RSOR will report directly to the RSO and will perform on-site duties as designated by the RSO. In accordance with Navy requirements, the RSO or a qualified designee will be on-site during radiological work activities conducted under this Work Plan. The RSOR has the responsibility and authority to perform the following:

- Implement, direct, and supervise on-site radiological activities.
- Assist in identifying radiological analysis needs.
- Provide health physics guidance.
- Assist in establishment of radiological controls.
- Oversee preparation and approval of radiological documents and field procedures.
- Establish personnel monitoring requirements.
- Establish, implement, and monitor on-site radiological training programs.
- Conduct assessments of field practices and procedures.
- Review and approve data from radiological investigations, surveys, and remediations.
- Assist the RSO in ensuring adequate radiological controls are in place at the work site.
- Ensure that specified radiological safety procedures are followed and that the radiological safety tests and inspections are complete and acceptable.
- Conduct daily oversight and field safety inspections and tests required by the project technical specifications and applicable professional standards.

- Attend required meetings, including the preconstruction conference, weekly quality control (QC) meetings, pre- and postconstruction site inspections, and other scheduled and unscheduled meetings.
- Administer the on-site dosimetry program.
- Verify compliance with on-site RWPs and SOPs.
- Assist the RSO in reviewing changes to the SAP to ensure radiological requirements are met.
- Approve issuance of any work document pertaining to radiological safety issues.
- Provide surveillance of radiological-related activities.
- Assist the RSO in directing the production of radiological work documents and reports.
- Ensure that a Radiological Task Supervisor (RTS) will be on-site during radiological activities.
- Confer with radiological personnel to provide technical advice and resolve problems.
- Prepare daily project status reports.
- Notify the RSO regarding radioactive anomalies.
- Manage the storage of radioactive waste in accordance with the RML.

4.1.3 Radiological Task Supervisor

The RTS will direct field survey personnel and health physics operations as assigned by the RSO, RSOR, or designee. The RTS has the responsibility and authority to perform the following:

- Oversee task-specific radiological field activities for compliance with the RML and approved plans, work instructions, SOPs, instrument specifications, and state-of-the-art health physics practices.
- Coordinate task-specific activities with the RSOR.
- Prepare RWPs to outline field conditions, radiological control requirements, and personal protective equipment requirements in the field for RSO approval.
- Be physically on-site when radiological operations are performed by field staff.
- Ensure all field staff are properly trained and comply with the RWP.
- Supervise field staff during survey, site remediation, and decontamination activities; use survey equipment and instrumentation; and support other radiological activities.
- Ensure compliance with the applicable SOPs for safety program, survey, and/or remediation activities.
- Interpret and verify task-specific data accumulated during surveys and monitoring activities.

- Ensure compliance with TSPs, as directed by the RSO and RSOR.

4.1.4 Radiological Control Technicians

Radiological Control Technicians (RCTs) will support projects in the field and have the responsibility and authority to perform the following:

- Perform radiological field activities under the direction of the RTS or RSOR in accordance with approved work documents and RML requirements.
- Document field survey activities in accordance with this Work Plan, TSPs, and SOPs.
- Interpret and verify field data gathered during survey and monitoring activities.
- Support dose assessments, and ensure compliance with emergency plans and procedures.
- Perform airborne radioactivity monitoring and radioactive material inventories.
- Perform survey equipment response checks and daily checks of the survey instruments.
- Conduct safety evaluations of health physics field equipment.
- Implement use of RWPs, including being present at active work areas to ensure compliance in the absence of the RTS.

4.2 MINIMUM TRAINING REQUIREMENTS

The minimum training requirements for personnel working in the field at former NAVSTA PS include the following:

- Occupational Safety and Health Administration 40-hour and annual 8-hour refresher course
- Radiation awareness and RWP training
- TSP training for a specific site or task
- Activity Hazard Analysis training for the specific site or task
- Training required by the APP/SSHP

4.3 WORK CONTROL PROCEDURES

Prerequisites for the initiation of survey activities include review of the associated TSP, radiological evaluation of the designated work areas, and identification of any potential safety concerns. Work control procedures include the preparation and review of TSPs, RWPs, work instructions, and appropriate notifications of anomalies or significant radiological events.

4.3.1 Task-specific Plan

This Work Plan provides the procedures and methodologies for performing radiological activities that will be implemented in support of radiological release of buildings, sites,

structures, areas, materials and equipment, and personnel at former NAVSTA PS. TSPs will be prepared for surveys and remediation performed under this Work Plan and will provide supplemental information. Each TSP will provide relevant location-specific data and identify variances and/or additions to this Work Plan.

At a minimum, each TSP will include the following information:

- Task description, including the specific location history, purpose of the task, and the radionuclides of concern
- Data quality objectives (DQOs) defined to a level sufficient to ensure that the data obtained will support the goals of the task
- An activities plan consisting of a survey description and discussion of additional activities necessary to support the survey, which will include a description of applicable specific construction or decontamination and decommissioning activities (as required)
- Specific identification of variations, if any, to this Work Plan, including the requirement and variations, and the technical justification for the variations
- Specific survey figures (as required) that provide sampling and survey data points, and other figures necessary to support the activity
- Attachments (as necessary) to provide further description, information, or delineation of the task activities

Each TSP will be provided to the Navy Remedial Project Manager (RPM) and the Radiological Affairs Support Office (RASO) for review and approval.

4.3.2 Radiological Health and Safety

SOPs and work instructions will be used to address controls necessary for radiologically safe operations and referenced as necessary in appropriate TSPs. Table 1-1 lists each of the TtEC field SOPs developed for performing radiological work at former NAVSTA PS.

Dose rate, contamination, and air monitoring, including initial baseline sampling to determine radiological background conditions, will be performed as necessary and in accordance with the APP/SSHP. Field activities will be performed in accordance with the approved RWP and APP/SSHP. RWPs will be prepared in accordance with the applicable RPP and SOP NAVSTA PS-Tt-001, Issue and Use of Radiation Work Permits. Personal protective equipment (PPE) levels, dictated by radiological considerations and physical and chemical safety issues identified at each work location, will be assigned or modified, according to the approved RWP and APP/SSHP and SOP NAVSTA PS-Tt-012, Radiological Protective Clothing Selection, Monitoring, and Decontamination.

4.3.3 Task-specific Work Instructions

In limited situations involving ancillary radiological activities (e.g., soil sampling or destruction in radiologically impacted areas, or decontamination with a vacuum system), or to further augment TSPs or SOPs, radiological work instructions may be prepared to facilitate a specific activity. These radiological work instructions, when used, will be provided to the RPM and the RASO for review and approval.

4.3.4 Notifications

During survey activities, radioactive anomalies may be identified and significant radiological events could occur. For the purposes of this Work Plan, an anomaly is described as a reading or result that appears to be an outlier in the professional judgment of the RSOR. When an anomaly is identified, the RSOR will notify the RSO and TtEC Project Manager who will notify the RPM and the RASO. If neither the RSO nor the TtEC Project Manager is available, the RSOR will leave a voice mail and confirmatory e-mail describing the anomaly and follow up with a call to the appointed designee, if any.

Significant events include regulatory visits (such as by the NRC or other regulatory agencies), radiological issues, injuries, and breaches in security. All significant events will be disclosed to the RPM and RASO as described above. Radiological issues such as suspected personnel radioactive contamination and security breaches will also be reported to the RSO, the Washington State Department of Health, and the Washington State Department of Ecology.

5.0 RADIOLOGICAL SURVEY TYPES, AREA CLASSIFICATION, AND SELECTION

Several types of radiological surveys will be conducted at former NAVSTA PS. Surveys will be used to identify radionuclides and levels of contamination present, support remedial actions, and support the release of materials, equipment, open areas, utilities, and/or buildings.

5.1 SURVEY TYPES

This section describes the types of surveys that may be performed at former NAVSTA PS.

5.1.1 Reference (Background) Area Survey

The reference area is a geographical area or structure from which representative radioactivity measurements are performed for comparison with measurements performed in an impacted area. The selected reference area should have physical, chemical, radiological, and biological characteristics similar to the impacted area(s) being investigated. The reference area must not be identified as impacted by historical information or investigative surveys. All on-site and off-site locations selected as reference areas will be approved by the RSO or RSOR and concurred upon by the RASO. The intent will be to use the same reference areas established during the radiological remedial investigation. Depending on the conditions encountered while executing the fieldwork, additional reference areas may become necessary. The same survey methods and equipment that will be used for conducting a survey in an impacted area will be used for the background area survey. Reference area data will normally be provided to the RSO prior to the start of a survey.

5.1.2 Scoping Survey

Scoping surveys provide site-specific information based on limited measurements. Scoping surveys are to be conducted with guidance from MARSSIM (DoD et al. 2000) and will consist of judgment measurements based on applicable information in the Radiological Remedial Investigation Report (Shaw 2011), historical documents, and professional experience. Sufficient information will be collected to identify situations that require immediate radiological attention or to support development of other project activities.

The primary objectives of scoping surveys are to:

- Perform a preliminary contamination assessment
- Identify radionuclide contaminants
- Assess radionuclide ratios
- Assess general levels and extent of radionuclide contamination, if present
- Support classification of impacted areas

- Evaluate whether the survey strategy can be optimized for use in a characterization survey or FSS

5.1.3 Characterization Survey

The characterization survey is performed to determine the nature and extent of radiological contamination at the site. This includes preparing a reference grid, collecting systematic as well as judgment measurements, and performing surveys of different media (e.g., surface soils, interior and exterior surfaces of buildings). The decision as to which media will be surveyed is a site-specific decision addressed throughout this Work Plan and each TSP.

Characterization surveys are planned based on the Radiological Remedial Investigation Report (Shaw 2011), MARSSIM guidance, and/or scoping survey results. The primary objectives of characterization surveys are to:

- Assess the nature and extent of the contamination, if present
- Collect data to support evaluation of remedial alternatives and technologies
- Evaluate whether the survey strategy can be optimized for use in the FSS
- Provide input to the FSS design

5.1.4 Remedial Action Support Survey

Remedial action support surveys are performed to assess the effectiveness of the remedial action while remediation is being conducted, and to guide the cleanup in a real-time mode. The primary objectives of remedial action support surveys are to:

- Support remediation activities
- Assess when an area is ready for the FSS
- Provide site-specific information used for planning the FSS

5.1.5 Final Status Survey

The FSS provides data to demonstrate that radiological parameters satisfy the established guideline values and conditions for radiological release. Data from other surveys conducted during the course of site investigations at former NAVSTA PS—such as scoping, characterization, and remedial action support surveys—can provide valuable information for planning an FSS in accordance with MARSSIM (DoD et al. 2000). The primary objectives of FSSs are to:

- Verify classification
- Demonstrate that the potential dose or risk from residual activity is below the release criterion

- Demonstrate that the potential dose or risk from small areas of elevated activity is below the release criterion

5.1.6 Personnel Surveys

Surveys will be performed on personnel leaving a radiological area to ensure that individuals are free of radiological contamination as identified in the RPP and associated SOPs.

5.1.7 Equipment and Materials Surveys

Before being put into service or leaving a radiological work area, equipment and/or materials will be surveyed in an area of low background concentrations to ensure that the equipment and materials release criteria are not exceeded. Appropriate SOPs will be used.

- If results of surveys of incoming equipment and/or materials intended for service in a radiological work area at former NAVSTA PS exceed the release criteria, the equipment and/or materials will be returned to the supplier for replacement or decontamination.
- If the results of surveys of outgoing equipment and/or materials exceed the release criteria, the equipment and/or materials will be decontaminated before being taken from the radiological work area or stored for disposal.

5.2 SURVEY AREA CLASSIFICATION

The radiological remedial investigation has identified areas at former NAVSTA PS that have been classified as impacted (Shaw 2011). Based on available information from previous surveys, each area will be given one of the three classifications described below.

5.2.1 Class 1 Areas

Class 1 areas have (or had prior to remediation) a potential for radioactive contamination. This potential is based on site operating history or known contamination based on previous surveys above the wide-area derived concentration guideline level ($DCGL_W$). Examples of Class 1 areas include:

- Site areas previously subjected to remedial actions
- Locations where leaks or spills are known to have occurred
- Former burial or disposal sites
- Waste storage sites
- Areas designated as such in the radiological remedial investigation survey

5.2.2 Class 2 Areas

Class 2 areas have (or had prior to remediation) a potential for radioactive contamination or known contamination that is not expected to exceed the $DCGL_W$. Examples of Class 2 areas include:

- Locations where radioactive materials were present in an unsealed form
- Potentially contaminated transport routes
- Areas downwind from stack release points
- Upper walls and ceilings of buildings or rooms subjected to airborne radioactivity
- Areas handling low concentrations of radioactive materials
- Areas designated as such in the radiological remedial investigation survey
- Buffer areas on the perimeter of Class 1 areas

5.2.3 Class 3 Areas

Class 3 areas are not expected to contain residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the $DCGL_W$, based on site operating history and previous radiation surveys. Examples of Class 3 areas include:

- Buffer zones around Class 1 or Class 2 areas
- Areas with very low potential for residual contamination but where there is insufficient information to justify a non-impacted classification
- Areas designated as such in the radiological remedial investigation survey

5.3 CLASSIFICATION AND SURVEY UNIT SIZE

A survey unit is a physical area consisting of structures or land areas of specified size and shape for which a separate decision will be made as to whether or not that area exceeds the release criteria. This decision is made as a result of the FSS. The survey unit is the primary entity for demonstrating compliance with the release criteria.

Survey units will be limited in size based on classification, exposure pathway modeling assumptions, and site-specific conditions. The limitation on survey unit size for Class 1 and Class 2 areas ensures that each area is assigned an adequate number of data points. Table 5-1 lists the survey unit sizes.

5.4 REFERENCE COORDINATE SYSTEMS

A reference coordinate system will be laid out for each survey unit to identify survey/sample locations. Two different grid systems, as specified in MARSSIM (DoD et al. 2000), may be used. Although the preferred method is the triangle grid, the TSP will specify the grid system to be used.

5.4.1 Square Grid

A square grid system may be used for Class 1 and Class 2 survey units. For Class 3 survey units, a square grid system can be used, if specified in the TSP. The length, *L*, of a side of the square grid is determined by the total number of samples or measurements to be taken. The length of the square will determine the distance between survey data points. The length or spacing of the grids will be calculated for each of the survey units using Equation 5-1:

Equation 5-1

$$L = \sqrt{\frac{A}{N}}$$

Where:

L	=	length of spacing (meters [m])
A	=	surface area of the survey unit (square meters [m^2])
N	=	number of data points

Grid locations are then positioned throughout the survey unit by first randomly selecting a start point and establishing a systematic pattern. Random numbers for the square grid method, between zero and 1, are determined for both the X and Y locations in each survey unit. The random number is then multiplied by the *L* (length of square grids) to determine both the starting X and Y locations in each survey unit. The length *L* is then used to determine all remaining data points based on this starting location.

5.4.2 Triangular Grid

A triangular grid system may be used for Class 1 and Class 2 survey units, but will not normally be used in Class 3 survey units. The length between triangular grid data points (*L*) is determined by the total number of samples or measurements to be taken, using Equation 5-2:

Equation 5-2

$$L = \sqrt{\frac{A}{0.866 * N}}$$

Where:

L	=	length of spacing (m)
A	=	surface area of the survey unit (m^2)
0.866	=	constant factor from MARSSIM
N	=	number of data points

A second row of points is then developed, parallel to the first row, at a distance of $0.866 \times L$ from the first row. Survey points along that second row are midway (on the X-axis) between the points on the first row. This process is repeated to identify a pattern of survey locations throughout the survey unit. If identified points fall outside the survey unit or at a location that cannot be surveyed, additional points are determined using the random process described above, until the desired total number of points is identified.

The triangular grid system is generally more efficient for locating small areas of elevated activity. A more detailed discussion is provided in Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference Based Standards for Soils and Solid Media (EPA 1992).

5.5 SURVEY TYPE SELECTION

The type of survey selected for an area or survey unit will be either specified by the recommendations contained in the remedial investigation survey or based on discussions with and technical direction from the RASO. The exceptions will be remedial action support surveys, personnel surveys, equipment and material surveys, and vehicle surveys that will be used as necessary to assess the effectiveness of decontamination activities and to release personnel, equipment, and material.

The survey progression is typically reassessed when a survey unit fails to meet the release criterion during an FSS effort. If a Class 2 or 3 survey unit fails to meet the criterion for release, it will undergo decontamination or remedial actions, where necessary, and be reclassified as a Class 1 unit for the follow-up survey actions. If a Class 1 survey unit fails to meet the release criterion, decontamination and remedial action support surveys will be performed. A Class 1 survey will follow decontamination or remedial activities. If the Class 1 survey meets the release criterion, the survey will serve as an FSS.

6.0 SURVEY OVERVIEW

This section provides an overview of survey planning, implementation, and data assessment. Survey details are given in succeeding sections of this Work Plan. Additional details will be provided in the project-specific TSPs, as appropriate.

6.1 DATA LIFE CYCLE

Compliance demonstration is simply a decision as to whether or not a survey unit meets the release criterion. This decision is based on the results of one or more surveys. Positive actions must be taken to manage the uncertainty addressed in the MARSSIM guidelines (DoD et al. 2000), which ensure 95 percent confidence in the survey results so that sound, defensible decisions may be made. These actions include proper survey planning to control known causes of uncertainty, proper application of QC procedures during implementation of the survey plan to detect and control significant sources of error, and careful analysis of uncertainty before the data are used to support decision making. These actions describe the flow of data throughout each type of survey, referred to as the Data Life Cycle.

There are four phases in the Data Life Cycle:

- **Planning Phase.** The survey design is developed and documented using the DQO process, which is summarized in Section 6.2.3.
- **Implementation Phase.** The survey design is carried out in accordance with the TSPs resulting in the generation of raw data. In addition, quality assurance and QC measurements will generate data and other important information that will be used during the Assessment Phase.
- **Assessment Phase.** The data generated during the Implementation Phase are first verified to ensure that the TSPs were actually followed and that the measurement systems were performed in accordance with the criteria specified in this plan. Then the data are validated to ensure that the results of data collection activities support the objectives of the survey, as documented in the applicable TSP, or permit a determination that these objectives should be modified.
- **Decision-making Phase.** Based on the conclusions drawn from the assessment process, a decision is made in coordination with the responsible regulatory agency. The ultimate objective is to make technically defensible decisions with a specified level of confidence.

6.2 SURVEY PLANNING

The Radiation Survey and Site Investigation (RSSI) process includes a series of surveys that will be used at former NAVSTA PS to demonstrate compliance with the release criterion. This

process will be used as a framework for collecting the information required for scoping, characterization, remediation, and FSS activities during the removal action.

Table 6-1 provides a simplified overview of the principal surveys in the RSSI process and how the Data Life Cycle in accordance with MARSSIM (DoD et al. 2000) can be used in an iterative fashion within the process.

Figure 2.4 of MARSSIM illustrates the RSSI process in terms of area classification and lists the major decision to be made for each type of survey. The flow chart, illustrated on Figures 2.5 through 2.8 of MARSSIM, presents the principal steps and decisions in the site investigation process and shows the relationship of the survey types to the overall assessment process.

6.2.1 Survey Design Elements

Survey and sampling process design includes, but is not limited to, the following elements:

- The *types of samples and sampling matrices* for the survey: scan and fixed gamma surveys and solid samples for outdoor surveys; and alpha, beta, and gamma scan and fixed measurements for indoor surveys
- The *measurement frequency* for direct measurement locations for each survey unit and scan percentage of each survey unit
- The *sampling frequency* for solid sample collection locations in the survey unit(s)
- The *methods* for performing remedial action support surveys and other ancillary surveys

However, before the elements listed above can be established, a general strategy must be determined.

6.2.2 Survey Strategy

Strategies for implementing the various survey types at former NAVSTA PS are provided in Table 6-2. The selection of specific survey types for each area investigated under this Work Plan will be based on information in the Radiological Remedial Investigation Report (Shaw 2011) and will be identified in each corresponding TSP. For an FSS, the standard survey strategy will be based on using a MARSSIM Scenario A approach, as described in Section 6.5.3. On a case-by-case basis, as identified in a TSP, the FSS design using the Scenario B approach will be considered.

6.2.3 Data Quality Objectives

MARSSIM (DoD et al. 2000) recommends using the seven-step DQO process in the design of radiological surveys. This process tailors the survey to the particular conditions of each survey

situation. DQO elements are applicable to all the surveys to be performed under this Work Plan. Specific DQOs for each survey will be established in the relevant TSP.

The seven steps in the DQO process are as follows:

1. State the problem
2. Identify the goal of the study
3. Identify information inputs
4. Define the boundaries of the study
5. Develop the analytical approach
6. Specify performance or acceptance criteria
7. Develop the plan for obtaining data

6.3 SURVEYS

Survey implementation for each type of survey to be conducted at former NAVSTA PS is discussed below. While implementation requires instrumentation and survey techniques, this section will concentrate on the general approach. The instrumentation to be used is discussed in Section 8.0 and survey techniques are presented in Section 9.0. Other survey specifics will be presented in the TSP.

6.3.1 Scoping and Characterization Surveys

These surveys will be implemented as described in their individual TSPs. In practice, scoping and characterization survey data that indicate the residual activity is below the derived concentration guideline level (DCGL) for the building/area will be used in the FSSs where possible. Scoping and characterization surveys will include gamma scans for outdoor and indoor survey units. The investigation level will be established at the mean plus three sigma of the survey unit gamma scan count rate, or another RASO-approved investigation level.

6.3.2 Remedial Action Support Surveys

These surveys are implemented during the remedial activity. For example, surveys to support remediation would follow the decontamination work to assess progress.

6.3.3 Final Status Surveys

For the FSS, the data analysis framework is critical to survey development because it drives the sampling requirements. For contaminants present in background, the analysis uses the Wilcoxon Rank-Sum (WRS) test. For contaminants not present in background, the analysis uses the Sign test. The WRS test and Sign test are described in Section 6.4.3. In each case, the minimum number (*N*) of samples (or fixed measurements) is calculated as follows: the method to calculate

any additional number of required data points is stated in Section 7.1, and grid spacing methods and requirements are listed in Section 5.4. The statistical tests are described in Section 6.4.

6.3.3.1 Determination of the Relative Shift

Using Equation 6-1, the value of the relative shift can be determined. For single radionuclide analysis, the values for the lower boundary of the gray region (LBGR) will be set at half the DCGL during the planning phase, and at the median concentration in a survey unit for the data assessment phase.

When analyzing multiple radionuclides, the values for the LBGR and σ are determined using Equation 6-1:

Equation 6-1

$$\frac{\Delta}{\sigma} = \frac{DCGL_W - LBGR}{\sigma}$$

Where:

$DCGL_W$	=	$DCGL_W$ as appropriate
$LBGR$	=	lower boundary of the gray region, as appropriate
σ	=	standard deviation from the survey unit, as appropriate

The value of the relative shift is used with the appropriate random measurement probability presented in MARSSIM (DoD et al. 2000) Tables I.2a and I.2b.

6.3.3.2 Determination of the Number of Data Points

When the contaminant is present in background, Equation 6-2 is used with the WRS test:

Equation 6-2

$$N = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{3\left(P_r - 0.5\right)^2}(1.2)$$

When the contaminant is not present in background, Equation 6-3 is used with the Sign test:

Equation 6-3

$$N = \left(\frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4\left(Sign\ p - 0.5\right)^2}\right)(1.2)$$

Where:

$Z_{1-\alpha}$	=	Type I decision error level
$Z_{1-\beta}$	=	Type II decision error level
P_r	=	random measurement probability
Sign p	=	random measurement probability
(1.2)	=	20% increase in number of samples over the minimum

During the data assessment phase, the 20 percent increase of samples is omitted for statistical purposes.

6.3.4 Error Control

Actions to minimize errors will be instituted during the data collection phase of the surveys. Qualified radiation survey personnel will perform the survey and record the data. Automated recording of survey data will be used where possible to minimize errors. Data transcribing is an activity where errors may arise. To minimize data errors for manual surveys, experienced personnel will record and transcribe the data.

Standard applicable quality assurance and QC measures will be implemented to control errors.

The ongoing on-site analyses and evaluation of survey results provide a verification check for errors, which will be corrected if detected.

A knowledgeable individual, such as the RTS, who is not involved in the direct data collection process will review the survey data on a daily basis. This will ensure an ongoing independent review for consistency of survey data collected.

6.4 ASSESSMENT OF SURVEY RESULTS

A preliminary evaluation of the data set will be conducted to assess the structure of the data and identify appropriate approaches and limitations for utilization. For non-FSSs, this may be merely identifying areas of elevated contamination or reviewing the mean, median, and standard deviation of the data set. FSS evaluations include, but are not limited to, reviewing quality assurance reports, calculating statistical quantities, and graphing the data.

6.4.1 Scoping and Characterization Surveys

Basic statistical quantities (mean, maximum, standard deviation) will be calculated from the data collected. When a reference area is surveyed, the same quantities will be calculated. The focus of the data assessments will normally be the comparison of the survey data to the DCGL for the building/area. If all measurements are less than the DCGL, then the data will be used in the FSSs, where possible. Measurements above the DCGL will be assessed for further action.

6.4.2 Remedial Action Support Surveys

The focus of these data assessments will also be the comparison of the survey data to the DCGL for the building/area. If all measurements are less than the DCGL, then the remedial action can be declared complete and an FSS performed. Otherwise, measurements above the DCGL will be identified for continued remedial action.

6.4.3 Final Status Surveys

When determining compliance with FSS goals, the survey data are examined. Compliance tests are summarized as follows:

- Compare the largest measurement to the DCGL (net of background, if present in background). If all measurements are lower than the release limits (net of background, if present in background), no statistical test is necessary.
- Compare the average measurement to the DCGL (net of background, if present in background).
- Use the appropriate statistical test to determine whether the survey data exceed the release limits, if necessary.
- If scan measurements are above the DCGL, then a fixed measurement will be taken to confirm the elevated reading. If the elevated reading is confirmed, then the unit would fail.

When multiple nuclides are present, each with an individual DCGL, they will be assessed in accordance with the methods described in Section 7.2.

This Work Plan will use an analysis structure incorporating three possible common statistical procedures, as well as conventional qualitative and semiquantitative comparisons for FSS data. The statistical tests are applied only to measurements made at fixed locations. The tests are:

- **Sign test** – The Sign test is a one-sample, nonparametric test that can be used to evaluate compliance with the release limit. The Sign test is the recommended compliance evaluation procedure when the contaminant(s) under evaluation are not present at significant levels in background. Any one of the individual samples (each individual survey unit is a "sample" in this context) or any combination can be compared to the release limit with the Sign test. For example, each of the Class 1 survey units could be pooled for an overall building comparison to the release limits rather than comparing an individual survey unit to the release limit.
- **Wilcoxon Rank-Sum test** – The WRS test is a two-sample, nonparametric procedure that can be used to evaluate compliance when the contaminant is present in background. The WRS test can be used as a two-sample test to compare medians between samples (contamination concentration measured in reference background materials versus the same parameter measured in site investigative materials) when either or both sampling distributions deviate significantly from normal.

- **Normal means test** – This is the traditional two-sample t-test based on the central limit theorem (i.e., normality). It can be used to assess compliance, derive confidence intervals, and compare between samples (mean removable surface contamination concentration in 1 survey unit versus the same parameter measured in another survey unit) when both sample distributions are normal or do not deviate appreciably from normality.

Both scan and fixed measurements are subject to the elevated measurement comparison. The result of this comparison is not conclusive as to whether the survey unit meets or exceeds the release criterion, but is a flag or trigger for further investigation. This comparison is described in Section 7.1.

6.5 DECISION MAKING

6.5.1 Scoping and Characterization Surveys

For a scoping survey, the decision rule is, "If the survey results meet the criteria defined in the TSPs, then design and perform an optimized FSS. If the survey results do not meet the criteria defined in the TSPs, then design and perform an optimized characterization survey." In practice, most scoping surveys will be tested against DCGLs. If no contamination above the $DCGL_w$ is found, then the survey data will be used in an FSS. If contamination is found, then a characterization survey would be performed.

For a characterization survey, the decision rule is, "If the survey results meet the criteria defined in the TSPs, then design and perform an optimized FSS. If the survey results do not meet the criteria defined in the TSPs, then perform remedial action." If no contamination above the $DCGL_w$ is found, then the survey data would be used in an FSS.

6.5.2 Remedial Action Support Surveys

The decision rule is, "If the survey results indicate that the remediation is complete (as defined in the TSPs), then design and perform an optimized FSS. If the survey results indicate that the remediation is incomplete, then reevaluate the remedial alternative and continue."

6.5.3 Final Status Surveys

The results of the statistical testing of the data set for each survey unit will be used to evaluate whether to accept or reject the null hypothesis. Using the MARSSIM (DoD et al. 2000) Scenario A methodology, the null hypothesis is stated as "the residual activity in the survey unit exceeds the release criterion." Thus, in order to pass the survey unit (that is, release the area), the null hypothesis must be rejected. The objective of FSSs will be to demonstrate that residual radioactivity levels meet the release criterion. In demonstrating that the objective is met, the null hypothesis (H_o) is tested that residual contamination exceeds the release criterion; the alternative hypothesis (H_a) is then tested that residual contamination meets the release criterion.

To validate the use of a test, the data will be verified to be consistent with the underlying assumptions made for the statistical procedure. Assumptions that can be made in the survey design are:

- The sample sizes determined for the tests are sufficient to achieve the DQO set for the Type I and Type II error.
- The data from the reference area or survey unit consist of independent samples from each distribution.
- The reference area and survey unit data distribution are similar, except for a possible shift in the medians.
- Whether the data represent a normal or asymmetric distribution.

Certain departures from these assumptions may be acceptable when given the actual data and other information about the study. One of the primary advantages of the nonparametric test is that it involves fewer assumptions about the data than the parametric test.

For Scenario B methodology, as defined in NUREG-1505 (NRC 1997a), the null hypothesis is stated as "the residual activity in the survey unit meets the release criterion." Scenario B methodology is typically used when the $DCGL_w$ is difficult to distinguish from background concentrations and may be used only with concurrence from the RASO. If Scenario B is used, specific details will be listed in the TSP as a deviation or exception to this Work Plan.

7.0 RELEASE CRITERIA AND INVESTIGATION LEVELS

The release criteria for buildings, structures, material, and land areas at former NAVSTA PS are listed in Table 7-1. Release criteria for equipment and material are taken from AEC Regulatory Guide 1.86 (AEC 1974). Criteria for structures (surfaces) are taken from either Regulatory Guide 1.86 or a dose-based calculation, whichever is lower. The dose-based calculation will be performed with a dose limit of 15 millirems per year, using the most current version of RESRAD (for outdoor areas) or RESRAD-BUILD (for structures) software packages.

Release criteria for soil/sediment are derived from a dose limit of 15 millirems per year using the industrial worker exposure scenario, with the radon pathway turned on and lead-210, a daughter product of Ra-226, in secular equilibrium with Ra-226. The RESRAD code default parameter defines a 10,000-square-meter contaminated soil mass that is 2 meters thick and has no material cover (clean soil). This was changed to 1,000 square meters and a 1-meter depth to match the contamination scenarios previously identified during the radiological remedial investigation conducted at former NAVSTA PS. The indoor and outdoor fractions were adjusted for the industrial worker scenario from 75 percent indoors and 25 percent outdoors during a typical 2,000-hour work year to distribute the worker's time to 50 percent indoors and 50 percent outdoors (occupancy factor of 0.115). Limits for a specific building or area will be provided in the TSPs, which will be congruent with the criteria defined in the Action Memorandum (Shaw 2013). Release criteria organized by survey type are as follows:

- A remedial action support survey will use the release criteria for equipment, material, structures, and soil.
- An FSS will use all the release criteria in Table 7-1.

7.1 ASSESSING SMALL AREAS OF ELEVATED ACTIVITY

Using guidance from MARSSIM (DoD et al. 2000), systematic measurements and sampling, in conjunction with surface scanning, are used to obtain adequate assurance that small areas of elevated radioactivity will satisfy the release criterion for small areas. Under RASO direction, this procedure may be implemented for survey units classified as Class 1.

The $DCGL_W$ is the average concentration across the site that is equivalent to the release criterion based on dose or risk. The general assumption is that the concentrations of the radionuclides in the source are homogeneous. The degree to which any single localized area can be elevated above the average, assuming the average is at the $DCGL_W$, and not invalidate the homogeneous assumption is characterized by the small area criteria ($DCGL_{EMC}$).

Values for the $DCGL_{EMC}$ are obtained by modifying the $DCGL_W$ using an area factor that accounts for the difference in area and the resulting change in dose or risk. The area factor is the

magnitude by which the concentration within the small area of elevated activity can exceed the $DCGL_W$ while maintaining compliance with the release criterion. The area factor takes into consideration how a smaller area would affect the dose or risk.

The first step in the process is to assess the scan minimum detectable concentration (MDC); this process is described in Section 8.2. The next step is to determine the "required" scan MDC. The required scan MDC is the product of the $DCGL_W$ and the area factor (also known as the $DCGL_{EMC}$). This can be calculated using Equation 7-1:

Equation 7-1

$$\text{"required" Scan MDC} = DCGL_{EMC} = (DCGL_W) \times (\text{Area Factor})$$

The area factor is obtained from dose modeling using RESRAD or RESRAD-BUILD software, the industry standard accepted by the NRC, EPA, Department of Energy, and other regulatory agencies for radioactive contamination modeling. The area factor is determined based on the size of the area bounded by the sample size in the survey unit. This bounded area (*a'*) is simply the survey unit area (in m^2) divided by the number of samples determined as discussed in Section 6.3.3. Equation 7-2 is used to derive the size of the area:

Equation 7-2

$$a' = \text{Survey Unit Area (in } m^2) \text{ / number of samples}$$

The "actual" scan MDC is then compared to the required scan MDC. If the actual scan MDC is less than the required scan MDC, then no additional samples are required. However, if the actual scan MDC is greater than the required scan MDC, an increase in the number of samples taken may be required. To determine if there is to be an increase in the number of samples, the area factor is determined using Equation 7-3:

Equation 7-3

$$\text{Area Factor} = (\text{"actual" Scan MDC}) / (DCGL_W)$$

A table of possible area factors is determined by taking the ratio of doses established by using the most current version of RESRAD for outdoor areas or RESRAD-BUILD for structures. For each radionuclide of concern, all exposure pathways are calculated assuming a concentration of radioactive contamination at the release criterion.

The area of contamination in RESRAD defaults to 10,000 m^2. Other than changing the area (i.e., 1, 3, 10, 30, 100, 300, 1,000, or 3,000 m^2), the RESRAD exposure pathways remain constant. A table of area factors is then computed by taking the ratio of the dose or risk per unit concentration generated by RESRAD for the 10,000 m^2 to that generated for the other areas

listed. If the DCGL for residual radioactivity distributed over 10,000 m^2 is multiplied by this value, the resulting concentration distributed over the specified smaller area delivers the same calculated dose.

Indoor area factors are calculated in a similar manner using the most current version of RESRAD-BUILD. The area of contamination in RESRAD-BUILD defaults to 36 m^2. The other areas to be compared to this value are 1, 4, 9, 16, and 25 m^2. Removable surface contamination is assumed to be 20 percent. No other changes to exposure pathways are to be made between iterations when calculating a table of values.

This area factor is then used to determine the new area bounded by samples a' by logarithmically interpolating from a generated table of possible area factors using Equation 7-4, and solving for a':

Equation 7-4

$$\ln(a') = \frac{\ln(\frac{y}{z}) \cdot \ln(\frac{AF_x}{AF_z})}{\ln(\frac{AF_y}{AF_z})} + \ln(z)$$

Where:

y	=	size of area with lower area factor than area factor determined
z	=	size of area with higher area factor than area factor determined
AF_x	=	area factor determined
AF_y	=	area factor of area y
AF_z	=	area factor of area z

Substituting the new bounded area a' into Equation 7-5 provides the increased number of samples required, if any:

Equation 7-5

Additional number of samples required = Survey Unit Area (in m^2) / (a')

The additional number of samples required, in addition to the number required for a particular statistical test from Section 6.3.3, will form the total number of samples required for a particular survey unit when using elevated measurement comparisons. This new total number of samples required will then be applied to the systematic sampling pattern described in Section 5.4 to determine the grid spacing.

7.2 ASSESSING MULTIPLE RADIONUCLIDES

When multiple radionuclides are present, a combined DCGL will be used, as directed by the RASO. A combined DCGL is calculated using Equation 7-6:

Equation 7-6

$$\text{Combined DCGL} = \frac{1}{\frac{f_1}{DCGL_1} + \frac{f_2}{DCGL_2} + ... + \frac{f_n}{DCGL_n}}$$

Where f_n is the anticipated fraction of each radionuclide versus the total, and $DCGL_n$ is the DCGL for each radionuclide present, the sum of f_1, f_2,…f_n equals 1.

7.2.1 $DCGL_W$ for Multiple Radionuclides

As stated in MARSSIM (DoD et al. 2000) the $DCGL_W$, when using multiple radionuclides, is established by definition at 1.0. The unity rule, represented in the expression below (Equation 7-7), is satisfied when the radionuclide mixture yields a combined fractional concentration limit that is less than or equal to 1. Statistical tests will be used to prove that the total sum of all radionuclides does not exceed the applicable release criterion.

7.2.2 Determination of LBGR for Multiple Radionuclides

The LBGR is the net median concentration of the contaminant in the survey unit. Since this value is unknown, MARSSIM suggests using a value for the LBGR of half the DCGL during planning purposes. However, once the median concentration activity in the survey unit is established, this value is used as a ratio to the lowest DCGL for the decay method to determine the LBGR. Equation 7-7, taken from MARSSIM, gives the method used to determine the LBGR:

Equation 7-7

$$LBGR = \frac{C_1}{DCGL_1} + \frac{C_2}{DCGL_2} + \frac{C_2}{DCGL_2} + ... + \frac{C_i}{DCGL_i} \leq 1$$

Where:

C_i = median concentration of radionuclide "i"
$DCGL_i$ = DCGL of radionuclide "i"

7.2.3 Determination of Standard Deviation for Multiple Radionuclides

There is no estimate of the standard deviation of the contaminant in a survey unit, especially if no contaminant is initially expected or if concentrations of radionuclides are spatially unrelated.

Therefore, σ is assigned the value of the standard deviation of the adjusted measurement values in the survey unit as shown in Equation 7-8 from Section 7.2.3 of Decommissioning Health Physics (Abelquist 2001):

Equation 7-8

$$\sigma = \sqrt{\left(\frac{\sigma_{C1}}{DCGL_1}\right)^2 + \left(\frac{\sigma_{C2}}{DCGL_2}\right)^2 + \ldots + \left(\frac{\sigma_{Ci}}{DCGL_i}\right)^2}$$

Where:

σ_{Ci} = standard deviation from radionuclide "i"
$DCGL_i$ = DCGL of radionuclide "i"

7.3 CONVERTING DCGL UNITS

At times, it may be necessary to convert the DCGL from pCi/g to counts per minute (cpm) in order to calculate the number of samples required in a given survey unit. To perform this conversion, an arbitrary concentration of the radionuclide is divided by the associated exposure rate produced by the concentration (as identified in Section 8.2.8). The resulting number is then divided by the average net cpm per microroentgens per hour (μR/hr) for the detector being used. Once the number is derived, the release criterion is divided by this number, as shown in Equation 7-9:

Equation 7-9

$$cpm = \frac{DCGL}{DCGL_{AC} / M * DCGL_{AC} / \mu Rcpm}$$

Where:

$DCGL$ = release criterion (pCi/g)
$DCGL_{AC}$ = arbitrary concentration of radionuclide (pCi/g)
M = exposure rate calculated by MicroShield™ (Grove Engineering 1996)
$\mu Rcpm$ = counts per minute per μR/hr for the detector

7.4 INVESTIGATION LEVELS

Investigation levels are specific levels of radioactivity used to indicate when additional investigation may be necessary. Investigation levels also serve as a QC check. For example, in addition to indicating potential contamination, a measurement that exceeds the investigation level may indicate that the survey unit has been improperly classified or may indicate a failing instrument.

When determining an investigation level using a statistical-based parameter (e.g., standard deviation), the following may be considered: survey objectives, underlying radionuclide distributions (e.g., normal, log normal, nonparametric), data population descriptors (e.g., standard deviation, mean, median), and prior survey and historical information.

When an investigation level is exceeded, the measurement will be confirmed to ensure that the initial measurement/sample actually exceeds the particular investigation level. This will involve taking further measurements to confirm the initial result, and as appropriate, to quantify the area of elevated residual radioactivity.

7.4.1 Investigation Levels for Gamma Radiation Surveys

For gamma surveys, the investigation level will normally be established at the reference area mean + 3σ, where σ is the standard deviation of the gamma readings in the reference area. This investigation level will be established for each gamma survey instrument at a frequency not to exceed monthly. Other investigation levels may be implemented with prior RASO concurrence.

7.4.2 Investigation Levels for Alpha and Beta Radiation Surveys

For alpha and beta surveys, the investigation level will be the $DCGL_W$ or a statistical-based parameter, if used.

8.0 INSTRUMENTATION

Instruments will be selected that are suitable for the physical and environmental conditions at the site. The selected instruments and measurement methods will be able to detect the radionuclide of concern or radiation types of interest, and are, in relation to the survey or analytical technique, capable of measuring levels sufficient to support the DQOs. Table 8-1 identifies the instrumentation resources available to support the survey objectives.

8.1 FIELD SURVEY INSTRUMENTS

Portable survey instruments will be used to perform measurements in the field. Table 8-1 lists the types of portable survey equipment expected to be used during survey activities at former NAVSTA PS, and Table 8-2 provides examples of field radiological survey instrument calculations.

8.1.1 Calibration

Portable survey instrument calibration will be completed on an annual frequency. Instrument calibration will also be performed after repairs or modifications have been performed on the instrument. The instrument will be calibrated in accordance with the manufacturer's recommended method.

8.1.2 Daily Performance

Prior to use of the portable survey instruments, calibration verification, physical inspection, battery check, and source-response check will be performed per SOP NAVSTA PS-Tt-004, Preparation of Portable Radiation and Contamination Survey Meters and Instruments for Field Use.

All portable survey instruments will have a current calibration label that will be verified daily prior to use of the instrument.

Physical inspection of the portable survey instrument will include:

- General physical condition of the instrument and detector prior to each use
- Knobs, buttons, cables, connectors
- Meter movements/displays
- Instrument cases
- Probe/probe window(s)
- Other physical properties that may affect the proper operation of the instrument or detector

Any portable survey instrument or detector having a questionable physical condition will not be used until the problems have been corrected.

A battery check will be performed to ensure that sufficient voltage is being supplied to the detector and instrument circuitry for proper operation. This check will be performed in accordance with the instrument's operations manual.

The instrument will be exposed to the appropriate (alpha, beta, gamma) check source to verify that the instrument response is within the plus or minus percent range determined during the initial response check.

The results of the daily operation checks discussed above will be documented. Instruments that do not pass the daily operation checks will be removed from service until all deficiencies have been corrected.

8.1.3 Instruments for Surface Scan Surveys for Alpha Activity

Scan surveys for alpha radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43 series alpha-beta gas proportional probes (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent).

8.1.4 Instruments for Surface Scan Surveys for Beta Activity

Scan surveys for beta radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37 alpha-beta gas proportional probes (or equivalent) or a Ludlum 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent).

8.1.5 Instruments for Direct Measurement Static Surveys for Alpha Activity

Static surveys for alpha radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37 alpha-beta gas proportional probes (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent).

8.1.6 Instruments for Direct Measurement Static Surveys for Beta Activity

Static surveys for beta radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37 alpha-beta gas proportional probes (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) plastic scintillation detector (or equivalent).

8.1.7 Instruments for Scan Surveys for Gamma Activity

Scan surveys for gamma radiation will be performed using a Ludlum Model 2350-1 data logger (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) scintillation detector (or equivalent) or RASO-approved towed array gamma survey system.

8.1.8 Instruments for Direct Measurement Static Surveys for Gamma Activity

Direct measurement static surveys for gamma radiation will be performed using a Ludlum Model 2350-1 (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector (or equivalent).

8.1.9 Instruments for Direct Measurement Surveys for Beta Gamma Activity

Direct measurement surveys for beta and gamma radiation will be performed using Ludlum Model 3, Model 12, Model 177 or equivalent, with a model 44-9 Geiger Mueller pancake probe (or equivalent). This instrument combination is normally used for routine surveys associated with operational aspects of decommissioning activities such as monitoring personnel and equipment exiting an RCA.

8.1.10 Instrument for Exposure Rate Surveys

Exposure rate surveys are conducted with use of a Ludlum Model 19 MicroR meter (or equivalent). Compatible with anticipated exposure rates, the instrument is equipped with an internally mounted 1-inch by 1-inch NaI scintillation detector that is integral to the meter housing.

8.2 INSTRUMENTATION EQUATIONS

The following equations are used to calculate efficiencies, MDCs, and minimum detectable count rates (MDCRs).

8.2.1 Instrument Efficiency

The instrument efficiency (ε_i) is defined as the ratio between the net count rate, in cpm, of the instrument and the surface emission rate of the calibration source for a specified geometry. The surface emission rate is the 2π particle fluence that is affected by both the attenuation and backscatter of the radiation emitted from the calibration source.

Equation 8-1 will be used to calculate the instrument efficiency in counts per particle, although efficiency is typically reported as having no units or unitless:

Equation 8-1

$$\varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi}\left(\frac{W_A}{S_A}\right)}$$

Where:

R_{S+B} = the gross count rate of the calibration measurement (cpm)
R_B = the background count rate in cpm
$q_{2\pi}$ = surface emission rate of the calibration source (National Institute of Standards and Technology [NIST] traceable) in particles per minute
W_A = active area of the detector window (cm^2)
S_A = area of the source (cm^2)

The instrument efficiency procured from the instrument calibration service is determined by obtaining static counts with the detector over a calibration source that has a NIST-traceable surface emission rate. The 2π particle fluence rate is corrected for decay, attenuation, and scatter. Then the surface emission rate of the source must be corrected for the area subtended by the probe. Factors that can also affect instrument efficiency are discussed below:

- Efficiency Check Sources. Efficiency check sources that emit alpha or beta radiation with energies similar to those expected from the contaminant in the field (similar to the expected radionuclide[s] of concern) will be selected.
- Source Geometry Factors. Instrument efficiency will usually be determined with an efficiency check source equal to or greater than the area of the probe. If a source smaller than the probe is used, a conversion factor is applied to the MDC to account for the active region of the probe.
- Source-to-Detector Distance. The detector efficiency will be calculated at a source-to-detector distance the same as the detector-to-surface distance used in the field.

8.2.2 Surface Activity Measurements

Surveillance measurements are used to quantify surface activity levels on concrete and other building surfaces. International Organization for Standardization (ISO) 7503-1 (ISO 1988), NUREG/CR-1507 (NRC 1997b), and Selection and Use of Portable Radiological Survey Instruments for Performing Insitu Radiological Assessments in Support of Decommissioning (ASTM 1998) are used as technical guidance to ensure accuracy in the measurement of surface activity.

Equation 8-1a is used to calculate the surface activity in units of dpm per 100 cm^2:

Equation 8-1a

$$A_S = \frac{R_{S+B} - R_B}{\varepsilon_i \varepsilon_s \frac{W_A}{100\,cm^2}}$$

Where:

A_S	=	total surface activity (dpm/100 cm^2)
R_{S+B}	=	the gross count rate of the measurement in cpm
R_B	=	the background count rate in cpm
ε_i	=	the instrument efficiency
ε_S	=	the contaminated surface efficiency
W_A	=	the area of the detector window (cm^2)

8.2.3 Count Detection Probability for Alpha Scans (≤ 126-cm^2 Probe)

Scanning for alpha emitters differs significantly from scanning for beta and gamma emitters in that the expected background response of most alpha detectors is very close to zero. The following sections cover scanning for alpha emitters.

Since the time a contaminated area is under the probe varies and the background count rate of some alpha instruments is less than 1 cpm, it is not reasonable to determine a fixed MDC for scanning. Instead, it is more practical to determine the probability of detecting an area of contamination at a predetermined DCGL for given scan rates.

For alpha survey instrumentation with backgrounds ranging from less than 1 to 3 cpm, a single count provides a surveyor sufficient cause to stop and investigate further. Assuming this to be true, the probability of detecting given levels of alpha surface contamination can be calculated by use of Poisson summation statistics.

Given a known scan rate and a surface contamination release limit, the probability of detecting a single count while passing over the contaminated area is given by Equation 8-2:

Equation 8-2

$$P(n \geq 1) = 1 - e^{-\frac{GEd}{60v}}$$

Where:

$P(n \geq 1)$	=	probability of observing a single count
G	=	contamination activity (dpm)
E	=	detector efficiency (4π)
d	=	width of detector in direction of scan (cm)
v	=	scan speed (centimeters per second)

Once a count is recorded and the guideline level of contamination is present, the surveyor should stop and wait until the probability of getting another count is at least 90 percent. This time interval can be calculated by Equation 8-3:

Equation 8-3

$$t = \frac{13,800}{CAE}$$

Where:

t	=	time period for static count(s)
C	=	contamination guideline (dpm/100 cm^2)
A	=	physical probe area (cm^2)
E	=	detector efficiency (4π)

8.2.4 Count Detection Probability for Alpha Scans (582-cm^2 Probe)

The larger (582 cm^2) gas-proportional detectors have background count rates on the order of 5 to 10 cpm, and a single count will not cause a surveyor to investigate further. A counting period long enough to establish that a single count indicates an elevated contamination level would be prohibitively inefficient. For these types of instruments, the surveyor usually will need to get at least two counts while passing over the source area before stopping for further investigation.

Assuming this to be a valid assumption, the probability of getting two or more counts can be calculated by Equation 8-4:

Equation 8-4

$$P(n \geq 2) = 1 - \left[1 + \frac{(GE + B)t}{60}\right]\left[e^{\frac{-(GE+B)t}{60}}\right]$$

Where:

$P(n \geq 2)$	=	probability of getting two or more counts during the time interval t
t	=	time interval(s)
G	=	contamination activity (dpm)
E	=	detector efficiency (4π)
B	=	background count rate (cpm)

8.2.5 Minimal Detectable Count Rate and Minimum Detectable Concentration for Beta Scans

The minimum detectable number of net source counts in the scan interval can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the

detectability value associated with the desired performance (as reflected in *d′*) as shown in Equation 8-5:

Equation 8-5

$$MDCR = \mathrm{d}'\sqrt{\mathrm{b_i}}\left(\frac{60}{i}\right)$$

Where:

d'	=	index of sensitivity (α and β errors [performance criteria])
b_i	=	number of background counts in scan time interval (count)
i	=	scan or observation interval(s)

The required rate of true positives will be 95 percent, and the false positives will be 5 percent. From Table 6.5 of MARSSIM (DoD et al. 2000), the value of *d'*, representing this performance goal, is 3.28.

The minimum detectable number of net source counts in the interval is given by S_i. Therefore, for an ideal observer, the number of source counts required for a specified level of performance can be arrived at by multiplying the square root of the number of background counts by the detectability value associated with the desired performance (as reflected in *d'*), as shown in Equation 8-5a:

Equation 8-5a

$$S_i = d'\sqrt{b_i}$$

The scan MDC is determined from the MDCR by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. As discussed below, the MDCR accounts for the background level, performance criteria (*d′*), and observation interval. The observation interval during scanning is the actual time that the detector can respond to the contamination source. This interval depends on the scan speed, detector size in the direction of the scan, and area of elevated activity.

The scan MDC for structure surfaces is calculated using Equation 8-6:

Equation 8-6

$$Scan\ MDC = \frac{MDCR}{\sqrt{p}\ \varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2}}$$

Where:

MDCR is discussed above
p = surveyor efficiency factor
ε_i = instrument efficiency (count per particle)
ε_s = contaminated surface efficiency (particle per disintegration)
W_A = area of the detector window (cm^2)

8.2.6 MDC for Static Alpha and Beta Counts

The static MDC is the level of radioactivity practically achievable by the overall measurement process. Equation 8-7 is used to calculate instrument MDC in dpm per 100 cm^2 when the background and sample are counted for the same time intervals:

Equation 8-7

$$MDC = \frac{3 + 4.65\sqrt{R_B T_B}}{\varepsilon_s \varepsilon_i \frac{W_A}{100} T_B}$$

Where:

R_B = background count rate (cpm)
T_B = background counting time (minute [min])
ε_i = instrument efficiency (counts per particle)
ε_s = contaminated surface efficiency (particles per disintegration)
W_A = active area of the detector window (cm^2)

In Equation 8-7, W_A is the size of the "active" area of the detector window. If the area of the detector window (cm^2) does not equal 100 cm^2, it is necessary to convert the detector response to units of dpm per 100 cm^2.

If the background and sample are counted for different time intervals, Equation 8-8 is used to calculate the MDC in dpm per 100 cm^2:

Equation 8-8

$$MDC = \frac{3 + 3.29\sqrt{R_B T_{S+B}\left(1 + \frac{T_{S+B}}{T_B}\right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

Where:

R_B = background count rate (cpm)
T_B = background counting time (min)
T_{S+B} = sample counting time (min)
ε_i = instrument efficiency (counts per particle)
ε_s = contaminated surface efficiency (particles per disintegration)
W_A = active area of the detector window (cm^2)

8.2.7 Surface Efficiency (ε_s) for Surface Activity Measurements

The surface efficiency term in the preceding equations is used to determine the 4π total efficiency for a particular surface and condition. Suitable values are based on the radiation and radiation energy, and are primarily impacted by the backscatter and self-absorption characteristics of the surface on which the contamination exists in the field. Backscatter is most affected by the energy of the radiation and the density of the surface material. Self-absorption characteristics or attenuation are also a function of the radiation's energy and surface condition. Surfaces typically encountered in the field include concrete, asphalt, wood, drywall, plaster, carpet, and metal. Surface conditions include both physical effects, such as scabbled concrete, and the effect of surface coatings: dust, paint, rust, water, and oil.

In the absence of experimentally determined surface efficiencies, ISO-7503-1 (ISO 1988) and NUREG-1507 (NRC 1997b) provide conservative recommendations for surface efficiencies. ISO-7503-1 recommends a surface efficiency of 0.5 for maximum beta energies exceeding 0.5 megaelectron volt (MeV) and to use a surface efficiency of 0.25 for beta energies between 0.15 and 0.4 MeV and for alpha emitters (ISO 1988; NRC 1997b). NUREG-1507 provides surface efficiencies based on studies performed for the NRC. In general, NUREG-1507 indicates that the ISO rule of thumb for surface efficiencies is conservative, particularly for beta-emitting radionuclides with end-point energies between 0.25 MeV and 0.4 MeV. A surface efficiency of 0.25 will be used for alpha and beta emitters at former NAVSTA PS.

8.2.8 MDC for Gamma Scans of Surface Areas

The scan MDC (in pCi/g) for land areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions). To establish the scan MDC, the relationship between the detector's net count rate to net exposure rate must be established first. This is accomplished by determining the MDCR using Equation 8-5 and then applying a surveyor efficiency factor *p* to get the $MDCR_{Surveyor}$ as shown in Equation 8-9:

Equation 8-9

$$MDCR_{Surveyor} = MDCR \Big/ \sqrt{p}$$

The $MDCR_{Surveyor}$ is then converted into the corresponding minimum detectable exposure rate (MDER) by use of a calibration constant specific to the detector being used and the radionuclide of concern. For example, when used with the Ludlum Model 2350-1, the calibration records for the Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector provide a calibration constant that can be used to determine the ratio of cpm to µR/hr, as shown in Equation 8-10:

Equation 8-10

$$MDER\,(\mu R/hr) \quad = \quad \frac{MDCR_{Surveyor} * 6\times10^{7}}{cc}$$

Where:

$MDCR_{Surveyor}$	=	as calculated in Equation 8-9
6×10^{7}	=	a conversion factor accounting for differences in time and activity units ([µR-min]/[R-hr])
cc	=	calibration constant ([counts]/[R])

Next, the relationship between the radionuclide concentration and exposure rate is established. This is accomplished by modeling (using MicroShield) to determine the net exposure rate produced by the radionuclide at a distance above the ground. The factors considered in modeling include:

- Dose point above the surface
- Density of material in grams per cubic centimeter
- DCGL of the radionuclide of concern in pCi/g
- Depth of detection for the DCGL
- Circular dimension of the cylindrical area of detector capability (m^2)

The concentration of the radionuclide of concern (Scan MDC) necessary to yield the MDER may be calculated by taking the ratio of the MDER to the exposure rate calculated by MicroShield or Monte Carlo *N*-Particle code, as shown in Equation 8-11:

Equation 8-11

$$Scan\ MDC\,(pCi/g) = \frac{DCGL\ pCi/g * MDER\mu R/hr}{Microshield\ Exposure\ Rate\mu R/hr}$$

8.2.9 Minimum Detectable Count Rate for Static Gamma Counts

For gamma surveys, MDCR, rather than MDC, is calculated in cpm. If the background and sample are counted for the time intervals, Equation 8-12 is used to calculate the MDCR:

Equation 8-12

$$MDCR = \frac{3 + 4.65\sqrt{R_B T_B}}{T_B}$$

Where:

3 + 4.65	=	constant factor provided by MARSSIM
R_B	=	background count rate (cpm)
T_B	=	background counting time (min)

TSPs will not normally be designed to use different background and sample count times for gamma scan surveys; any deviation from this requires RASO approval, and notation in the TSP and final reports as an exception to the Work Plan. If the background and sample are counted for different time intervals, Equation 8-13 is used to calculate the MDCR:

Equation 8-13

$$MDCR = \frac{3 + 3.29\sqrt{R_B \cdot T_{S+B} \cdot (1 + \frac{T_{S+B}}{T_B})}}{T_{S+B}}$$

Where:

3 + 3.29	=	constant factor provided by MARSSIM
R_B	=	background count rate (cpm)
T_{S+B}	=	background counting time (min)
T_B	=	background counting time (min)

8.3 LABORATORY SAMPLES

All samples collected will be analyzed by a Department of Defense Environmental Laboratory Accreditation Program accredited laboratory.

This page intentionally left blank.

9.0 SURVEY IMPLEMENTATION

This section discusses the types of surveys and their implementation in the field with a focus on the methods for conducting each type of survey. The survey procedures described in this section will be performed in accordance with approved SOPs. Additional survey implementation details will be identified in each TSP.

9.1 REFERENCE (BACKGROUND) AREAS

An average background level will be determined by performing measurements at systematic or random locations within the designated background area. The detector probe will be held approximately 10 centimeters (4 inches) from the surface area for gamma radiation and 0.25 inch from the surface area for alpha/beta radiation. Instrumentation will be allowed to stabilize before background readings are taken. The average of the larger of the readings or the method detection limit or minimum detectable activity reported by the laboratory for all the readings taken will determine the background. Background scan ranges, swipes, and exposure rates will also be collected for reference data. In some cases, solid samples will need to be collected in the background area for comparative analyses of specific survey units. The same survey methodology and instruments used to collect the background data will be used to perform measurements within survey units.

9.2 SCAN SURVEYS

Scan surveys are an integral part of survey programs conducted to determine contamination levels. The surveys are an evaluation technique performed by moving a detection device over a surface at a specified speed and distance above the surface to detect radiation. It will be used to identify areas that may require additional survey measurements.

9.2.1 Scan Surveys for Alpha/Beta Radiation

Surface scan surveys for alpha and beta radiation will be performed by moving the detector over the surface being surveyed at a rate of approximately 1 inch per second. The detector will be held within 0.635 centimeter (0.25 inch) over the surface being surveyed.

9.2.2 Scan Surveys for Gamma Radiation

Scan measurements are obtained by traversing a path at a maximum speed (scan rate) of approximately 0.5 meter per second and slowly moving the detector assembly in a serpentine (S-shaped) pattern, while maintaining the detector approximately 10 centimeters (4 inches) above the area being surveyed.

9.3 STATIC SURVEYS

Static contamination surveys are used to determine contamination levels on surface areas for scoping, characterization, and/or release surveys. The surveys are an evaluation technique performed by holding a detection device over a surface for a specified time at a set distance to detect radiation.

9.3.1 Static Surveys for Alpha and Beta Surface Activity

Direct measurements will be conducted with the detector within 0.635 centimeter (0.25 inch) above the surface. Count time for conducting the measurement will be dependent upon the radionuclide of concern.

9.3.2 Static Surveys for Gamma Radiation

Static gamma measurements require positioning the detector assembly approximately 10 centimeters (4 inches) above the surface and completing a stationary 60-second survey.

9.4 EXPOSURE RATE MEASUREMENTS

Exposure rate surveys are performed to measure ambient gamma radiation levels. These measurements are obtained by holding the detection device at the required distance from the surface being surveyed. Instrumentation will be allowed to stabilize before taking the measurement.

9.5 SWIPE SAMPLE MEASUREMENTS

Swipe sampling will be performed to assess the presence of radioactive contamination that is readily removed from a surface. Swipe samples will be taken to evaluate the presence of alpha and beta surface activity. The procedures for collecting swipe samples are discussed in the attached SAP.

9.6 SURVEY AND SAMPLE LOCATIONS

Static measurements, swipe samples, exposure rate measurements, and media samples will be taken from the same predetermined locations within each survey unit to obtain data for use in FSSs. Section 5.4, Reference Coordinate Systems, and Section 7.1, Assessing Small Areas of Elevated Activity, provide further discussion of survey and sample locations for FSSs. Static measurement locations for equipment and material surveys are given in TSPs; SOPs NAVSTA PS-Tt-003, Radiation and Contamination Surveys; NAVSTA PS-Tt-009, Release of Materials and Equipment from Radiologically Controlled Areas; and other work instructions. Table 1-1 lists each of the TtEC field SOPs developed for performing radiological work at former NAVSTA PS.

9.7 EQUIPMENT AND MATERIAL SURVEYS

Equipment and materials surveys will be performed in accordance with SOPs. Table 7-1 lists acceptable levels of contamination based on the AEC Regulatory Guide 1.86 limits. In the event that survey results indicate levels of contamination exceeding the limits listed in Table 7-1 (for surfaces), appropriate decontamination procedures will be performed using methods described in these SOP NAVSTA PS-Tt-010, Decontamination of Equipment and Tools.

9.8 PERSONNEL SURVEYS

Properly trained staff will perform personnel surveys in a predesignated low-background area before leaving an RCA, as specified in the RWP or when deemed necessary by the RCT. Personnel who are not qualified to administer a self-survey will be monitored by a qualified technician. Personnel surveys will be performed using the appropriate survey methods described above and in accordance with appropriate SOP NAVSTA PS-Tt-003, Radiation and Contamination Surveys.

9.9 MEDIA SAMPLING

Various samples may be collected for radiological analysis, including soil, water, brick, porcelain, wood, and others. The SAP will describe the methods for collecting samples, sample numbering, sample labeling, sample shipment, and completion of the associated chain of custody, and other required documentation.

9.10 AIR SAMPLING

WAC 246-247-110 Appendix A requires an Air Emissions Plan designed to ensure that the general public is safe from radioactive airborne emissions. This plan, which is provided as Attachment 5, includes continuous monitoring of airborne radioactive emissions at four locations around the area where radiological remediation work is performed.

As specified in the RWP, airborne activity monitoring (continuous or grab samples) and engineering controls will be necessary during the course of work to monitor for worker safety. To control occupational exposures, establish PPE, and determine respiratory-protection requirements, monitoring and trending for airborne radioactive material will be performed as necessary. Engineered controls will be implemented if required to maintain airborne concentrations below 10 percent of the applicable derived air concentration (DAC) value for the radionuclides of concern (Table 9-1).

If, during the course of work, an airborne concentration exceeds 10 percent of the DAC, ongoing activities will cease and the affected location will be posted until the source of the airborne concentration is eliminated and levels are confirmed to be below 10 percent of the DAC. Air monitoring will be performed using the methods described in SOP NAVSTA PS-Tt-005, Air Sampling and Sample Analysis.

9.11 GLOBAL POSITIONING SYSTEM MEASUREMENTS

As specified in TSPs, Global Positioning System (GPS) units may be used while performing outdoor area field surveys. For example, during an outdoor gamma scan survey, a GPS unit may be carried adjacent to the gamma detector. The GPS output will be logged along with the gamma count rates, so that each gamma reading will have an associated location point. After the survey, gamma data may be color coded and plotted on a survey map.

In addition, outdoor survey units may be mapped by walking the perimeter with a GPS unit. Once the outline is digitized, static reading locations for that survey unit can be generated in latitude and longitude, using Visual Sample Plan software (Gilbert et al. 2001). These points can be located using the GPS unit followed by the collection of static readings and samples, as appropriate.

Although GPS cannot be used for indoor surveys, building locations will be recorded using GPS readings taken at the exterior building corners, taken from geospatially referenced aerial photographs, or found through other investigations or accepted land-surveying practices.

10.0 DECONTAMINATION, DISMANTLING, AND DISPOSITION

Decontamination, dismantling, and disposition activities will be performed, as identified in a TSP, as part of radiological remedial action activities performed at former NAVSTA PS. Decontamination is the removal, by chemical or physical means, of radioactive material from various types of internal and external surfaces including equipment, materials, components, systems, and structures. Dismantling is the removal, as applicable, of furniture, equipment, and walls or similar structural outworks and components for the purpose of permanently breaking down, removing, and eliminating such materials. This would also include conducting work in open land areas to support the removal of contaminated material or devices. To assess the extent and type of contaminants identified during the course of ongoing fieldwork, various remedial activity support surveys will be necessary.

10.1 DECONTAMINATION

To support ongoing work at former NAVSTA PS, decontamination of materials, equipment, and structures may be necessary. There are numerous decontamination methods available for use. If practical, manual decontamination methods should be used. Abrasive methods may be necessary if areas of fixed contamination are identified. Chemical decontamination can also be advantageous by using detergents for nonporous surfaces with contamination present. Chemicals should be selected for decontamination that will minimize the creation of mixed waste.

Decontamination activities will be conducted using SOP NAVSTA PS-Tt-010, Decontamination of Equipment and Tools.

10.2 DISMANTLING AND REMEDIATION

To support the release of buildings, structures, equipment, materials, and land areas, remedial support activities will need to be conducted. These activities include, but are not limited to, soil removal, and dismantling, disassembling, and/or removal of various systems, components, and structures. The following is a list of expected remedial support activities that may be performed at former NAVSTA PS:

- Piping system removal
- Ventilation system removal
- Equipment, furniture, and material removal
- Soil, asphalt, or concrete removal
- Building demolition
- Structure removal

Specific control methods and more detailed information will be provided in the TSP.

10.3 DISPOSITION

Disposition is the methodology of identifying the radiological status of equipment, materials, and structures for its end use. Disposition will be conducted after the decontamination and/or dismantling activities have been completed and will include the following key elements:

- Control of equipment and materials
- Free release of equipment and materials
- Off-site disposal

To prevent the inadvertent spread of contamination, it is essential to control equipment and materials to ensure that contaminated items are not used in uncontrolled areas.
If decontamination methods are unsuccessful, some materials and equipment may be stored temporarily for future use in RCAs. If it is not feasible or cost-effective to control contaminated equipment and materials, they will be disposed of off-site as low-level radioactive waste.

11.0 DOCUMENTATION AND RECORDS MANAGEMENT

This section defines standards for the maintenance and retention of radiological records. Radiological records provide historical data, document radiological conditions, and record personnel exposure.

Sample collection, field measurements, and laboratory data will be recorded both electronically and on paper, to the extent practicable. Electronic data and other information will be saved to a site computer and backed up to a separate dedicated drive on a nightly basis. Data and information recorded on paper will be recorded using indelible ink. Both electronic and paper records of field-generated data will be reviewed by the RSOR or a designee knowledgeable in the measurement method for completeness, consistency, and accuracy. Data manually transposed to paper from electronic data collection devices will be compared to the original data sets to ensure consistency and to resolve noted discrepancies. Electronic copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device. No data reduction, filtering, or manipulation will be performed on the original electronic versions of data sets.

Changes or corrections to project documentation will be made by crossing out the erroneous item with a single line and initialing (by the person performing the correction) and dating the correction. The original item, although erroneous, must remain legible beneath the crossed-out line. The new information will be written above the crossed-out item. Corrections must be written clearly and legibly with indelible black or blue ink.

11.1 REQUIREMENTS

Records resulting from implementation of this Work Plan shall meet the quality standards as outlined herein. All records must be retrievable and maintained for their prescribed retention time defined in the PCQC Plan (Attachment 2 of this Work Plan). Working copies of records used for reference will be stored separately from the original.

Completed records awaiting transfer to long-term storage shall be stored in an appropriate manner to minimize loss and damage that could result from exposure to weather, fire, or other conditions.

Principal personnel who create, review, and approve radiological records must sign and date the record and follow quality standards specified in the PCQC Plan.

11.2 DOCUMENT QUALITY STANDARDS

Records shall be legible and completed with an indelible ink that provides reproducible and legible copies. Records shall be dated and contain a verifiable signature of the originator. Errors

shall be corrected by marking a single line through the error and by initialing and dating the correction. Radiological records shall not be corrected using an opaque substance. Shorthand or nonstandardized terms may not be used.

To ensure traceability, each record shall clearly indicate:

- Identification of the facility
- Specific location
- Function and process
- Date
- Document number (if applicable)

The quantities used in records shall be clearly indicated in standard units (curie, rad, rem, dpm, becquerel), including multiples and subdivisions of these units.

11.3 DOCUMENTATION

The four types of documentation that will be maintained and assessed are field operation records, laboratory records, data handling records, and work support documents. The majority of the data produced will be entered into the electronic data management system to produce quality data for inclusion in reports, documents, and presentations.

11.3.1 Data Management System

Supportable and definitive data must be produced and managed to achieve the removal action objectives. The TtEC team developed a unique "cradle-to-grave" data management system that seamlessly integrates all phases of the radiological and construction work process from initial survey, excavation, remediation, and FSS activities through backfill of survey units and site restoration. Acquiring, evaluating, and managing data are the principal tasks involved in every aspect of the removal action activities. The resulting survey data are easily uploaded to the Navy Electronic Document Deliverable–Naval Installation Restoration Information Solution database.

11.3.2 Field Operation Records

The information contained in field operation records will document overall field operations and may consist of the following:

- Field measurement records – At a minimum, this documentation will identify the names of the persons conducting the activity, measurement identification, measurement locations, measurement results, maps and diagrams, equipment, and unusual observations. Data record forms, bound field notebooks, and electronic data loggers will be used to record raw data and make references to prescribed procedures and changes in planned activities.

- Sample tracking records – These records will be documented as identified in the SAP.
- QC records – QC records will be prepared as indicated in the PCQC Plan.
- Personnel files – Personnel files record the names and training certificates of the staff collecting data and will be maintained as indicated in the PCQC Plan.
- Deficiency and problem identification reports – These reports will be prepared as indicated in the PCQC Plan.
- Corrective action reports – Corrective action reports will be prepared as identified in the PCQC Plan.

11.3.3 Laboratory Records

Laboratory records will be prepared as indicated in the SAP.

11.3.4 Data Handling Records

Data-handling records document protocols used in data reduction, verification, and validation (as applicable). Data reduction involves data transformation processes such as converting raw data into reportable quantities and units, using significant figures, and calculating measurement uncertainties. Data verification involves reviewing reports of data entered into the electronic data management systems by the appropriate supervisory personnel knowledgeable of and with access to the original data to verify data transcription accuracy in accordance with SOPs. Data comparison and evaluation will be done on radiological samples as discussed in the SAP. Record copies of surveys, sampling, and analytical data (and their supporting data) will be protected and maintained in project record files. Table 1-1 lists each of the current TtEC field SOPs developed for use at former NAVSTA PS.

11.3.5 Work Support Documents

Work support documents may include RWPs, TSPs, reports, and work instructions that will be prepared, reviewed, and approved in the PCQC Plan.

This page intentionally left blank.

12.0 REMOVAL ACTION FIELDWORK IMPLEMENTATION

This section provides the basis for performing construction-related fieldwork activities associated with the removal of radiologically contaminated soil, storm drains (including associated sludge, catch basins, and piping), and building materials. Specifics regarding the surveys that will be performed and the evaluation of data are addressed in the TSPs. Two TSPs provide task-specific information that supplement this Work Plan. One TSP focuses on the work associated with the soil and drains, and the other addresses the building-related work, including the sink drain pipes beneath the building ground floor slabs.

12.1 SUPPORTING PLANS

The following plans and procedures also apply to the execution of the removal action fieldwork.

- Sampling and Analysis Plan (Attachment 1)
- Project Contractor Quality Control Plan (Attachment 2)
- Environmental Protection Plan/Waste Management Plan (Attachment 3)
- Standard Operating Procedures (Attachment 4)
- Air Emissions Plan (Attachment 5)
- Task-specific Plan for Buildings 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys (Attachment 6)
- Task-specific Plan for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (Attachment 7)
- Radiation Protection Plan (Attachment 8)
- Accident Prevention Plan/Site Safety and Health Plan (prepared under separate cover)

12.2 MOBILIZATION

Upon mobilizing, temporary fence will be erected as shown on Figure 3-1 to section off areas near the work sites to support a site office facility and provide for storage of equipment, tools, and materials needed for the work. Equipment and materials arriving at the site that will be used within an RCA will undergo an incoming survey as discussed in Section 12.5. All equipment will be inspected upon arrival to confirm its suitability for service. Equipment failing inspection will be rejected and returned to the supplier for repair or replacement.

12.3 PERMITS AND NOTIFICATIONS

Because the removal action is being conducted under Section 121(e) of CERCLA, administrative requirements such as permits are not required; however, site activities will comply with the substantive requirements of the permits. In coordination with the Navy, the stakeholders and

area tenants who may be affected by TCRA activities will be notified of the fieldwork plans and the corresponding schedule. Coordination with affected parties at the site will be an ongoing effort as the work progresses and conditions at the site change.

Northeast NOAA Drive is wholly owned by the U.S. Department of Commerce, NOAA. The north boundary of their property may extend into the grassy area between NE NOAA Drive and the Building 27 South Shed, where contaminated soil removal will occur. Therefore, NOAA will be consulted prior to performing intrusive work in this area.

Prior to the removal of asbestos, including demolition and/or renovation activities, a notice must be filed with state and local agencies as specified in the regulations. For demolition activities, Puget Sound Clean Air Agency, Regulation III, Section 4.03, requires an Asbestos/Demolition Notification and filing fee 10 days before any friable asbestos is removed and before demolition begins. Washington State demolition requirements are listed in *Washington Administrative* Code 296-155-775. In addition, the Washington State Department of Labor and Industries must be notified of any abatement projects 10 days prior to beginning abatement activities.

12.4 AREA ACCESS AND TRAFFIC CONTROL

The planned work activities are expected to have minimal effect on traffic flow on the streets of the facility. When removing contaminated soil located near the southeast and southwest corners of Building 2, it may be necessary to occupy a small portion of the street/shoulder surface (NE 77th Street and/or 63rd Avenue NE) for a limited period of time. Although not anticipated, the contamination nearby the southeast corner of the building is very close to the edge of NE 77th Street and could extend under the pavement. In this case, limited pavement removal (and subsequent restoration) may be required to permit access to the contaminated soil. A localized area of soil contamination also potentially exists adjacent to 62nd Avenue NE immediately north of the NOAA overpass. Similar to the work at Building 2, short-term occupancy of a portion of the street may be required and localized pavement removal may be required if contamination extends under the pavement. None of the above operations is expected to prevent or significantly impede traffic flow. Where work will encroach on city streets, traffic control and safety measures will comply with the city of Seattle Traffic Control Manual for in-street work.

In addition to the above, temporary area closures will be required in the vicinity of Buildings 2, 12, and 27 to prevent unauthorized entry into work areas, accommodate equipment engaged in the work, and allow for temporary storage of waste. These closures are not expected to encroach onto roadways, but may prompt the need for alternate means of building entry by building tenants and alternate traffic routes and parking areas near the buildings.

Figures will be produced showing proposed area closures and traffic diversions and controls. These figures will be developed in the field to ensure they reflect current conditions at the site

and will be submitted to the Navy Technical Representative (NTR) and/or RPM to facilitate coordination with affected property owners and tenants and minimize impacts.

12.5 EQUIPMENT AND MATERIAL SURVEYS

Equipment and material arriving at the site that will be used in an RCA will undergo an incoming survey. Before leaving an RCA, equipment and material will undergo an outgoing survey. These surveys, which will be performed in accordance with SOP NAVSTA PS-Tt-009, Release of Materials and Equipment from Radiologically Controlled Areas, typically consist of a 100 percent scan of accessible areas for alpha/beta contamination and swipe sampling to ensure that no removable contamination is present.

Equipment leaving the RCA to be used in another area or returned to the equipment supplier will be decontaminated, as necessary, in accordance with SOP NAVSTA PS-Tt-010, Decontamination of Equipment and Tools. If the results of an outgoing equipment survey are below the release criteria, the equipment will be allowed to exit the RCA. If the results of an outgoing survey identify an exceedance of the release criteria, the affected item will remain inside the RCA until additional decontamination measures are implemented and a subsequent survey indicates that the release criteria have been met, or the item has been properly packaged for disposal as radioactive waste. The release criteria for former NAVSTA PS incoming and outgoing surveys are addressed in Section 7.0 of this Work Plan.

12.6 PERSONNEL SURVEYS

Before exiting an RCA, each worker will undergo a personnel survey in a predesignated low-background area, as specified in the RWP or when deemed necessary by the RCT. Personnel who are not qualified to administer a self-survey will be monitored by a qualified technician. Personnel surveys will be performed in accordance with SOP NAVSTA PS-Tt-003, Radiation and Contamination Surveys.

12.7 ADDITIONAL SOIL CHARACTERIZATION SAMPLING

During the radiological remedial investigation, Shaw identified 66 potential soil boring locations for the purpose of collecting and analyzing soil samples to define the magnitude and extent of radiological contamination. Soil from 24 of the 66 boring locations identified was analyzed during the radiological remedial investigation. As part of the radiological removal action, the remaining 42 boring locations, shown on Figure 3-1, will be investigated. Some boring locations may be eliminated and some may be added based on conditions encountered in the field. In addition, gamma walkover surveys of the surrounding ground surface may be necessary in some locations based on conditions encountered in the field. The following summarizes the required activities:

- Obtain necessary permits and approval.
- Identify soil boring locations using GPS or conventional survey methods; if feasible, measurements of known fixed site features may be used.
- Conduct utility clearances (Section 12.8.1).
- Establish RCAs if not already in place.
- Implement traffic control measures where necessary.
- Using a hand auger, collect core samples at 6-inch intervals and log the borings.
- Field-screen each sample interval for volatile organic compounds and gamma count rate; document radiological field-screening results in the boring logs.
- Collect two soil samples from each boring location; document, package, and ship samples to an off-site laboratory for analysis.
- Backfill the borings with bentonite chips and restore surface features as necessary.

From each boring, 6-inch-long hand auger segments will be retrieved continuously from the ground surface to the full depth of the borings. The borings will not extend beyond a depth of 8 feet or below the level of the groundwater, with one exception. If contamination is encountered at a depth of 8 feet before encountering groundwater, the intent will be to extend the boring beyond the contamination or to the water table, whichever is encountered first. In the event that elevated gamma activity is encountered at a shallower depth, sampling will continue, subject to the limit noted above, until two successive 6-inch-long hand auger segments exhibit no elevated gamma activity, as determined by the RSOR. A minimum 2-inch-diameter hand auger will be used. Each hand auger segment will be logged for soil type, surveyed for gamma count rate, and considered for collection for laboratory analysis.

Upon recovery from the boring hole, the soil will be removed and placed into a clean stainless steel bowl or onto clean plastic sheeting. Each sample interval will be visually examined to determine whether or not soil from a higher sample interval has sloughed onto the sample just collected. If this has occurred, the soil from the higher interval will be segregated and discarded. Each discrete soil sample must be representative of the material recovered from a given depth. Each hand auger segment will be examined and lithology will be logged. A drilling log form will be completed for each boring and will include the geological description and radiological field-screening results.

Each hand auger segment will be screened for volatile organic compounds (VOCs) using a flame ionization detector or a photoionization detector. The VOC screening will involve monitoring the breathing zone air for health and safety purposes during sample collection activities. Each hand auger segment will also be field-screened for gamma count rate using a Ludlum 2350-1 data logger with a 44-10 NAI detector (1-minute count at 4 inches from the soil sample). This measurement shall be performed in a “background” area that does not exhibit elevated

gamma count rate resulting from hot spot contamination. The background shall be measured (10 each 1-minute counts) and documented prior to performing these gamma count rate measurements. The purpose of the radiological field screening is to provide real-time radiological activity data to guide the delineation efforts.

Samples from two 6-inch intervals will be sent to an off-site laboratory for radiological analyses for Cs-137 and Ra-226 by EPA Method 901.1 and Sr-90 by EPA Method 905 as described in the SAP (Attachment 1). One sample will be collected from the interval exhibiting the highest gamma count. The second sample will be collected from a lower level where it is determined that sampling has progressed beyond the point of elevated gamma activity. If no elevated gamma count is identified at a given boring location, the sample from the interval exhibiting the highest reading will be analyzed. Completed borings will be filled with bentonite chips, and the surface features will be restored, as necessary.

12.8 REMOVAL OF RADIOLOGICALLY CONTAMINATED SOIL AND DRAIN LINES

The primary field activities associated with the radiologically contaminated soil and/or drain line removal actions include:

- Delineating the areas where excavating will occur
- Clearing vegetation or removing asphalt or concrete pavement
- Performing geophysical investigations to identify and locate underground utilities; coordinate utility outages if necessary
- Implementing stormwater management measures
- Installing plugs and diversion systems to control flow in storm drains
- Establishing RCAs at the work sites
- Ensuring that waste bins are available at the work area
- Setting up air monitors prior to initiating excavation activities
- Surveying asphalt in impacted areas prior to removal, and surveying the underlying soil surface
- Excavating and removing radiologically contaminated storm drain piping and associated components
- Excavating radiologically contaminated soil
- Performing in situ surveys of accessible excavation surfaces (walls and bottom)
- Collecting and analyzing systematic soil samples from the excavations
- Removing additional soil if analytical results identify an exceedance of the release criteria, followed by verification soil sampling and analysis

- Collecting and analyzing FSS soil samples
- Installing new storm drain components
- Placing/compacting fill material and restoring surface features (vegetation or pavement)

12.8.1 Locating Underground Utilities

Before groundbreaking activities begin, historic drawings for the facility will be reviewed to determine whether underground utilities or other obstacles may be present within the areas where excavation will occur. This may require coordinating with the City and tenants, such as Arena Sports in Building 27, regarding utilities installed more recently to support their operations. A geophysical utility-locating service will be contracted to trace and mark the locations of these utilities and inspect the site for evidence of other utilities not identified on the drawings. Utility marking will comply with the American Public Works Association Uniform Color Code requirements. Finally, a call will be made to the Utility Notification Center at 800-424-5555 at least 2 business days before intrusive activities (including removal of pavement or vegetation) begin.

12.8.2 Vegetation and Pavement Removal

Disturbance of existing surface features such as vegetation and pavement will be kept to the minimum necessary to safely and effectively execute the work. Before intrusive work is begun, pavement and vegetation that could cause interference will be removed from the affected area using mechanical means.

12.8.3 Excavations in Non-Radiologically Impacted Areas

No excavating is planned in non-radiologically impacted areas. Should this become necessary, overlying vegetation and pavement will be segregated and evaluated for potential recycling, subject to the approval of the Navy, or will be disposed of in accordance with the applicable requirements of the WMP.

12.8.4 Excavation in Areas of Known Radiological Contamination

Where excavating will take place within radiologically contaminated sites, gamma radiation surveys will be performed using a Ludlum 2350-1 survey meter with a Ludlum 44-10 2-inch by 2-inch NaI detector (or equivalent) before beginning intrusive activities. The purpose of these surveys is to identify and allow mitigation of potential worker exposure risks caused by discrete radioactive sources that may be present at or near the ground surface. Initial surface scans for radiation will be performed in accordance with the associated TSP and TtEC SOP NAVSTA PS-Tt-003, Radiation and Contamination Surveys.

Vegetation and other obstructions that could interfere with performing the survey will first be cleared. The initial surface survey will encompass an area that extends beyond the expected excavation boundaries. The survey will be performed using approved data loggers with probes identified in the TSP. The results will be evaluated before intrusive activities begin.

If an area of elevated activity is identified and confirmed during the initial surface scan, the location data (coordinates) will be recorded and the location will be marked or flagged. The field survey team or the data group analyzing collected field information will notify the TtEC RSO or designee and the Project Manager (PjM). The RSO or PjM will notify the RASO and RPM. Areas known or suspected to contain radioactive contamination will be isolated pending further evaluation and removal of the material.

Supervised radiological support personnel will investigate the suspect area using survey instruments to determine whether the elevated activity is a discrete point source or radiologically impacted material such as soil, asphalt, or concrete. The results will be reported to the RSO or designee.

Once the area of elevated activity is confirmed with the RSO or designee, the typical removal action for radiological contamination will involve excavating an area within a radius of 1 foot around the coordinates of the radioactive material. The removed material will be placed directly into a low-level radioactive waste bin pending off-site disposal by the Navy radiological waste contractor (Army Joint Munitions Command). After the radioactive material and surrounding soil are excavated, the resulting area will be resurveyed to ensure that the contamination has been removed. If elevated gamma emitters persist, further examination of the soil will be required until the source of contamination is found and removed.

If the source of elevated radioactivity can be readily identified as a point source, the item will be given a unique identification number, placed in a plastic bag, and photographed. The item will be stored in an approved container and placed in a designated and posted radioactive material storage area for subsequent packaging and disposal by the Navy radiological waste contractor. Storage and disposal of radioactive contamination or point sources will be performed in accordance with the WMP (Attachment 3 of this Work Plan).

12.8.5 Excavating and Trenching

12.8.5.1 Drain Line Removal

Drain line and catch basin removal will be accomplished using a hydraulic excavator where feasible. Due to access considerations, concern over underground utilities, or the limited size of the area to be remediated, manual soil removal may be necessary or preferred in some areas. Prior to excavating, adjoining open drain lines that will be left in place during the removal process will be plugged to prevent water from escaping the excavation and potentially spreading

contamination. The general approach to drain line removal will be to remove the overlying pavement, remove the soil overlying the drain line, and then remove the drain line. A minimum of 1 foot of soil will be removed from either side and below the pipe. When drain line and soil removal are tentatively complete, the trench surface soil will be scanned and sampled as discussed in Section 12.8.6 to confirm whether or not the removal effort was successful. Excavated materials will be loaded directly into bins provided by the government-designated waste contractor. Utilities encountered while excavating will be protected and supported as necessary.

Ongoing development at the facility may have necessitated changes to the underground drain systems that may not have been well documented. As a result, the discovery of an abrupt pipe termination, unexpected lateral connection, or abandoned line is possible during planned line removal activities. When an unanticipated lateral connection or abandoned line is encountered, an attempt will be made to identify the source of the lateral line, and the PjM will contact the RPM for further direction.

If a drain line ends abruptly during excavation, the PjM will coordinate with the Navy to determine whether a previous removal action may have occurred in the area. When no area-specific knowledge is available, potholing along the projected line routing may be used to verify whether the pipe segment was removed. No further action is required when previous removal actions or potholing confirms that no further pipe exists. This information will be documented in the FSS Report.

12.8.5.2 Soil Removal

Prior to beginning intrusive activities in radiologically contaminated soil removal areas, the survey results and associated location data collected during the remedial investigation will be used to bound the known points of elevated activity. These boundaries, which will be identified in the TSP, will define the tentative soil removal areas. Soil removal will be accomplished using a hydraulic excavator where feasible. Due to access considerations, concern over underground utilities, or the limited size of the area to be remediated, manual soil removal may also be necessary or preferred in some areas. Soil removal will begin near the center of the bounded area and progress outward and downward, as necessary, until complete. The removal effort will be guided using hand-held instruments. The excavation will then be scanned and sampled as discussed in Section 12.8.6 to confirm whether the removal effort was successful. Utilities encountered during excavation will be protected and supported as necessary.

12.8.6 Excavation Surveys

Once hand-held survey instruments indicate that soil removal is tentatively complete, scoping or characterization surveys of the exposed excavation bottom and sidewalls will be performed. The TtEC data management system will track each trench survey unit from designation, survey

activities, sampling and analysis, remediation (when appropriate), and the entire iterative process through the selection of backfill material and the completion of backfilling activities. The total surface area of an excavation survey unit will not exceed 2,000 m^2. Scoping or characterization surveys and FSSs for the trenches will include surface scans and systematic soil sampling. Systematic sample collection locations will be generated using the most current version of Visual Sample Plan.

The systematic soil samples will be analyzed for Ra-226, Cs-137, and Sr-90 by an approved off-site laboratory in accordance with the procedures and methodologies identified in the SAP (Attachment 1). Areas of radiological contamination identified during the scoping surveys will be characterized and remediated, as necessary. Once evaluation of the results of a set of systematic samples analyzed by the off-site laboratory indicate that that there is no additional contamination above the release criteria, the trench survey unit will be considered acceptable for backfilling, subject to concurrence by the RASO. No trenches will be backfilled without RASO concurrence.

12.8.7 Restoration of Disturbed Areas

When the results of the surveys and sampling confirm that contamination above the release criteria has been removed and the RASO has provided its concurrence, restoration efforts may begin. All excavations will be backfilled using clean imported material. Import material sources must be verified clean by laboratory analysis as specified in the SAP. Written certification from the proposed source that its material meets the acceptance criteria stated in the SAP for chemical constituents can be used in lieu of analysis. However, analysis for radionuclides of concern cannot be waived. All excavations for the purpose of removing radiologically contaminated soil and/or storm drains must extend to a depth of at least 12 inches below the planned finish grade to accommodate a minimum 12-inch surface layer of clean imported fill material.

12.8.7.1 Installing and Backfilling Storm Drains

Only those storm drain segments that are part of an active system will be replaced. Storm drain system components (e.g., catch basins, pipe, and appurtenances) will comply with the current edition of the city of Seattle Standard Plans and Specifications. Pipe material will be corrugated polyethylene, corrugated high-density polyethylene, or polyvinyl chloride. Pipe diameters, slopes, and inlet grades will match those of the system that was removed, except where minor variations may be warranted to improve system performance. The as-built condition of the new storm drains will be documented in the After Action Report, which will be prepared at the conclusion of the fieldwork.

Shallow groundwater at the site is expected to cause soil in the storm drain trenches to be wet, and correspondingly unstable. As a result, before placing aggregate for pipe bedding, it may be necessary to stabilize the trench bottom using a packed layer of coarse angular rock. Aggregate

used to bed and surround the pipe will be selected with consideration for the type of pipe used. This material will be non-moisture sensitive, containing minimal fines, and will stabilize the pipe in place with little or no compaction effort required. A minimum of 6 inches of bedding material is required above and below the pipe.

Above the level in the trench influenced by groundwater, fill material may be a readily compactable, pit run sandy gravel or common borrow. Trench fill in areas not subject to traffic loading, such as the vegetated areas located south of Building 27, will be compacted using a walk-behind vibratory plate to provide a firm, stable fill section. No in-place testing will be required.

Fill material in areas that will be paved and subject to traffic loading will be placed in maximum 12-inch-deep compacted lifts. The final 12 inches of fill material will consist of 8 inches of crushed gravel base course and 4 inches of crushed gravel top course. Within 2 feet of the final pavement subgrade level, the fill material will be compacted to 95 percent of the maximum density as determined by American Society for Testing and Materials (ASTM) D 1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort. All material below this 2-foot range, but above the pipe zone material, will be compacted to 90 percent of the same maximum density.

In-place density will be tested in accordance with ASTM D 2922, Standard Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth). Test frequency will be a minimum of 1 test per 50 feet of trench length and 2 feet of fill depth.

12.8.7.2 Backfilling Soil Remediation Areas

The final surface feature in these areas will be either vegetation (generally grass) or pavement. Remediation areas located outside of paved areas (grass covered) will be backfilled using pit run sandy gravel or common borrow. The material will be packed into place by tracking over it with an excavator and/or compacting it with moderate effort using a vibratory plate to provide a stable fill section. No in-place testing will be required. The restoration areas will be graded to approximate or improve upon the conditions that existed prior to ground disturbance and facilitate proper surface drainage. The final 4 inches of fill material will be topsoil.

Excavations in paved areas will be backfilled using pit run sandy gravel or common borrow. In-place density will be tested in accordance with ASTM D 2922, Standard Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth). Test frequency will be a minimum of one test per 500 square feet of fill area and 2 feet of fill depth.

12.8.7.3 Final Surface Features

The final restoration grades will blend with surrounding grades and substantially match surface conditions that existed prior to disturbing the area. Some grade and contour changes may be

warranted to ensure proper drainage and reduce the potential for erosion. Grass groundcover will be re-established using seed-impregnated biodegradable matting or sod. If established trees must be removed to accommodate the removal action, replacement (if required) will be coordinated with the NTR and the property owner. Depending on weather conditions at the time, temporary irrigation may be necessary to ensure proper growth. Paved areas will be restored with 3 inches of hot mix asphalt concrete over a prepared base. The mix design will be submitted to the RPM and/or NTR for review. The surrounding pavement will be saw cut, as necessary, to remove ragged edges and provide suitable edges against which new pavement will be placed. The edges of existing pavement will receive an asphalt tack coat before paving against them. The joints between existing and new pavement will be sealed with asphalt emulsion.

12.9 REMOVAL OF RADIOLOGICALLY CONTAMINATED BUILDING COMPONENTS

The primary field activities associated with the radiologically contaminated building components removal action include:

- Establishing RCAs
- Inspecting the buildings to identify potential safety hazards
- Completing an asbestos survey in building areas where removal action work will be performed
- Abating asbestos (if needed) where it will interfere with the removal action
- Conducting a scoping survey
- Removing or remediating contaminated building materials
- Disposing of both noncontaminated waste and contaminated waste in permitted landfills
- Conducting remedial action support surveys
- Conducting an FSS
- Restoring building features where required
- Preparing FSS reports

12.9.1 Control of Access and Egress

Work in the buildings will be initiated by establishing an RCA within the building (SOP NAVSTA PS-Tt-007). The RCA delineates an area of known or potential contamination in which protective measures are employed, such as the use of PPE (NAVSTA PS-Tt-012) and dosimetry (NAVSTA PS-Tt-002). Any physical entrance to the RCA is known as a control point. Any person entering the RCA will be signed in and out in a log book at the control point.

When exiting the RCA, everyone's hands and feet will be surveyed to ensure they are not tracking radiological contamination outside the area.

12.9.2 Asbestos/Lead-Based Paint Surveys and Abatement

To facilitate the radiological surveys and removal of radiologically contaminated building materials and components, some known asbestos-containing material (ACM) may need to be removed. For example, ACM is known to exist in the form of 9-inch by 9-inch floor tiles in Building 2. Removal of ACM will be required prior to demolishing the Building 27 South Shed, as described in Section 12.9.5. An asbestos survey will be performed, as required, to assess the presence of asbestos. This survey will be performed by an Asbestos Hazard Emergency Response Act-accredited building inspector. ACM removal will be performed by an abatement contractor licensed in the state of Washington, who will prepare and submit an Asbestos Abatement Plan to TtEC.

Lead-based paint may also be present on some building surfaces and have to be removed. In conjunction with the asbestos survey, painted surfaces will be tested, as necessary, to determine if lead is present. If necessary, lead-based paint will be removed using a solvent.

Health hazards associated with ACM, lead-based paint, and solvent use, as well as measures for the control of these hazards, are addressed in the APP/SSHP. Waste characterization and disposal are addressed in the WMP (Attachment 3 to this Work Plan). All ACM requiring removal will be surveyed for radiological contamination to determine the proper disposal pathway. The WMP will describe the means and methods, air monitoring strategies, removal, and disposal that are consistent with regulatory requirements in the state of Washington, King County, and city of Seattle.

12.9.3 Radiological Surveys and Remediation

Scoping surveys will be completed, if needed, to assess the extent of radiological contamination in the buildings (Section 5.1.2). If the remedial investigation or scoping surveys identify radiation levels above the release criteria, remediation will be performed. A remediation event aims to safely and fully remove radiological contamination above the release criteria. Remediation methods will vary by the type of contaminated material. Hard surfaces such as concrete floors will be scabbled to remove a layer of the floor. Other contaminated surfaces such as wood flooring or wall board may be cut away to remove the contamination. Contaminated ventilation systems may be vacuumed using a high-efficiency particulate air vacuum to achieve release criteria, or it may be necessary to completely remove contaminated sections of the ventilation system.

Prior to disturbing any contaminated building materials, an inspection will be performed throughout the area to identify potential avenues, such as duct or pipe penetrations, through

which contamination could spread into adjacent areas. For example, the Building 27 South Shed shares a common wall with the hangar structure to the north, which is occupied by an active tenant (Arena Sports). It also may be necessary to breach the thickness of a wall or floor when remediating contaminated building surfaces. To prevent the escape of contamination, a barrier consisting of an impermeable membrane or enclosure will be installed on the side of the wall or floor opposite of where the work is taking place.

Although there was no evidence of such during prior investigations, there is potential that radiological contamination has spread to building components where remediation or removal of the affected material could jeopardize the integrity of the structure. If during the removal action this is found to have occurred, an engineering assessment will be made on a case-by-case basis to determine the impact, if any, that remediation or removal could have and whether or not implementation of measures might be necessary to maintain the integrity of the structure.

Once removed, the generated waste will be stored in appropriate containers pending turnover to the government-designated waste contractor for disposal. During the remediation process, remedial action support surveys are conducted to assess the effectiveness of a remediation effort (Section 5.1.4). Once all necessary remediation has been completed, the building will be ready for an FSS.

The goal of the FSS is to provide sufficient data to show that no radiological contamination above the release criteria remains in the building (Section 5.1.5). This is achieved by first separating the building into survey units. These survey units are then systematically surveyed. All collected data will be assembled into an FSS Report. The FSS Report is provided to the applicable regulators as a request to release the building for unrestricted use.

12.9.4 Building 2 Restoration

Once survey results indicate that all identified radiological contamination above project release criteria has been removed from Building 2 and the RASO has provided its concurrence, restoration of disturbed areas of the buildings may occur. The intent of restoration will be to return the building to a condition that is similar to that which existed prior to the removal action. Building components associated with systems that are no longer functional, such as the ventilation system ductwork, will not be restored. Wood floors, where decking material has been removed, will be restored using comparable materials that are readily available on the local market (generally plywood). Floor covering such as roll vinyl or tile will not be required. Wall insulation removed to accommodate remediation will be restored. Restoration of wall surfacing (e.g., gypsum board or plywood) will not be required, nor will any plastering, sanding, caulking, or painting.

12.9.5 Building 27 South Shed Demolition

Once the FSS is completed, indicating that all identified radiological contamination above project release criteria has been removed from the Building 27 South Shed, and the RASO and NAVFAC NW have concurred, the wood-framed superstructure will be demolished. The concrete foundations, floor slab, and stem walls will remain in place, except for a portion of the floor slab that will be removed to accommodate drain pipe removal and a portion of the stem wall that may have to be removed to accommodate access by demolition equipment. The demolition work will be performed by a specialty contractor, who will be required to submit a demolition plan detailing the planned activities and health and safety risks and controls that will be implemented. TtEC will review this plan and, if necessary, the contractor will address comments. Demolition activities will not begin until the plan is approved and necessary notifications have been made as noted in Section 12.3.

Before demolition activities can begin, ACM identified during the asbestos survey that was not removed to accommodate removal of radiologically contaminated building materials and components will be abated. This may include siding and roofing materials, thermal system insulation, or other forms of ACM.

When the Building 27 South Shed was constructed, the hangar siding and secondary support steel were removed, leaving only the main structural columns. In place of the materials that were removed, the north wall of the South Shed serves as a common wall with the hangar structure. To minimize concern of impact or risk to the occupants of the hangar structure (Arena Sports), the existing common wall will be separated from the South Shed and remain in place after the South Shed is demolished. Due to the potential risks associated with demolition activities, it may be necessary to coordinate the demolition work with other activities within the hangar, require temporary evacuation of the hangar, or limit hangar use to areas determined to be a safe distance from the south hangar wall.

12.9.6 Building 27 Hangar South Wall Restoration

Once demolition of the South Shed superstructure is complete, the remaining wooden wall that was common to the South Shed and the hangar structure will be evaluated by a structural engineer to determine if reinforcement or modifications will be required as part of the restoration. Restoration of the wall will comply with Historic Preservation Act standards. The intent will be to substantially match the appearance of the existing exterior building materials (e.g., siding). The selected siding material will be coated, corrugated metal sheeting having a pitch and depth consistent with those of the asbestos siding currently covering the building. Existing downspouts that now collect rainwater and discharge it onto the South Shed roof will be extended to ground level. TtEC will coordinate with the Navy during the planning phase with regard to consultation with the State Historic Preservation Office and the Seattle Landmark Preservation Board.

12.10 DEMOBILIZATION

As equipment and other items brought to the site are no longer required, they will be removed from the site. Upon acceptance of the work by the Navy, final site cleanup will be performed and remaining equipment, materials, and temporary facilities will be demobilized. All items that have been used in conjunction with work in RCAs will be subject to an outgoing radiological survey to ensure that no contamination is carried from the site on the surfaces of those items.

12.11 AFTER ACTION REPORT AND FINAL STATUS SURVEY REPORTS

At the conclusion of the fieldwork, an After Action Report will be prepared to document the removal action. The report will describe the remedial processes that were implemented, as well as the findings, conclusions, and recommendations of the removal action. The report will also include as appendices all instrument calibration data and data resulting from radiological surveys and sample analyses performed during the course of the removal action, as well as waste characterization and disposal documentation. The FSS reports will be included as attachments to the After Action Report. The FSS reports will include the information necessary to demonstrate that the net residual dose is less than 15 millirems per year.

This page intentionally left blank.

13.0 REFERENCES

Abelquist, E. 2001. Decommissioning Health Physics: A Handbook for MARSSIM. Bristol, England: Institute of Physics Publishing.

AEC (Atomic Energy Commission). 1974. Regulatory Guide 1.86. Termination of Operating Licenses for Nuclear Reactors. June.

Argus (Argus Pacific, Inc.). 2009a. Radiation Screening, Building 27, Former Sand Point Naval Facility, Seattle, Washington. April.

———————. 2009b. Radiation Screening, Building 2 and Pump Houses, Former Sand Point Naval Facility, Seattle, Washington. May.

ASTM (American Society for Testing and Materials). 1998. Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments in Support of Decommissioning.

DoD (Department of Defense). Department of Energy, Nuclear Regulatory Commission, and U.S. Environmental Protection Agency. 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, Revision 1. August.

EPA (U.S. Environmental Protection Agency). 1992. Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference Based Standards for Soils and Solid Media. December.

Gilbert, R.O., J.R. Davidson, J.E. Wilson, and B.A. Pulsipher. 2001. Visual Sample Plan (VSP) Models and Code Verification. PNNL-13450, Pacific Northwest National Laboratory, Richland, Washington.

Grove Engineering. 1996. MicroShield™ Version 5.05 software. Grove Engineering: Rockville, Maryland.

ISO (International Organization for Standardization). 1988. Evaluation of Surface Contamination – Part 1: Beta-emitters (Maximum Beta Energy Greater than 0, 15 MeV) and Alpha-emitters. ISO 7503-1, International Organization for Standardization, Geneva, Switzerland.

NRC (Nuclear Regulatory Commission). 1997a. A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys (Draft Report for Comment); NUREG-1505; Nuclear Regulatory Commission: Washington, DC.

———————. 1997b. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions Guide. NUREG-1507, U.S. Nuclear Regulatory Commission: Washington, DC.

Shaw (Shaw Environmental & Infrastructure, Inc.). 2011. Final Radiological Remedial Investigation Report; Former Naval Station Puget Sound, Seattle, Washington. May.

———————. 2013. Final Action Memorandum. Former Naval Station Puget Sound, Seattle, Washington. May.

TtEC (Tetra Tech EC, Inc.) 2013. Final Accident Prevention Plan/Site Safety and Health Plan, Radiological Materials Time-Critical Removal Action. Former Naval Station Puget Sound, Seattle, Washington. July.

URS (URS Consultants, Inc.) 1996. Environmental Baseline Survey, Naval Station Puget Sound, Seattle, Washington. January.

TABLES

This page intentionally left blank.

TABLE 1-1

FORMER NAVAL STATION PUGET SOUND
STANDARD OPERATING PROCEDURES[a]

Standard Operating Procedures	
SOP Number	**SOP Title**
NAVSTA PS-Tt-001	Issue and Use of Radiation Work Permits
NAVSTA PS-Tt-002	Project Dosimetry
NAVSTA PS-Tt-003	Radiation and Contamination Surveys
NAVSTA PS-Tt-004	Preparation of Portable Radiation and Contamination Survey Meters and Instruments for Field Use
NAVSTA PS-Tt-005	Air Sampling and Sample Analysis
NAVSTA PS-Tt-006	Sampling Procedures for Radiological Surveys
NAVSTA PS-Tt-007	Radiologically Controlled Areas – Posting and Access Control
NAVSTA PS-Tt-008	Control of Radioactive Material
NAVSTA PS-Tt-009	Release of Materials and Equipment from Radiologically Controlled Areas
NAVSTA PS-Tt-010	Decontamination of Equipment and Tools
NAVSTA PS-Tt-011	Radiological Respiratory Protection Policy
NAVSTA PS-Tt-012	Radiological Protective Clothing Selection, Monitoring, and Decontamination

Notes:

[a] The most current version of each controlled SOP and Work Instruction is available in the TtEC offices at former NAVSTA PS and can be provided to the Navy and regulatory agencies upon request.

Abbreviations and Acronyms:

NAVSTA PS – Naval Station Puget Sound
Navy – Department of the Navy
SOP – Standard Operating Procedure
TtEC – Tetra Tech EC, Inc.

This page intentionally left blank.

TABLE 5-1

SURVEY UNIT SIZE

Area Classification	Survey Unit Size
Class 1 Structure	Up to 100 m^2 floor area
Class 1 Land area	Up to 2,000 m^2
Class 2 Structure	100 to 1,000 m^2
Class 2 Land area	2,000 to 10,000 m^2
Class 3 Structure	No limit
Class 3 Land area	No limit

Abbreviations and Acronyms:

m^2 – square meter

This page intentionally left blank.

TABLE 6-1

DATA LIFE CYCLE USED TO SUPPORT THE RADIATION SURVEY PROCESS

RSSI Process	Data Life Cycle	Phases	MARSSIM Guidance
Scoping Survey	Scoping Data Life Cycle	Plan Implement Assess Decide	Discusses the purpose and general approach for performing scoping surveys, especially as sources of information when planning FSSs (Section 5.2)[a]
Characterization Survey	Characterization Data Life Cycle	Plan Implement Assess Decide	Discusses the purpose and general approach for performing characterization surveys, especially as sources of information when planning FSSs (Section 5.3)[a]
Remedial Action Support Survey	Remedial Action Data Life Cycle	Plan Implement Assess Decide	Discusses the purpose and general approach for performing remedial action support surveys, especially as sources of information when planning FSSs (Section 5.4)[a]
FSS	Final Status Data Life Cycle	Plan Implement Assess Decide	Provides detailed guidance for planning FSSs (Chapter 4 and Section 5.5)[a], selecting measurement techniques (Chapters 6 and 7, and Appendix H)[a], and assessing the data collected during FSSs (Chapters 8 and 9)[a]

Notes:

[a] MARSSIM (DoD et al. 2000).

Abbreviations and Acronyms:

FSS – Final Status Survey

MARSSIM – Multi-Agency Radiation Survey and Site Investigation Manual

RSSI – Radiation Survey and Site Investigation

This page intentionally left blank.

TABLE 6-2

SURVEY STRATEGIES

Survey Type	Minimum Survey Requirement	Sampling and/or Direct Measurements[a]	Minimum Scanning Requirements	Static Measurements	Surface Scans	Exposure Rates	Swipes[b]	Media Samples[c]	General Operational Surveys[d]
Scoping	N/A	Random and Additional Biased	Judgmental	X	X	X	I	O	
Characterization	N/A	Systematic and Additional Biased	Judgmental	X	X	X	I	O	
Remedial Action Support	N/A	Random and Biased	Judgmental						X
Final Status	Class 1	Systematic with Random Start	100% Coverage	X	X	X	I	I, O	
	Class 2	Systematic with Random Start	50% Coverage	X	X	X	I	I, O	
	Class 3	Random	25% Coverage	X	X	X	I	I, O	

Notes:

I = indoor surveys; O = outdoor surveys; X = both

[a] Additional locations will be chosen based on history and the judgment of the radiological technician. The minimum number of sample points will be calculated as in Section 6.3.3.2.

[b] In addition to the swipes taken at each randomly or systematically determined sampling point, swipe sampling will be performed on floor drains, exhaust fans, work benches, sinks, and other suspect locations.

[c] Indoor locations may be chosen based on scanning results and the judgment of the radiological technician.

[d] General operation surveys may include static measurements, surface samples, exposure rates, swipes, and media samples.

Abbreviations and Acronyms:

N/A – not applicable

This page intentionally left blank.

TABLE 7-1

RELEASE CRITERIA

Radionuclide[a]	Surfaces			Soil/Sediment	
	Equipment, Waste (dpm/100 cm^2)[b]	Structures (dpm/100 cm^2)[c]	Residual Dose (mrem/y)[d]	Industrial Worker (pCi/g)[e]	Residual Dose (mrem/y)[d]
Cesium-137	5,000	5,000	1.64	25.63	15
Radium-226	100	100	1.71	1.07	15
Strontium-90	1,000	1,000	0.685	9.45	15

Notes:

[a] Criteria for other radionuclides will be listed in TSPs, if needed.

[b] These limits are based on AEC Regulatory Guide 1.86 (1974). Limits for removable surface activity are 20 percent of these values.

[c] These limits are based on AEC Regulatory Guide 1.86.

[d] The resulting dose is based on modeling using RESRAD-Build Version 3.5 or RESRAD Version 6.5.

[e] The release criteria listed are the values to be added to the mean background reference area concentration for each specific radionuclide. A background investigation and establishment of radionuclide specific site background reference area concentrations will be conducted prior to implementation of the time-critical removal action.

Abbreviations and Acronyms:

AEC – Atomic Energy Commission
cm^2 – square centimeter
dpm – disintegrations per minute
MDA – minimum detectable activity
mrem/y – millirems per year
pCi/g – picocuries per gram
TSP – Task-specific Plan

This page intentionally left blank.

TABLE 8-1

PORTABLE SURVEY INSTRUMENTS

Measurement/ Technique	Primary Use	Type of Instrumentation		Typical Background	Typical Total Efficiency (%)	Detection Sensitivity	Typical Minimum Detectable Concentration
		Detector Type and Model Number(s)	Meter Description and Model Number(s)				
Surface alpha/beta scans	Structures	Large-area gas - proportional 43-37 Series (582 cm^2)	Data logger 2360	800–1,200 cpm β 10-15 cpm α	~12 β total efficiency ~12 α total efficiency	474 dpm/100 cm^2 β 56 dpm/100 cm^2 α	900 dpm/100 cm^2 β 80 dpm/100 cm^2 α
	Equipment, materials, debris, structures	Large-area gas - proportional 43-68 (126 cm^2)		150–250 cpm β 0–2 cpm α	~6 β total efficiency ~6 α total efficiency	900 dpm/100 cm^2 β 100 dpm/100 cm^2 α	553 dpm/100 cm^2 β 53 dpm/100 cm^2 α
Direct measurement static alpha/beta		Scintillation, Ludlum Model 43-89 or 43-93 or equivalent (100 cm^2)		100–200 cpm β 0–5 cpm α	~6 β total efficiency ~6 α total efficiency	900 dpm/100 cm^2 β 100 dpm/100 cm^2 α	553 dpm/100 cm^2 β 53 dpm/100 cm^2 α
				150–300 cpm β 0–3 cpm α	~10 β total efficiency ~10 α total efficiency	700 dpm/100 cm^2 β 100 dpm/100 cm^2 α	350 dpm/100 cm^2 β 50 dpm/100 cm^2 α
Surface gamma scans	Equipment, materials, debris structures	NaI 2-inch × 2-inch scintillation Ludlum Model 44-10	Data logger 2350-1	5,000 cpm γ	N/A	1,500 cpm γ 0.58 pCi/g ^{226}Ra	2,541 cpm γ
Direct measurement static gamma							332 cpm γ
Low energy gamma scans and statics	Soil, structures, debris	Fiddler Model G-5	Data logger 2350-1	50–100 cpm γ	Dependent on threshold settings	Dependent on threshold settings	Dependent on threshold settings

TABLE 8-1

PORTABLE SURVEY INSTRUMENTS

Measurement/ Technique	Primary Use	Type of Instrumentation		Typical Background	Typical Total Efficiency (%)	Detection Sensitivity	Typical Minimum Detectable Concentration
		Detector Type and Model Number(s)	Meter Description and Model Number(s)				
Towed array surface gamma scans	Surfaces	(2) TSA 12 inches × 39 inches × 1.5 inches (30.5 cm × 99 cm × 3.8 cm) DA372 organic plastic scintillators	TSA SC-770	750 cps γ	N/A	0.2 pCi/g Ra-226	110 cps γ
Surface beta/gamma scans	Equipment, materials, debris, personnel	Geiger-Mueller Ludlum Model 44-9 or equivalent	Ratemeter 3	50–100 cpm β γ	~ 10 β γ total efficiency	~ 1,000 dpm per probe area β γ	3,420 dpm/100 cm^2 β γ
Direct measurement static beta/gamma			Ratemeter 12	50–100 cpm β γ	~ 10 β γ total efficiency	~ 1,000 dpm per probe area β γ	4,784 dpm/100 cm^2 β γ
			Ratemeter 177	50–100 cpm β γ	~ 10 β γ total efficiency	~ 1,000 dpm per probe area β γ	4,784 dpm/100 cm^2 β γ
Exposure rates	All inclusive	MicroR Meter with integral 1-inch × 1-inch NaI scintillation	Ratemeter 19	7–8 µR/hr	N/A	2 µR/hr	N/A
Beta, gamma, X-ray surveys	Devices, gauges, dials	220 cm^2 Ion chamber/RO20	Analog movement with 5 linear ranges	Less than 1 µR/hr	N/A	N/A	N/A

Abbreviations and Acronyms:

α – alpha
β – beta
γ – gamma
µR/hr – microroentgens per hour
cm – centimeter
cm^2 – square centimeter
cpm – counts per minute
cps – counts per second
dpm – disintegrations per minute
N/A – not applicable
NaI – sodium iodide
Ra-226 – radium-226

TABLE 8-2

EXAMPLES OF FIELD RADIOLOGICAL SURVEY INSTRUMENT CALCULATIONS

Measurement Technique	Calculation Type and Applicable Equations	Meter [a]	Detector [a]	Probe Area (cm^2)	Typical Detector Efficiency (%)	Surface Efficiency (%) [b]	Bkg Count Time (min)	Sample Count Time (min)	Bkg Count Rate (cpm)	Required Detection Sensitivity (dpm/100 cm^2)	Scan Speed (cm/s)	Probe Width (cm)	Scan Interval(s)	Surveyor Efficiency (%)	Bkg Counts Per Scan Interval	Results [c]
Surface alpha scans	Count detection probability for α scans; Equations 8-2, 8-3, or 8-4 (depends on detector area)	Ludlum Model Number(s) 2360 or 2350-1 data logger	Gas-proportional, Ludlum Model 43-37	582	0.120	N/A			10.0	100	1.3	14.0	10.8	N/A		90%
			Gas-proportional, Ludlum Model 43-68	126	0.120				1.0	100	0.7	8.8	12.6			92%
			Scintillation, Ludlum Model 43-89	126	0.130				0.4	100	0.7	7.6	10.9			90%
Surface beta scans	MDC for β scans; Equations 8-5 and 8-6	Ludlum Model Number(s) 2360 or 2350-1 data logger	Gas-proportional, Ludlum Model 43-37	582	0.250	0.25	N/A		800	N/A	1.7	14.0	8.2	0.50	110	974 dpm/100 cm^2
			Gas-proportional, Ludlum Model 43-68	126	0.250	0.25			200		0.2	8.8	44.0	0.50	147	973 dpm/100 cm^2
			Scintillation, Ludlum Model 43-89	126	0.250	0.25			180		0.2	7.6	38.0	0.50	114	993 dpm/100 cm^2
Direct measurement static alpha	MDC for static α counts; Equations 8-7 and 8-8	Ludlum Model Number(s) 2360 or 2350-1 data logger	Gas-proportional, Ludlum Model 43-37	582	0.250	0.25	5	0.3	15.0	N/A						93 dpm/100 cm^2
			Gas-proportional, Ludlum Model 43-68	126	0.250	0.25	5	1.2	2.0							92 dpm/100 cm^2
			Scintillation, Ludlum Model 43-89	126	0.250	0.25	5	0.7	0.4							88 dpm/100 cm^2
Direct measurement static beta	MDC for static β counts; Equations 8-7 and 8-8	Ludlum Model Number(s) 2360 or 2350-1 data logger	Gas-proportional, Ludlum Model 43-37	582	0.250	0.25	5	0.1	1,000	N/A						996 dpm/100 cm^2
			Gas-proportional, Ludlum Model 43-68	126	0.250	0.25	5	0.5	200							953 dpm/100 cm^2
			Scintillation, Ludlum Model 43-89	126	0.250	0.25	5	0.5	180							908 dpm/100 cm^2
Surface gamma scans	MDC for γ scans; Equation 8-9	Ludlum Model Number(s) 2360 or 2350-1 data logger, or 2221 scaler/rate meter	NaI 2-inch × 2-inch scintillation, Ludlum Model 44-10	N/A			1	0.017	5,000	N/A						4.8 μR/hr
Direct measurement static gamma	MDCR for static γ counts; Equation 8-12	Ludlum Model Number(s) 2360 or 2350-1 data logger, or 2221 scaler/rate meter	NaI 2-inch × 2-inch scintillation, Ludlum Model 44-10	N/A			1	1.0	5,000	N/A						332 cpm (net)
Direct measurement beta/gamma	N/A	Ludlum Model Number 3	Geiger-Mueller, Ludlum Model 44-9	N/A					50	N/A						~1,000 dpm/probe area
Exposure rates	N/A	Ludlum Model Number(s) 19 MicroR Meter	Integral NaI 1-inch × 1-inch scintillation	N/A					6 μR/hr	N/A						~2 μR/hr

Notes:

[a] or equivalent.

[b] 0.25 will be assumed surface efficiencies unless otherwise noted in the TSP.

[c] Results for alpha scans reflect the probability of detecting one or more counts during the scan interval, as appropriate.
Results for other activities reflect the instrument sensitivities calculated using the provided equations, or as provided by the manufacturer where equations in this plan are not applicable.

TABLE 8-2

EXAMPLES OF FIELD RADIOLOGICAL SURVEY INSTRUMENT CALCULATIONS

Abbreviations and Acronyms:
α – alpha
β – beta
γ – gamma
µR/hr – microroentgens per hour
Bkg – background
cm – centimeter
cm^2 – square centimeter
cm/s – centimeters per second
cpm – counts per minute
dpm – disintegrations per minute
MDC – minimum detectable concentration
MDCR – minimum detectable count rate
min – minute
N/A – not applicable
NaI – sodium iodide
TSP – Task-specific Plan

TABLE 9-1

DERIVED AIR CONCENTRATION

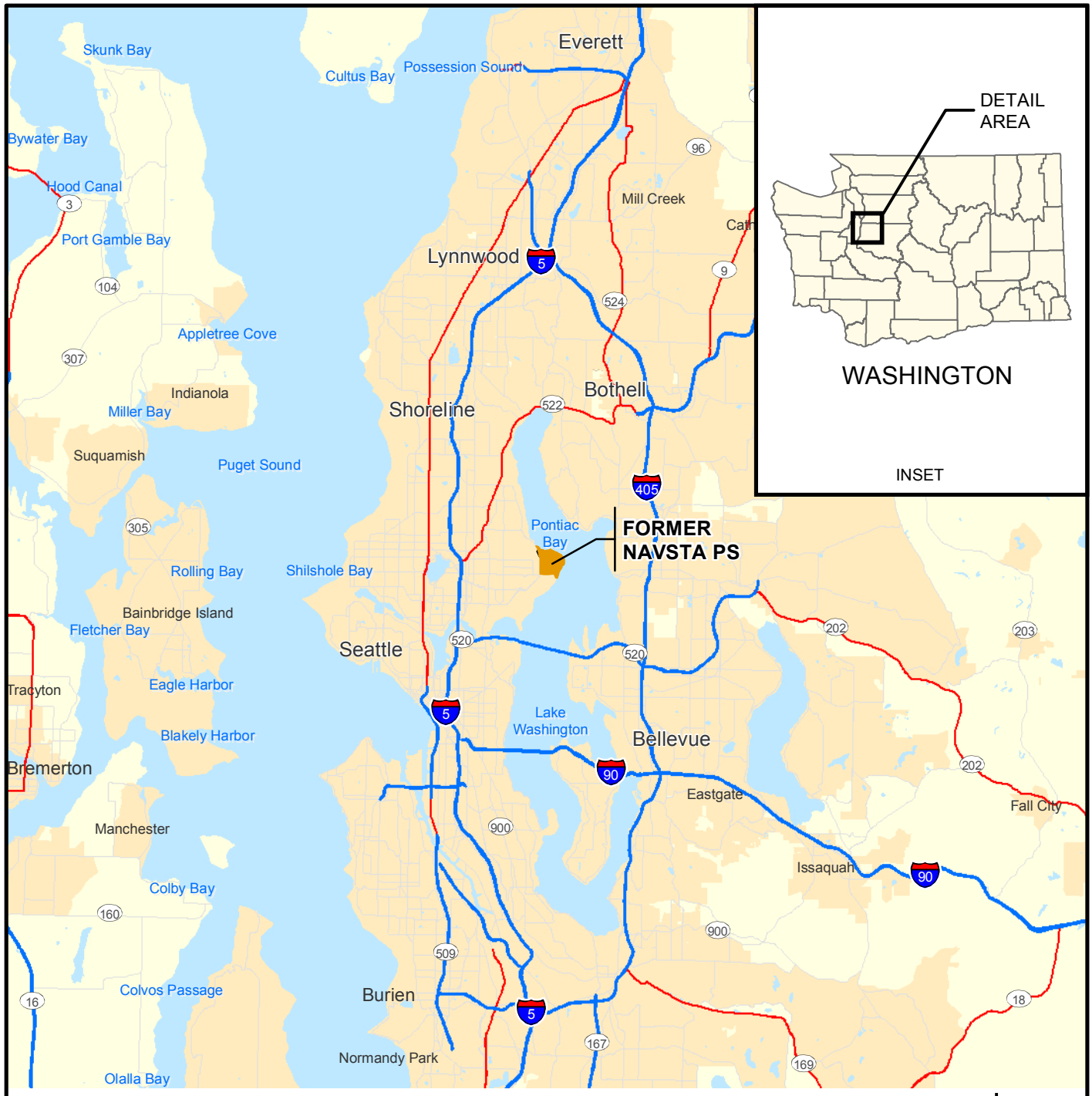
Radionuclide	Radiation	DAC (µCi/mL)	10% DAC (µCi/mL)
Radium-226	Alpha (α)	3.0×10^{-10}	3.0×10^{-11}
Strontium-90	Beta (β-)	8.0×10^{-9}	8.0×10^{-10}
Cesium-137	Beta/gamma (β-,γ)	6.0×10^{-8}	6.0×10^{-9}

Abbreviations and Acronyms:
% – percent
µCi/mL – microcuries per milliliter
CFR – *Code of Federal Regulations*
DAC – derived air concentration (10 CFR 20 Appendix B)

This page intentionally left blank.

FIGURES

This page intentionally left blank.



LEGEND

- STATE HIGHWAY
- INTERSTATE HIGHWAY
- WATER

2.5 0 2.5 5 Miles

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

RADIOLOGICAL REMOVAL ACTION WORK PLAN
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 2-1

REGIONAL LOCATION MAP

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7449.mxd

TETRA TECH EC, INC.

LEGEND

PROJECT SITE

1,000 0 1,000 Feet

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

RADIOLOGICAL REMOVAL ACTION WORK PLAN
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 2-2

SITE LOCATION MAP

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7450.mxd

TETRA TECH EC, INC.

Boring #	WA State Plane (NAD83, Washington North, US Feet)	
2	1288072.89	253758.42
3	1288072.00	253738.01
4	1288063.99	253738.61
6	1288071.29	253715.59
7	1288066.39	253705.28
9	1288073.31	253700.78
10	1288073.45	253686.19
11	1288066.66	253690.07
13	1288093.80	253661.95
14	1288084.33	253644.89
15	1288129.41	253616.70
20	1288152.45	253635.19
21	1288209.19	253638.29
26	1288228.86	253616.17
27	1288251.10	253620.31
31	1288339.39	253635.20
32	1288004.93	253810.76
33	1288001.60	253821.50
34	1288016.24	253814.40
35	1287992.35	253807.72
36	1288008.55	253792.18
37	1288012.12	253774.73
38	1288023.85	253777.01
39	1287999.42	253771.20
40	1288012.03	253761.53
41	1288011.48	253747.12
42	1288024.16	253747.79
43	1288013.22	253733.81
44	1288000.17	253746.20
45	1287997.92	253648.38
46	1287981.11	253660.23
47	1288091.65	253519.81
48	1288077.55	253499.28
50	1288104.83	253501.18
52	1288195.90	253511.76
53	1288205.45	253525.76
54	1288184.38	253512.02
55	1288197.60	253497.54
57	1288382.74	253090.57
58	1288392.25	253094.62
59	1288399.90	253090.55
62	1288568.27	253106.30

CONTRACTOR OFFICE AND LAYDOWN AREA

BUILDING 27

SOUTH SHED & STAIR TOWERS

BUILDING 12

BUILDING 2

NE NOAA DRIVE

NE 77TH STREET

SAND POINT WAY NE

63RD AVENUE NE

LEGEND

- PLANNED SOIL REMOVAL ACTION AREAS
- PLANNED BUILDING REMOVAL ACTION AREAS
- PLANNED STORM DRAIN AND SINK DRAIN REMOVAL ACTION AREAS
- MANHOLE
- CATCH BASIN
- CONTRACTOR CONTROLLED AREA
- TRAFFIC ROUTING
- SOIL CHARACTERIZATION BORING

90 0 90 Feet

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

RADIOLOGICAL REMOVAL ACTION WORK PLAN
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 3-1

PLANNED REMOVAL ACTION AREAS

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: L7421.mxd

TETRA TECH EC, INC.

ATTACHMENT 1

SAMPLING AND ANALYSIS PLAN

This page intentionally left blank.

SAP Worksheet #1 – Title and Approval Page

ATTACHMENT 1

FINAL

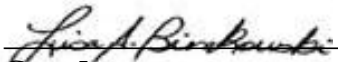
SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)
July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION AT FORMER NAVAL STATION PUGET SOUND SEATTLE, WASHINGTON

Prepared for:
U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

Prepared by:
Tetra Tech EC, Inc.
1230 Columbia Street, Suite 750
San Diego, California 92101-8536
(619) 234-8696

Prepared under:
Contract No. N62473-10-D-0809
CTO No. 0011

Review Signature:  for 07/01/13
Greg Joyce — Date
TtEC Quality Control Program Manager

This page intentionally left blank.

EXECUTIVE SUMMARY

The Department of the Navy (Navy) contracted with Tetra Tech EC, Inc. (TtEC) to perform a radiological materials time-critical removal action (TCRA) at the former Naval Station Puget Sound (NAVSTA PS) in Seattle, Washington. The TCRA will address remediation of radiologically contaminated building components, soil, and drain systems. The radiological work will be performed under TtEC's United States Nuclear Regulatory Commission Service Provider Radioactive Materials License. This project will be conducted under Contract No. N62473-10-D-0809, Contract Task Order (CTO) No. 0011. TtEC has prepared this Sampling and Analysis Plan to provide guidance on sampling, analysis, and quality control in support of the TCRA.

BACKGROUND

Former NAVSTA PS is located northeast of downtown Seattle on the western shore of Lake Washington. Former NAVSTA PS was initially named Naval Air Station (NAS) Seattle. Portions of the facility were built in 1925 on land donated by King County. Many of the major buildings were built in the late 1930s prior to World War II, including Building 27 (1937) and Building 2 (1929). Further building construction and remodeling took place in later years, including addition of the South Shed to Building 27 in 1944 and expansion of the instrument shop in Building 2 in 1943 (1943 Instrument Shop).

During World War II, NAS Seattle supported air transport and ship outfitting personnel for the Alaskan and Western Pacific theaters of operation. After World War II, NAS Seattle provided numerous support functions. In June 1991, the Base Realignment and Closure (BRAC) Commission of the Department of Defense announced the closure of NAVSTA PS. In accordance with recommendations of the 1991 BRAC Commission, the Navy closed NAVSTA PS in September 1995.

Subsequent to closure, the Navy conducted environmental investigations and cleanup of portions of the facility. The condition of the property was described in the Environmental Baseline Survey (EBS) report (URS 1996). The EBS described the significant operations and existing conditions at specific buildings and areas at former NAVSTA PS that were addressed in past environmental investigations. The EBS identified areas of potential environmental concern where storage or release of hazardous substances had occurred. No radiological contamination was identified in the EBS report.

The Navy transferred portions of the facility to the city of Seattle for recreational development. Because of the facility's long history of use by the Navy, and because of the potential that the environmental investigations conducted did not identify all environmental hazards that pose a threat to human health and the environment, the transfer deed between the Navy and the city included an environmental covenant that allowed the city to seek action by the Navy to address contamination that was not identified in the EBS (URS 1996).

The city of Seattle leased several of the original buildings to public and private organizations to support recreational redevelopment. In association with recent proposed renovations of

Building 27, the city's review of as-built drawings identified areas where radioactive materials may have been used or stored (i.e., a Radium Room in Building 27 and Instruments Room in Building 2). As a result, the city conducted a radiation screening survey that identified areas in Building 27 where the radiation dose appeared to exceed background. The city also conducted surveys in Building 2 and a pump house connected to the storm/sanitary sewer system. Results of the screening-level survey of Building 2 and the pump house were not conclusive. The city contacted the Navy regarding the potential need for action to address radiological contamination on the site.

Subsequently, the Navy conducted a remedial investigation, which focused on Buildings 2 and 27, the surrounding ground surfaces, and associated drain systems. The investigation, which is documented in a Radiological Remedial Investigation Report (Shaw 2011), confirmed that a removal action was warranted to address radiological contamination in Building 2 and the Building 27 South Shed structures, soil surrounding Buildings 2, 12, and 27, and associated drain systems. An Engineering Evaluation/Cost Analysis (EE/CA) was initiated to develop and evaluate removal action alternatives, with the intent that the selected alternative would be implemented as a non-time-critical removal action. However, due to continued deterioration of the buildings and the discovery of trespassers breaking into Building 2, the lead agency, Naval Facilities Engineering Command Northwest, decided to forego further development of the EE/CA and perform a TCRA to expedite the removal actions. An Action Memorandum (Shaw 2013), in which the appropriate removal action based on regulatory and public comments was documented, was prepared to present the written decision.

OBJECTIVES

This CTO has three primary performance objectives:

1. Mitigate known radiologically impacted materials in accordance with the Action Memorandum and approved project plans.
2. Confirm that radiological contamination has been mitigated by means of a confirmation survey and a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Final Status Survey to obtain radiological free release of areas with contamination.
3. Restore or preserve the integrity of affected structures, where required, so that existing land uses can continue.

TtEC will obtain final approval from the Navy, the city of Seattle Parks and Recreation Department, and other regulatory agencies prior to, and upon completion of, these performance objectives.

Where applicable, radiological survey activities will be conducted in accordance with the guidelines in the MARSSIM, NUREG-1575 (DoD et al. 2000), as discussed in the Work Plan to which this SAP is attached.

SAP Worksheets

Page

FIGURES

APPENDICES (on CD only)

Abbreviations and Acronyms

%R	percent recovery
APP	Accident Prevention Plan
Argus	Argus Pacific, Inc.
BHC	benzene hexachloride
BRAC	Base Realignment and Closure
CA	corrective action
CAS	Chemical Abstracts Service
CCB	continuing calibration blank
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeter
COC	chain of custody
CQC	contractor quality control
Cs-137	cesium-137
CTO	Contract Task Order
CVAA	cold vapor atomic absorption
DCC	daily calibration check
DCN	Document Control Number
DDT	dichlorodiphenyltrichloroethane
DL	detection limit
DoD	Department of Defense
DOE	Department of Energy
DOH	Washington State Department of Health
dpm	disintegrations per minute
DQA	data quality assessment
DQO	Data Quality Objective
EBS	Environmental Baseline Survey
EDD	electronic data deliverable
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
EWI	Environmental Work Instruction
FCR	Field Change Request
FID	flame ionization detector
FSS	Final Status Survey

Abbreviations and Acronyms
(Continued)

FWHM	full width at half maximum
g	gram
GC	gas chromatography
ICAL	initial calibration
ICB	initial calibration blank
ICP	inductively coupled argon plasma
ICS	interference check sample
IRCDQM	Installation Restoration Chemical Data Quality Manual
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDC	Laboratory Data Consultants
LLRW	low-level radioactive waste
LOQ	limit of quantitation
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
mL	milliliter
MOU	Memorandum of Understanding
MS	mass spectroscopy
MS/MSD	matrix spike/matrix spike duplicate
N_2	nitrogen gas
N/A	not applicable
NaI	sodium iodide
NAVFAC NW	Naval Facilities Engineering Command Northwest
NAVFAC SW	Naval Facilities Engineering Command Southwest
NAVSTA PS	Former Naval Station Puget Sound
Navy	Department of the Navy
NEDD	Navy Electronic Data Deliverable
NIRIS	Naval Installation Restoration Information Solution
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NTR	Navy Technical Representative
OSHA	Occupational Safety and Health Administration
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl

Abbreviations and Acronyms
(Continued)

pCi/g	picocuries per gram
PID	photoionization detector
PjM	Project Manager
PMO	Program Management Office
PQCM	Project Quality Control Manager
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCPM	Quality Control Program Manager
QL	quantitation limit
QSM	Quality Systems Manual
Ra-226	radium-226
Rad EMAC	Radiation Environmental Multiple Award Contract
RASO	Radiological Affairs Support Office
RCT	Radiological Control Technician
RER	relative error ratio
RI	remedial investigation
RL	reporting limit
RMA	Radioactive Material Area
ROC	radionuclide of concern
RPD	relative percent difference
RPM	Remedial Project Manager
RSD	risk-specific dose
RSO	Radiation Safety Officer
RSOR	Radiation Safety Officer Representative
Sr	strontium
SAP	Sampling and Analysis Plan
SDG	sample delivery group
SOP	Standard Operating Procedure
Sr-90	strontium-90
SSHP	Site Safety and Health Plan
SVOC	semivolatile organic compound
TBD	to be determined
TCRA	time-critical removal action

Abbreviations and Acronyms
(Continued)

TPH	total petroleum hydrocarbons
TSP	Task-specific Plan
TtEC	Tetra Tech EC, Inc.
UFP	Uniform Federal Policy
VOA	volatile organic analysis
VOC	volatile organic compound
Yt	yttrium

SAP Worksheet #2 – SAP Identifying Information

Site Name/Number: **Radiological Materials Time-Critical Removal Action (TCRA) at Former Naval Station Puget Sound (NAVSTA PS)**
Contractor Name: **Tetra Tech EC, Inc. (TtEC)**
Contract Number: **N62473-10-D-0809**
Contract Title: **Radiological Environmental Multiple Award Contract (Rad EMAC)**

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of the Uniform Federal Policy for Quality Assurance Project Plans (EPA 2005) and U.S. Environmental Protection Agency (EPA) Guidance for Quality Assurance Project Plans, EPA QA/G-5, QAMS (EPA 2002).

2. Identify regulatory program: The Naval Facilities Engineering Command Northwest (NAVFAC NW) plans to conduct a radiological materials TCRA at the former NAVSTA PS. This TCRA is being conducted in accordance with the Navy's Environmental Restoration Program using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. The Washington State Department of Ecology is the lead regulatory agency for the radiological cleanup at NAVSTA PS. The TCRA will follow the substantive requirements of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan. Per Title 40, *Code of Federal Regulations* Section 300.415(3)(b)(1), for any release, regardless of whether the site is included on the National Priorities List (former NAVSTA PS is not), where the lead agency (NAVFAC NW) makes the determination that there is a threat to public health or welfare or the environment, the lead agency may take any appropriate removal action to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release.

3. This SAP is a project-specific SAP.

4. List dates of scoping sessions that were held.

Scoping Session	Date
Kickoff meeting	10/28/11

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

Title	Date
Not applicable	

6. List organizational partners (stakeholders) and connection with lead organization: The Radiological Affairs Support Office (RASO), Washington State DOH, Washington State Department of Ecology, and city of Seattle Parks and Recreation Department will provide regulatory oversight and guidance.

7. Lead organization: Department of the Navy (Navy)

SAP Worksheet #2 – SAP Identifying Information (Continued)

8. If any required SAP elements or required information is not applicable to the project or is provided elsewhere, then note the omitted SAP elements and provide an explanation for its exclusion below:

    - Worksheets #12 (Measurement Performance Criteria Table) and #20 (Field Quality Control Sample Summary Table) are not applicable for this project as field QC samples are not required to meet the project objectives.
    - Worksheet #13 (Secondary Data Sources) is not applicable for this project as secondary data evaluation is not required.

SAP elements and required information that are not applicable to the project are noted below. An explanation is provided above and in the appropriate SAP worksheet(s), as necessary.

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
A. Project Management		
Documentation		
1	Title and Approval Page	
2	Table of Contents SAP Identifying Information	
3	Distribution List	
4	Project Personnel Sign-Off Sheet	
Project Organization		
5	Project Organizational Chart	
6	Communication Pathways	
7	Personnel Responsibilities and Qualifications Table	
8	Special Personnel Training Requirements Table	
Project Planning/Problem Definition		
9	Project Planning Session Documentation (including Data Needs tables) Project Scoping Session Participants Sheet	
10	Problem Definition, Site History, and Background Site Maps (historical and present)	
11	Site-Specific Project Quality Objectives	
12	Measurement Performance Criteria Table	Not applicable
13	Sources of Secondary Data and Information Secondary Data Criteria and Limitations Table	Not applicable
14	Summary of Project Tasks	
15	Reference Limits and Evaluation Table	
16	Project Schedule/Timeline Table	
B. Measurement Data Acquisition		
Sampling Tasks		

SAP Worksheet #2 – SAP Identifying Information (Continued)

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
17	Sampling Design and Rationale	
18	Sampling Locations and Methods/ SOP Requirements Table Sampling Location Map(s)	
19	Analytical Methods/SOP Requirements Table	
20	Field Quality Control Sample Summary Table	Not applicable
21	Project Sampling SOP References Table	
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	
Analytical Tasks		
23	Analytical SOPs Analytical SOP References Table	
24	Analytical Instrument Calibration Table	
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	
Sample Collection		
26	Sample Handling System, Documentation Collection, Tracking, Archiving and Disposal Sample Handling Flow Diagram	
27	Sample Custody Requirements, Procedures/SOPs Sample Container Identification Example Chain-of-Custody Form and Seal	
Quality Control Samples		
28	QC Samples Table Screening/Confirmatory Analysis Decision Tree	
Data Management Tasks		
29	Project Documents and Records Table	
30	Analytical Services Table Analytical and Data Management SOPs	
C. Assessment Oversight		
31	Planned Project Assessments Table Audit Checklists	
32	Assessment Findings and Corrective Action Responses Table	
33	QA Management Reports Table	
D. Data Review		
34	Verification (Step I) Process Table	
35	Validation (Steps IIa and IIb) Process Table	
36	Validation (Steps IIa and IIb) Summary Table	
37	Usability Assessment	

This page intentionally left blank.

SAP Worksheet #3 – Distribution List

The following distribution list represents the recipients of the final version of this SAP.

Name of SAP Recipients	Title/Role	Organization	Telephone Number	Mailing and E-mail Address
Mr. Chris Generous	Remedial Project Manager (RPM)	Naval Facilities Engineering Command Northwest (NAVFAC NW)	(360) 396-0935	1101 Tautog Circle, Suite 203 Silverdale, WA 98315 christopher.generous@navy.mil
Ms. Laurie Lowman	Lead Environmental Protection Manager (EPM)	RASO	(757) 887-7650	160 Main Road – Building 1971 NWS P.O. Drawer 260 Yorktown, VA 23691-0260 laurie.lowman@navy.mil
Mr. Joe Sevcik	Radiological EPM	RASO	(757) 887-4483	160 Main Road – Building 1971 NWS P.O. Drawer 260 Yorktown, VA 23691-0260 joseph.sevcik@navy.mil
Ms. Kim Ostrowski	Realignment Manager	BRAC PMO West	(619) 532-0909	1455 Frazee Road, Suite 900 San Diego, CA 92108-4310 kim.ostrowski@navy.mil
Ms. Anine Grumbles	Radiation Health Physicist	Washington State DOH Office of Radiation Protection	(360) 236-3222	P.O. Box 47827 Olympia, WA 98504-7827 anine.grumbles@doh.wa.gov
Mr. John Martell	Project Manager	Washington State DOH Office of Radiation Protection – Air Emissions Section	(509) 946-3798	309 Bradley Boulevard, Suite 201 Richland, WA 99352 john.martell@doh.wa.gov
Mr. Ching-Pi Wang	Project Manager	Washington State Department of Ecology	(425) 649-7134	3190 – 160th Avenue SE Bellevue, WA 98008-5452 cwan461@ecy.wa
Ms. Jodi Sinclair	Senior Environmental Analyst	Seattle Parks and Recreation	(206) 684-7292	6310 NE 74th Street, Suite 109E Seattle, WA 98115 jodi.sinclair@seattle.gov

SAP Worksheet #3 – Distribution List (Continued)

Mr. Steve Skeehan	Navy Technical Representative	NAVFAC NW	(360) 396-1114	1101 Tautog Circle, Suite 203 Silverdale, WA 98315-1101 steve.skeehan@navy.mil
Mr. Lee Boreen	Project Manager	TtEC	(619) 471-3544	1230 Columbia St., Suite 750 San Diego, CA 92101 lee.boreen@tetratech.com
Mr. Erik Abkemeier	Radiation Safety Officer (RSO)	TtEC	(757) 944-0921	Twin Oaks, Suite 309 5700 Lake Wright Drive Norfolk, VA 23502 erik.abkemeier@tetratech.com
Mr. Jeff Ambrose	Radiation Safety Officer Representative (RSOR)	TtEC	TBD	Project site (address TBD)
Mr. Greg Joyce	Quality Control Program Manager (QCPM)	TtEC	(360) 780-0371	1230 Columbia St., Suite 750 San Diego, CA 92101 greg.joyce@tetratech.com
Ms. Lisa Bienkowski	Program Chemist	TtEC	(949) 809-5028	17885 Von Karman Ave., Suite 500 Irvine, CA 92614 lisa.bienkowski@tetratech.com
Mr. Toby Petersen	PQCM	TtEC	(360) 661-3510	Project site (address TBD) toby.petersen@tetratech.com
Ms. Erika Starman	Laboratory Project Manager	TestAmerica	(314) 298-8566	13715 Rider Trail North Earth City, MO 63045 erika.starman@testamericainc.com
Mr. Phil Smith	Laboratory Supervisor	Curtis and Tompkins	(415) 216-2768	201A & 201B Fisher Avenue San Francisco, CA 94124 phil.smith@ctberk.com
Ms. Linda Rauto	Data Validator Project Manager	Laboratory Data Consultants (LDC)	(760) 634-0437	7750 EL Camino Real, Suite 2L Carlsbad, CA 92009 lrauto@lab-data.com

SAP Worksheet #4 – Project Personnel Sign-Off Sheet

The key personnel listed below will read the final version of this SAP. Their signature and date will be filled in below and included in the project file.

Name	Organization/Title/Role	Signature/Email Receipt	SAP Section Reviewed	Date SAP Read
Mr. Lee Boreen	TtEC/PjM		Entire document	
Ms. Sabina Sudoko	TtEC/Project Chemist		Entire document	
Mr. Toby Petersen	TtEC/PQCM		Entire document	
Mr. Jeff Ambrose	TtEC/RSOR		Entire document	
Mr. Phil Smith	Curtis and Tompkins/Laboratory Supervisor		Entire document	
Ms. Erika Starman	TestAmerica/Laboratory Project Manager		Entire document	
Ms. Linda Rauto	LDC/Data Validator Project Manager		Entire document	
TBD [a]	TtEC/Field Crews		Entire document	

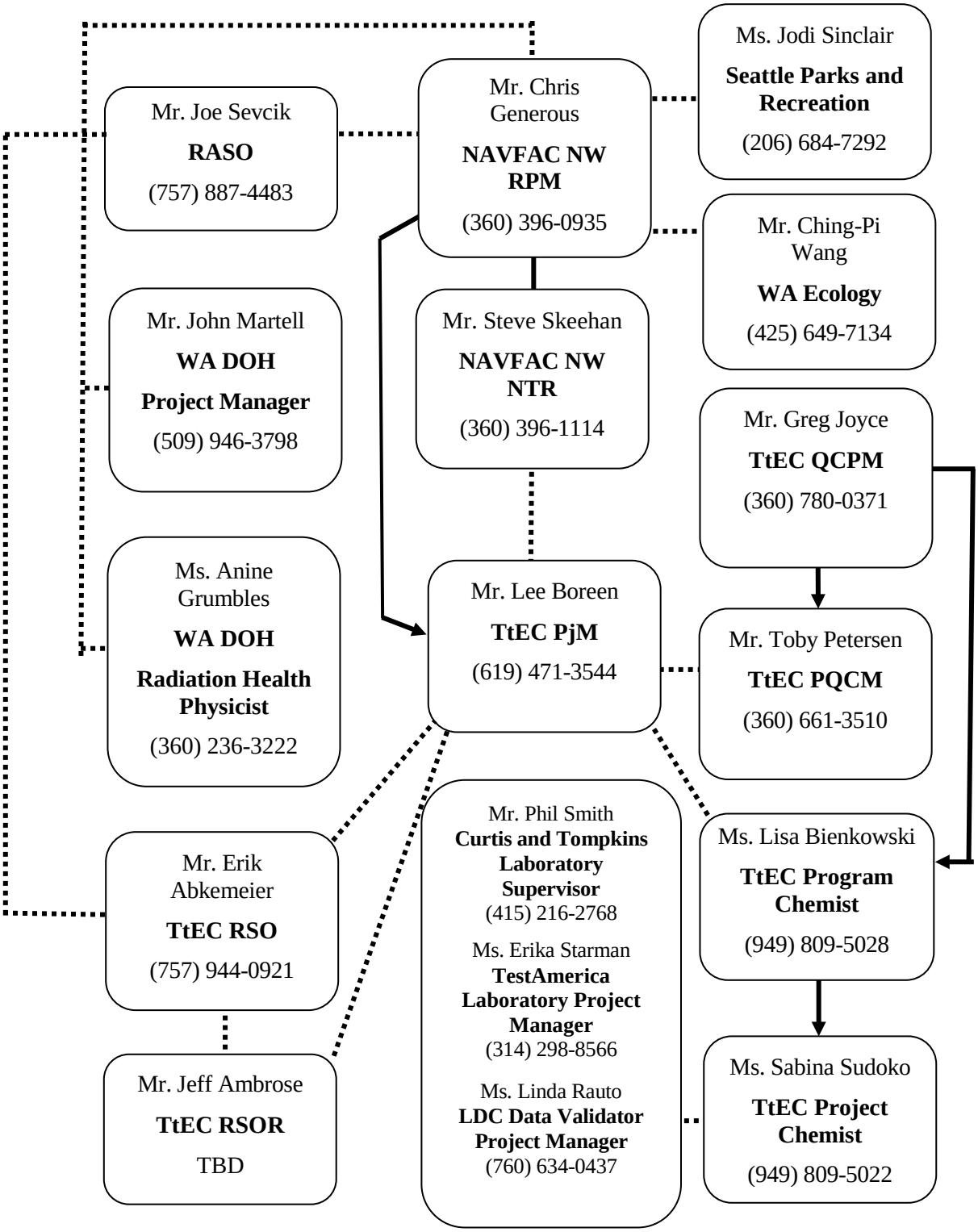
Notes:

[a] Field crews include multiple persons and vary from project to project. Therefore, persons identified by the on-site PQCM will read the SAP and sign this worksheet as required.

This page intentionally left blank.

SAP Worksheet #5 – Project Organizational Chart

Lines of Authority ——— Lines of Communication



Ths page intentionally left blank.

SAP Worksheet #6 – Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number	Procedure
Point of contact for Navy quality issues	Navy RPM	Mr. Chris Generous	(360) 396-0935	If during sampling, a change in sampling procedures or strategy is required, the RPM will be notified via email and give concurrence to issue a field change request. In addition, the RPM has the authority to suspend project execution if quality assurance requirements are not adequately followed.
Point of contact for contractor quality issues	TtEC QCPM	Mr. Greg Joyce	(360) 780-0371	The QCPM is responsible for overseeing program quality control (QC), including construction and chemical data acquisition. The QCPM has the authority to suspend project activities if quality standards are not maintained. The QCPM will approve all changes to project plans and procedures.
Project management	TtEC PjM	Mr. Lee Boreen	(619) 471-3544	If changes are necessary, the PjM is responsible for communicating the changes via phone and/or e-mail to the project staff and is authorized to stop work, if necessary.
SAP review and radiological concurrence	RASO	Mr. Joe Sevcik	(757) 887-4483	The RASO will review and concur with the SAP as related to the radiological aspects.
SAP review	TtEC RSO or QCPM	Mr. Erik Abkemeier or Mr. Greg Joyce	(757) 944-0921 (360) 780-0371	The SAP will be written by the Program Chemist and reviewed by the RSO and QCPM prior to submittal to the Navy.
Notification of nonusable analytical data	TtEC Program Chemist	Ms. Lisa Bienkowski	(949) 809-5028	If significant problems are identified by the laboratory or the project team that impact the usability of the data (i.e., the data are rejected or data quality objectives are not met), the Program Chemist will notify the PjM within 24 hours.

SAP Worksheet #6 – Communication Pathways (Continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number	Procedure
Coordination of laboratory supplies for field sampling activities	TtEC Project Chemist	Ms. Sabina Sudoko	(949) 809-5022	The Project Chemist will contact the laboratory to provide all necessary sample containers and appropriate shipping materials (such as coolers and bubble wrap) to be delivered on-site prior to commencement of field sampling activities and throughout the course of the project.
Reporting laboratory data quality issues or analytical corrective actions	Curtis and Tompkins Laboratory Supervisor / TestAmerica Laboratory Project Manager	Mr. Phil Smith Ms. Erika Starman	(415) 216-2768 (314) 298-8566	All data quality issues will be reported in writing by the Laboratory Supervisor or Project Manager to the Project Chemist accordingly within two (2) business days. Any corrective actions will be documented and verified by the Program Chemist who will notify in writing the QCPM, RSO, and PjM. The PjM will notify the NAVFAC NW RPM and RASO.
Field corrective actions	TtEC PQCM	Mr. Toby Petersen	(360) 661-3510	All field corrective actions will be documented in writing by the PQCM who will notify in writing the QCPM, RSO, and PjM. The PjM will notify the NAVFAC NW RPM and RASO.
Release of analytical data	TtEC Project Chemist	Ms. Sabina Sudoko	(949) 809-5022	The Project Chemist will review analytical data to verify that analytical requirements in this SAP have been met prior to releasing the data to the project team for evaluation.
Review of radiological data and concurrence on radiological actions	RASO	Mr. Joe Sevcik	(757) 887-4483	The RASO will review all appropriate radiological data provided by the RSO or designee and will provide concurrence with actions proposed.
SAP procedure revision during field activities	TtEC Program Chemist	Ms. Lisa Bienkowski	(949) 809-5028	The Program Chemist or designee will prepare a Field Change Request (FCR) for any changes in sampling procedures that occur due to conditions in the field.
SAP amendments	TtEC Program Chemist	Ms. Lisa Bienkowski	(949) 809-5028	Changes to the SAP will require that the Program Chemist prepare an addendum, which will be reviewed and approved by the Navy prior to initiating the affected field activities.

SAP Worksheet #7 – Personnel Responsibilities and Qualifications Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Mr. Chris Generous	RPM	NAVFAC NW	• Performing project management for the Navy • Ensuring that the project scope of work requirements are fulfilled • Overseeing the project cost and schedule • Providing formal technical direction to the TtEC project team, as needed • Acting as lead interface with agencies
Mr. Lee Boreen	PjM	TtEC	• Coordinating work activities of subcontractors and TtEC personnel, and ensuring that all personnel adhere to the administrative and technical requirements of the project • Monitoring and reporting the progress of work, and ensuring that the project deliverables are completed on time and within project budget • Monitoring the budget and schedule, and notifying the client and the RPM of any changes that may require administrative actions • Ensuring adherence to the quality requirements of the contract, project scope of work, and the QC plans • Ensuring that all work meets the requirements of the technical specifications and complies with applicable codes and regulations • Ensuring that all work activities are conducted in a safe manner in accordance with the Site-Specific Health and Safety Plan, United States Army Corps of Engineers' Safety and Health Requirements (Engineer Manual 385-1-1), and all applicable Occupational Safety and Health Administration (OSHA) regulations • Serving as the primary contact between the Navy and TtEC for actions and information related to the work and including appropriate TtEC technical personnel in the decision-making • Coordinating satisfactory resolution and completion of evaluation and acceptance report for nonconformance reports • Suspending project activities if standards are not maintained

SAP Worksheet #7 – Personnel Responsibilities and Qualifications Table (Continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Mr. Joe Sevcik	Radiological Environmental Protection Manager	RASO	• Reviewing radiological laboratory data on a routine basis • Performing on-site reviews of all radiological site operations • Reviewing and approving all radiological work plans and final reports • Performing quality reviews on chains of custody (COCs) to ensure samples are handled in accordance with the Work Plan and SAP • Providing review and concurrence on data for proposed radiological actions • Ensuring that all necessary sample results are provided and are consistent with proposed radiological actions • Comparing radiological data with the requirements of the Work Plan, Design Plans, Task-specific Plans, and SAP to ensure that all proper conditions have been met to implement the action requested • Ensuring that the radiological data reported are consistent with the intent for which the data were provided • Comparing the sample number matrix with the intent of the data package to ensure that the sample number is consistent with the intent of the data package • Reviewing sample acquisition information to ensure that the sample analytical duration meets the minimum required time necessary to meet the minimum detectable activity (MDA) • Comparing each radionuclide's specific activity with the release criteria to ensure that the decision made is consistent with the specific activity reported • Comparing the MDA with the release criteria to ensure that it is sufficiently below the release levels • Evaluating the qualifiers provided with the sample results to ensure that the information provided is consistent with the results provided • Reviewing uncertainty counting and the 2-sigma total uncertainty data along with the laboratory qualifiers to determine if the data are of sufficient quality

SAP Worksheet #7 – Personnel Responsibilities and Qualifications Table (Continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
			• Acting as primary point of contact with regulators regarding radiological aspects of the work
Mr. Erik Abkemeier	RSO	TtEC	• Overseeing overall radiological operations and documentation for the project • Supporting projects as the technical lead for radiological data collection and analysis • Ensuring that RSOR has adequate training in sample collection and analytical methods • Monitoring performance of on-site radiological contractors • Receiving and reviewing data from the laboratory to ensure the data quality objectives have been met • Reviewing and evaluating scan survey data and requiring additional scan data, as necessary
Mr. Jeff Ambrose	RSOR	TtEC	• Supervising day-to-day radiological operations • Overseeing performance of radiological static surveys • Identifying and assessing radiological contamination • Concurring on the identification of elevated areas for collection of biased samples and the locations of systematic samples • Overseeing the preparation of a remediation plan and the performance of remedial activities when sampling activities indicate the presence of radioactive materials at levels above the release criteria • Directing any additional biased sampling activities to ensure the isolation and removal of radioactive material • Reviewing and evaluating biased sampling data and identifying any additional radiological activities • Recommending radiological activities to the RASO for concurrence including additional sampling, backfilling of trenches, identification of material that can be used as backfill, etc. • Overseeing the plotting of systematic sample locations and collection of the appropriate number of samples • Reviewing and evaluating static survey readings used to verify scan surveys or to get a reading of a sampling point

SAP Worksheet #7 – Personnel Responsibilities and Qualifications Table (Continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Mr. Greg Joyce	QCPM	TtEC	• Establishing and maintaining the Quality Program • Overseeing program QC, including construction and chemical data acquisition • Working directly with the PjM and the Navy to ensure implementation of the program QC Plans • Acting as a focal point for coordination for quality matters across all projects and resolving quality issues • Suspending project activities if quality standards are not maintained • Interfacing with the Navy on quality-related items • Conducting field QC audits to ensure project plans are being followed • Performing reviews of audit and surveillance reports conducted by others • Implementing the Navy technical direction letters related to quality topics • Approving any FCRs and reviewing addendums to the SAP
Ms. Lisa Bienkowski	Program Chemist	TtEC	• Developing the SAP and any amendments or addendums to the SAP • Implementing contract requirements for data collection • Supporting projects as the technical lead for data collection and analysis • Ensuring the Project Chemist has adequate training in analytical methodology • Ensuring that sampling personnel have training on sampling procedures for specific project requirements • Evaluating and selecting a qualified laboratory and third-party data validation subcontractor • Monitoring performance of laboratory and data validator • Overseeing preparation of the Navy Electronic Data Deliverable (NEDD) deliverable to the Naval Installation Restoration Information Solution (NIRIS) website of the analytical data • Coordinating submittal of hard-copy analytical data packages with Navy Administrative Record

SAP Worksheet #7 – Personnel Responsibilities and Qualifications Table (Continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Ms. Sabina Suduko	Project Chemist	TtEC	• Tracking samples sent to laboratory to ensure laboratory receipt of samples and proper login of samples for analysis • Tracking receipt of analytical data from the laboratory • Reviewing laboratory data prior to use against requirements in this SAP • Coordinating third-party data validation of the laboratory data • Reviewing data validation reports • Coordinating with the Database Manager for upload of electronic data to database

This page intentionally left blank.

SAP Worksheet #8 – Special Personnel Training Requirements Table

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates
Sampling	General employee radiological awareness training	RSO or designee	Prior to field work	Sampling personnel	Sampler/TtEC	TtEC Project File

This page intentionally left blank.

SAP Worksheet #9 – Project Scoping Session Participants Sheet

Project Name: Radiological Materials TCRA **Projected Date(s) of Sampling:** 2012 **Project Manager:** Mr. Lee Boreen	**Site Name:** Radiological Materials TCRA **Site Location:** Former Naval Station Puget Sound, Seattle, WA
Date of Session: October 19, 2011 **Scoping Session Purpose:** Kick-off meeting to discuss scope of project with Navy. The purpose of this meeting was to develop a mutual understanding of the work to be performed and the planning documents to be developed and submitted.	

Name	Title	Affiliation	Phone #	E-mail Address
Lee Boreen	PjM	Tetra Tech EC, Inc.	(619) 471-3504	lee.boreen@tetratech.com
Mark Wicklein	RPM	NAVFAC NW	(360) 396-0226	mark.wicklein@navy.mil
Jeff Bray	Superintendent	Tetra Tech EC, Inc.	(415) 216-2774	jeff.bray@tetratech.com

Meeting Minutes

The following summarizes the key points of the meeting discussion:

- Meetings – The scope includes a kick-off meeting, 10 Navy/stakeholder meetings (includes 5 added by Mod. 1), weekly CQC, and project status meetings. TtEC will track the kick-off and Navy/stakeholder meetings on the monthly invoice. The Contract Task Order (CTO) award does not indicate the locations for the Navy/stakeholder meetings; TtEC anticipates that some meetings will be in person in Seattle/Poulsbo and some will be by phone.
- TtEC will provide an updated schedule to the Remedial Project Manager (RPM) within 2 weeks of kick-off meeting. (See further discussion below.)
- The plan set will include a main work plan with supporting plans (Waste Management Plan, Environmental Protection Plan, CQC, SAP, etc.) as appendices. The Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) will be a standalone document, requiring internal draft and final versions. Response to Comments will be prepared for comments to the internal draft. URS will review the APP/SSHP for the Navy; the Navy and Marine Corps Public Health Center will also review the document.
- The main work plan will be the overarching document, including the construction requirements and the more boilerplate radiological guidelines for the project. Task-specific Plans (TSPs) will be prepared to address the radiological surveys for a given task. For example, individual TSPs will be prepared for the soil remediation, storm drain remediation, and building remediations.
- The radionuclides of concern (ROCs) for the project are radium-226 (Ra-226) and strontium-90 (Sr-90). Asbestos is present in/on the buildings and lead-based paint is suspected. TtEC will check with its chemist regarding the potential need to address

SAP Worksheet #9 – Project Scoping Session Participants Sheet (Continued)

asbestos and lead sampling in the SAP. Subsequent to the meeting, the chemist (Lisa Bienkowski) was consulted. She confirmed that because the sampling would be for health and safety and waste disposal, it would not be addressed in the SAP. If through review of site records evidence of potential chemical contamination is found, it may be prudent, if not necessary, to account for it in the SAP to minimize delay during the fieldwork. The Navy will be consulted prior to doing so.

- It is typical for projects awarded under Naval Facilities Engineering Command Southwest (NAVFAC SW) that Navy review of SAPs is by the Navy's Quality Assurance Officer. The RPM will confirm whether or not this will be the case for the SAP for this project. The SAP will be an appendix to the main plan.
- The project cleanup criteria for Ra-226 and Sr-90 are included in Tables 3 and 4 of the Internal Draft Engineering Evaluation/Cost Analysis (EE/CA). Those criteria will provide the basis for the work plans, unless the criteria change before the EE/CA is finalized.
- Standard Operating Procedures (SOPs) will be included as attachments to the Work Plan.
- The Waste Management Plan (WMP) will address organizational responsibilities with regard to waste management and disposal. Low-level radioactive waste (LLRW) will be turned over to the Navy's LLRW waste broker. Memorandums of Understanding (MOUs) will be required between TtEC and the LLRW waste broker or other Nuclear Regulatory Commission (NRC) license holders with which TtEC must interface. An MOU already exists between TtEC and the RASO.
- The RPM will forward to TtEC the agreement (Military Interdepartmental Purchase Request) the Navy has with the U.S. Army Joint Munitions Arsenal for disposal of LLRW. The RPM will also provide copies of MOUs the Navy has in place at the site. (This agreement and other related documents were received the afternoon of the meeting).
- Radioactive Material Areas (RMAs) will be established at TtEC work sites. TtEC generated waste will be controlled within these areas pending turnover to the Navy's waste broker. TtEC intent will be to not keep the waste on hand any longer than necessary.
- The Radiation Protection Plan (RPP) is a Rad EMAC program-wide document addressing protection of workers and the public. As it has already been reviewed and approved by Base Realignment and Closure (BRAC) and the RASO, TtEC had not intended that it be subject to review and comment by the CTO 0011 stakeholders. On other Rad EMAC projects, it has been separately forwarded to the stakeholders for information only. The RPM will give further consideration as to whether it should be part of the work plan as it goes to the stakeholders.

SAP Worksheet #9 – Project Scoping Session Participants Sheet (Continued)

- TtEC will evaluate whether or not a Stormwater Pollution Prevention Plan is required. This will depend largely on the total site area that will be disturbed. TtEC will research the current criteria.
- Some technical specifications will be required (e.g., storm drain installation, backfill, asphalt pavement). It will be determined during plan development whether standalone specifications are warranted or whether technical requirements can be incorporated into the body of the work plan.
- An engineering evaluation of the Building 27 hangar south wall (north wall of shed) will likely be required if the South Shed is to be demolished. Engineering evaluation may also be required inside Building 2 if remedial effort will adversely affect structural members. Language will be included in the Work Plan provisions for additional evaluations if they become necessary.
- The scope of the TSPs will be based on known contamination. Field Change Requests (FCRs) may be necessary to reflect actual conditions encountered while executing the fieldwork.
- It will be important that the Environmental Protection Plan adequately address the measures to be implemented to protect the public and the environment.
- The award includes remediation of up to 2,150 cubic yards of radiologically contaminated soil (1,500+15% cubic yards from the base scope and another 500 cubic yards from Mod. 1). TtEC will delineate the tentative removal areas in the plans based on the information in the RI.
- The remedial investigation (RI) identifies exceedances in soil on either side (east and west) of the area filled and paved with asphalt concrete during construction of the National Oceanic and Atmospheric Administration (NOAA) overpass.
- There must be special attention given to site restoration with respect to slope and retaining wall stability. TtEC was unable to locate retaining wall details during review of the record drawings. The city representative provided NOAA contact information as a potential source of construction details.
- Although the award includes remediation of 1,000 feet of storm drain (200 feet of 8-inch line and 800 feet of 6-inch line), the locations of the drains are uncertain aside from being in the vicinity of Building 27. TtEC will review the internal draft EE/CA, which was provided on the morning of the kick-off meeting, and contact Shaw for further information.
- The plans will identify tentative survey limits and remediation areas inside Building 2 and the Building 27 South Shed.
- Although the scope of the award currently includes demolition of the Building 27 South Shed and restoration of the hangar south wall per historic preservation requirements, finalization of the EE/CA will ultimately establish whether demolition of the structure will proceed. Because this decision will determine the need for

SAP Worksheet #9 – Project Scoping Session Participants Sheet (Continued)

consultation with the State Historic Preservation Office, the RPM will contact the BRAC Program Management Office regarding initiating discussion with the city to facilitate plan development and avoid potential delay.

- Discussed the projected schedule for finalizing the EE/CA. Also discussed the deliverable schedule included in the award for the project plans. From the discussion, it was agreed that the length of some of the preparation and review periods provided in the award are insufficient. The RPM also indicated that he would like to review the internal draft plans and resolve comments before the plans are forwarded to the RASO for internal review. This will add a preparation/review/resolution step to the deliverable cycle. The following tentative new deliverable dates were identified during the meeting and will be used to develop a plan deliverable schedule (total duration – 359 days).
  - Prepare Internal Draft – 77 days
  - NAVFAC NW Review Internal Draft – 21 days
  - NAVFAC NW Comment Resolution/to RASO – 21 days
  - RASO Internal Draft Review – 60 days
  - RASO Comment Resolution – 21 days
  - Prepare Draft/to Stakeholders – 21 days
  - Stakeholder Review Draft – 30 days
  - Stakeholder Comment Resolution – 21 days
  - Prepare Draft Final/to Stakeholders – 21 days
  - Stakeholder Review Draft Final – 30 days
  - Stakeholder Comment Resolution – 15 days
  - Prepare/Submit Final – 21 days

  TtEC will develop an updated schedule within 2 weeks of the meeting. Per discussion at the meeting, this will address the upfront deliverables only, pending further progress on the EE/CA and plans. Internally, TtEC will also develop a tentative fieldwork schedule based on the above deliverable schedule. As it appears the fieldwork will not begin until after the 2012 rainy season begins, resequencing of the tasks will likely be necessary.

- Reviewed the billing matrix, which had been updated to include the estimated line items added by Mod. 1. TtEC will revise the Event 2 matrix to provide separation between the APP/SSHP and the balance of the plans, as now only two versions will be required. TtEC will also take another look at the estimated line item 0008 matrix to determine if a more definitive approach can be established, opposed to RPM/Project Manager (PjM) assessment of percent complete. Agreement has been reached on the balance of the matrix.

SAP Worksheet #10 – Problem Definition

The main problem defined for this project is: Based on site-specific investigative data, the Navy has determined that low-level radioactive contamination potentially present at former NAVSTA PS, Seattle, Washington, requires a TCRA. Therefore, the Navy initiated removal actions for the screening, characterization, and remediation of radiologically impacted materials at the site to protect the public health and welfare, and the environment, from actual or potential releases of radiological contaminants.

FORMER NAVAL STATION PUGET SOUND LOCATION

The former NAVSTA PS site is located approximately 6 miles northeast of downtown Seattle on the western shore of Lake Washington.

GENERAL SITE HISTORY

During World War II, NAVSTA PS supported air transport and ship outfitting personnel for the Alaskan and Western Pacific theaters of operation. Transport squadron personnel operated cargo flights to Alaska and the Aleutian Islands, supplying air stations such as Sitka, Kodiak, Dutch Harbor, Adak, and Attu. Outfitting personnel handled the preparation of escort carriers and seaplane tenders built in Tacoma and Vancouver, Washington, prior to departure. In 1945, at the peak of its activity, the NAVSTA PS supported more than 4,600 Navy/Marine Corps and civilian personnel. After the war, the NAVSTA PS was designated a Naval Reserve Air Station. From 1945 to 1970, the station maintained Naval Reserve squadrons for supplementing active duty forces, both in the continental United States and abroad. Aviation activities officially ceased on June 30, 1970. In subsequent years the station served as a Naval Support Activity, before being officially closed in September 1995.

Subsequent to closure, the Navy conducted environmental investigations and cleanup of portions of NAVSTA PS. The condition of the property was described in the Environmental Baseline Survey (EBS) report (URS 1996). The EBS described the significant operations and existing conditions at specific buildings and areas at former NAVSTA PS that were addressed in past environmental investigations. The EBS identified areas with potential environmental concern where storage or release of hazardous substances had occurred. No radiological contamination was identified in the EBS report. This EBS report was used by the Navy to generate the Finding of Suitability to Transfer for the property. After completion of these actions as well as the appropriate National Environmental Policy Act actions, the Navy initiated transfer of the former NAVSTA PS property to several government agencies in accordance with the BRAC closure plan.

The Navy transferred portions of the facility to the city of Seattle for recreational development. Because of the facility's long history of use by the Navy, and because of the potential that the environmental investigations conducted did not identify all environmental hazards that pose a threat to human health and the environment, the transfer deed between the Navy and the city included an environmental covenant that allowed the city to seek action by the Navy to address contamination that was not identified in the EBS (URS 1996).

SAP Worksheet #10 – Problem Definition (Continued)

RADIOLOGICAL HISTORY

During planning of recent proposed renovations of Building 27, the city of Seattle reviewed historical drawings and identified rooms labeled “Instrument Shop” and “Radium Room,” which implied that radioactive materials may have been used or stored in these areas of the buildings. Buildings 27 and 2 are both former aircraft hangars. Airplane maintenance and storage activities of the era typically included the use of self-luminescent radium paint for the maintenance and repair of aircraft instruments and parts.

Dose rate radiation surveys were performed in April and May 2009 by Argus Pacific, Inc. (Argus) under contract with the city of Seattle Parks and Recreation Department (Argus 2009a,b). The surveys were conducted within Building 27, three pump houses (Pump House A, B, and 116) near Building 27, and within Building 2.

The 2009 surveys identified two locations of radiological activity above background levels in Building 27. The two locations were associated with a former sink drain pipe located on the second floor of Building 27 (former Radium Room) and where the pipe extended to the first floor.

Following the 2009 surveys, Shaw Environmental and Infrastructure, Inc., completed a radiological RI at former NAVSTA PS. The survey results are presented in the Radiological Remedial Investigation Report (Shaw 2011). Radiological contamination above the project cleanup criteria was found within the South Shed and two adjoining towers of Building 27. Radiological contamination was also found in and around both the 1939 and 1941 Instrument Shop in Building 2. Radiological contamination above project cleanup criteria was identified in catch basins associated with the storm lines. Contamination was also identified in the soil outside Building 27 (Shaw 2011).

SAP Worksheet #11 – Project Quality Objectives/Systematic Planning Process Statements

The Data Quality Objectives (DQOs) specify project objectives, data collection boundaries and limitations, the most appropriate type of data to collect, and the level of acceptable decision error. The quality and quantity of data required to implement environmental removal actions are also defined.

The DQOs, as defined through the seven-step process (EPA 2006), are as follows:

1. State the problem

The main problem defined for this project is: The Navy has determined (based on site-specific investigative data) that low-level radioactive contamination potentially present at former NAVSTA PS, Seattle, Washington, requires a TCRA. Therefore, the Navy initiated removal actions for the screening, characterization, and remediation of radiologically impacted materials at the site to protect public health and welfare, and the environment, from actual or potential releases of radiological contaminants.

2. Identify the goal of the study

Soil Characterization Borings:

Do the soil characterization samples contain cesium-137 (Cs-137), Ra-226, and Sr-90 that may pose a threat to the public health and welfare and the environment?

Surface and Trench Soil:

After the initial soil removals, does material containing Cs-137, Ra-226, and Sr-90 remain that may pose a threat to the public health and welfare and the environment?

Building Surfaces:

Does floor and wall surfaces material containing alpha/beta remain that may pose a threat to the public health and welfare and the environment?

3. Identify information inputs

- Sample locations from the RI report (Shaw 2011)
- Reference (background) area readings for each matrix
- Alpha/beta/gamma scan survey readings of buildings
- Systematic alpha/beta/gamma static measurements
- Analytical data (Cs-137, Ra-226, and Sr-90) from soil sampling

SAP Worksheet #11 – Project Quality Objectives/Systematic Planning Process Statements (Continued)

4. Define the boundaries of the study

Spatial boundaries:

The interior walls and floors in Building 2 and Building 27 as identified on Figure 1.

The trench and pipe line shown on Figure 1.

The contaminated soil areas shown on Figure 1.

Temporal boundaries: None

The TSPs will provide greater detail on the boundaries of the study area.

5. Develop the analytic approach

Soil Characterization Borings:

The following Decision Rules apply to soil characterization boring samples proposed prior to any removal activities.

a. If gamma static readings are detected above background from the scan of each soil characterization boring, then a soil sample will be collected at the interval with the highest reading from that boring and also from the interval below the highest reading where the activity is found to return to background. These samples will be analyzed for Cs-137, Ra-226, and Sr-90. If gamma static readings are not detected above background at a given boring location, the Navy will determine which intervals, if any, may require sample collection and analysis.

b. If any of the soil characterization boring sample results for Cs-137, Ra-226, or Sr-90 exceed the release criteria (identified in Worksheet #15), then these data (along with data from the boring samples that are below the release criteria) will be presented to the Navy who will determine the following: 1) if additional soil characterization borings are required to define the extent of the contamination or 2) if all of the data are sufficient to determine the vertical and horizontal extent of contamination in order to proceed with removal activities. If all the soil characterization boring sample results are below the release criteria, then this data will also be presented to the Navy who will determine if any further action is required.

Surface and Trench Soil:

The following Decision Rules apply to surface soils and sidewalls and bottoms of trenches after pipe removal.

a. If surface soil contamination is reported at background plus 3 sigma during gamma scans, then a soil sample will be collected in the area above 3 sigma and sent off-site to be analyzed for Cs-137, Ra-226, and Sr-90. If surface soil contamination is not

SAP Worksheet #11 – Project Quality Objectives/Systematic Planning Process Statements (Continued)

reported at background plus 3 sigma during gamma scans, then the Final Status Survey (FSS) can be conducted.

b. If the analytical results exceed the release criteria (identified in Worksheet #15), then the soil will be removed and resampled. If analytical results are below release criteria, no further removal will be required and the FSS can be conducted.

c. If the FSS data identify areas that exceed the release criteria, then further soil removal will be required. If the FSS data does not identify areas that exceed the release criteria, no further action will be required.

Building Surfaces:

The following Decision Rules apply to surfaces of the walls and floors of Buildings 2 and 27:

a. If an area on the floor or wall exceeds mean plus 3 sigma during gamma scans, a static gamma measurement will be taken to verify the reading. If the gamma static reading is above mean plus 3 sigma of background, a static alpha/beta measurement will be taken. If the alpha/beta measurements are beneath the release criteria (100 disintegrations per minute [dpm]/100 square centimeters [cm^2] alpha or 1,000 dpm/100 cm^2 beta fixed contamination), the surface will be removed to investigate if radiological contamination is beneath the surface. If no gamma scan survey measurements exceed mean background plus 3 sigma, alpha and beta scanning may commence on the wall and floor surfaces.

b. If wall or floor surface contamination is reported above the release criteria during alpha/beta scans, then a swipe sample and a static alpha/beta measurement will be collected. If contamination is not reported above the release criteria (exceeding 20 dpm/100 cm^2 alpha or 200 dpm/100 cm^2 beta removable contamination), no screening is required and the FSS can be conducted.

c. If the contamination in a swipe sample exceeds the release criteria for loose contamination (exceeding 20 dpm/100 cm^2 alpha or 200 dpm/100 cm^2 beta removable contamination), the area will be decontaminated using appropriate methods per SOP NAVSTA PS-Tt-06. A swipe sample will be collected and analyzed. If contamination is not reported above the release criteria, decontamination activities for the area may cease. If contamination is reported above the release criteria, decontamination activities will continue.

d. If a static alpha/beta measurement exceeds the fixed contamination release criteria (100 dpm/100 cm^2 alpha or 1,000 dpm/100 cm^2 beta fixed contamination), the area will be remediated using appropriate methods for the material (e.g., scabbling for concrete, removal for drywall or wood). A static alpha/beta measurement will be collected in the remediated area. If contamination is not reported above the fixed contamination release criteria, remediation actions may cease in the area and the FSS

SAP Worksheet #11 – Project Quality Objectives/Systematic Planning Process Statements (Continued)

can proceed. If contamination is reported above the release criteria, remediation activities will continue.

e. If the FSS identifies areas with contamination above the release criteria (100 dpm/100 cm^2 alpha or 1,000 dpm/100 cm^2 beta for fixed contamination or 20 dpm/100 cm^2 alpha or 200 dpm/100 cm^2 beta for removable contamination), remediation activities will be implemented and the FSS will be reconducted. If the FSS does not identify contamination above the release criteria, the area can be evaluated by the Navy for free release.

6. Specify performance or acceptance criteria

Radioactive source readings will be used to check instruments for consistency prior to use in each daily shift. The instrument will only be used after readings are compared and agree within +/- 20 percent of predetermined responses. The on-site Radiation Safety Officer Representative (RSOR) will review the information to verify that equipment is operating satisfactorily.

Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (DoD et al. 2000) guidelines will be used for the final gamma surveys. A 95 percent confidence level for detecting radioactivity above the levels corresponding to a maximum annual dose to an individual of 25 millirems, and the excess lifetime cancer risk of 3×10^{-4} for the critical group in soil samples will be assumed with Type I and II errors limited to 5 percent. The design alternatives for data collection may change slightly if assumptions are reviewed based on conditions in the field differing from the furnished information derived from historical research and current knowledge.

7. Develop the plan for obtaining data

Soil Characterization Borings:

During the radiological RI, Shaw identified 66 potential soil boring locations for the purpose of collecting and analyzing soil samples to define the magnitude and extent of radiological contamination. Soil samples from 24 of the 66 boring locations identified were collected and analyzed during the radiological RI. As part of this project, the remaining 42 boring locations, shown on Figure 1, will be investigated. Some boring locations may be eliminated and some may be added based on conditions encountered in the field. Gamma static scans will be performed for each boring, and up to two samples per boring may be collected as described above in Step 5a of the Soil Characterization Boring section. Soil boring data will be evaluated by the Navy to determine further action.

Surface Soils:

After the surface soils identified in the RI report (Shaw 2011) have been removed, the confirmation process will be conducted by scanning the soils with a Ludlum Model 2350-1 data logger (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) scintillation detector (or equivalent). Scan measurements are obtained by traversing a path at a maximum speed (scan rate) of approximately 0.5 meter per second and

SAP Worksheet #11 – Project Quality Objectives/Systematic Planning Process Statements (Continued)

slowly moving the detector assembly in a serpentine pattern, while maintaining the detector approximately 10 centimeters (4 inches) above the area being surveyed. Areas that are determined to exceed background plus 3 sigma will be sampled and the samples sent off-site for Cs-137, Ra-226, and Sr-90 analysis. If the sample data exceeds the release criteria, the soil in the sampled area will be rescanned and the process repeated until samples from the area no longer exceed the release criteria.

Once the area is cleared by the scanning process, MARSSIM-based soil sampling will be conducted. Any area where a soil sample exceeding the release criteria is identified will be removed, and a new statistical sampling will be conducted until the area meets free release criteria.

Trenches:

Once the soil and piping are removed from the trenches, a full surface scan of the sidewalls and bottom will be performed using the Ludlum Model 2350-1 data logger (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector (or equivalent).

Areas that are determined to exceed background plus 3 sigma will be sampled and the samples sent off-site for Cs-137, Ra-226, and Sr-90 analysis. If the sample data exceed the release criteria, the soil in the sampled area will be rescanned and the process repeated until samples from the area no longer exceed the release criteria.

Once the area is cleared by the scanning process, a MARSSIM-based soil sampling will be conducted. Any area where a soil sample exceeding the release criteria is identified will be removed, and a new statistical sampling will be conducted until the area meets free release criteria.

Building Surfaces:

Scan surveys for alpha/beta/gamma radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43 series alpha-beta gas proportional detectors (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) scintillation detector (or equivalent) and a Ludlum Model 2350-1 data logger with Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector on the walls, piping, and floors on the interior of Buildings 2 and 27. Any areas exceeding the release criteria will be swipe sampled and static surveyed in accordance with NAVSTA PS-Tt-003, Radiation and Contamination Surveys. The swipe sample will be used to identify removable alpha/beta contamination.

Static surveys for alpha/beta/gamma radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37

SAP Worksheet #11 – Project Quality Objectives/Systematic Planning Process Statements (Continued)

alpha-beta gas proportional detector (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) scintillation detector (or equivalent).

Contamination will be remediated/removed until all areas are below the release criteria (100 dpm/100 cm^2 alpha or 1,000 dpm/100 cm^2 beta for fixed contamination or 20 dpm/100 cm^2 alpha or 200 dpm/100 cm^2 beta for removable contamination). A final MARSSIM statistical swipe and static sampling will be conducted for free release. Any areas identified as still contaminated will be remediated and a new MARSSIM statistical swipe and static sampling will be conducted for free release.

SAP Worksheet #12 – Measurement Performance Criteria Table for Samples

Field quality control (QC) samples are not required for this project to meet the project objectives. Therefore, measurement performance criteria for field QC sample collection are not applicable.

This page intentionally left blank.

SAP Worksheet #13 – Secondary Data Criteria and Limitations Table

For this project, secondary data are not applicable.

This page intentionally left blank.

SAP Worksheet #14 – Summary of Project Tasks

The following is a summary of the project tasks related to sampling activities.

Completion of Characterization Sampling in Radiologically Contaminated Areas

During the radiological RI, Shaw identified 66 potential soil boring locations for the purpose of collecting and analyzing soil samples to define the magnitude and extent of radiological contamination. Soil samples from 24 of the 66 boring locations identified were collected and analyzed during the radiological RI. As part of this project, the remaining 42 boring locations, shown on Figure 1, will be investigated. Some boring locations may be eliminated and some may be added based on conditions encountered in the field.

The following summarizes the required activities:

- Obtain necessary permits and approval.
- Identify soil boring locations using global positioning system or conventional survey methods; if feasible, measurements of known fixed site features may be used.
- Conduct utility clearances.
- Establish Radiologically Controlled Areas if not already in place.
- Implement traffic control measures where necessary.
- Using a hand auger, collect core samples at 6-inch intervals and log the borings.
- Field screen each sample interval for volatile organic compounds (VOCs) and gamma count rate; document radiological field-screening results in the boring logs.
- Collect two soil samples at each boring location; document, package, and ship samples to an off-site laboratory for analysis.
- Backfill the borings with bentonite chips and restore surface features as necessary.

From each boring, 6-inch-long hand auger segments will be retrieved continuously from the ground surface to the full depth of the boring. The borings will not extend beyond a depth of 8 feet or below the level of the groundwater, with one exception. If contamination is encountered at a depth of 8 feet before groundwater is encountered, the intent will be to extend the boring beyond the contamination or to the water table, whichever is encountered first. In the event that elevated gamma activity is encountered at a shallower depth, sampling will continue, subject to the limits noted above, until two successive 6-inch-long hand auger segments exhibit no elevated gamma activity, as determined by the RSOR. A minimum of 2-inch-diameter hand auger will be used. Each hand auger segment will be logged for soil type, surveyed for gamma count rate, and considered for collection for laboratory analysis.

Upon recovery from the boring hole, the soil will be removed and placed into a cleaned stainless steel bowl or onto clean plastic sheeting. Each sample interval will be visually examined to determine whether or not soil from a higher sample interval has sloughed onto the sample just collected. If this has occurred, the soil from the higher interval will be segregated and discarded. Each discrete soil sample must be representative of the material recovered from a given depth. Each hand auger segment will be examined and lithology will be logged. A drilling log form

SAP Worksheet #14 – Summary of Project Tasks (Continued)

will be completed for each boring and will include the geological description and radiological field-screening results.

Each hand auger segment will be screened for VOCs using a flame ionization detector or a photoionization detector. The VOC screening will involve monitoring the breathing zone air for health and safety purposes during sample collection activities. Each hand auger segment will also be field-screened for gamma count rate using a Ludlum 2350-1 data logger with a 44-10 sodium iodide detector (1-minute count at 4 inches from the soil sample). This measurement shall be performed in a "background" area that does not exhibit elevated gamma count rate resulting from hot spot contamination. The background shall be measured (10 each 1-minute count) and documented prior to performing these gamma count rate measurements. The purpose of the radiological field screening is to provide real-time radiological activity data to guide the delineation efforts.

Samples from two 6-inch intervals will be sent to an off-site laboratory for radiological analyses for Cs-137 and Ra-226 as described in Worksheet #18. One sample will be collected from the interval exhibiting the highest gamma count. The second sample will be collected from a lower level where it is determined that sampling has progressed beyond the point of elevated gamma activity. If no elevated gamma count is identified at a given boring location, the Navy will determine which intervals, if any, will require analysis. Completed borings will be filled with bentonite chips, and the surface features will be restored, as necessary.

Removal of Radiologically Contaminated Soils

Contaminated soil that was identified in the RI report (Shaw 2011) will be removed and handled as LLRW. A TSP will be prepared to determine the area and depth of soil to be excavated and stored in bins until sampled for waste and removed from the site. Following the removal of soil, a sampling process described in Step 7 of Worksheet #11 will be conducted to determine if further removal action needs to be conducted and determine free release.

Removal of Contamination from Walls and Floors in Buildings 2 and 27

As identified in the RI report, areas of Buildings 2 and 27 will be scanned to identify contamination of walls and floors. A TSP will be prepared for each building to determine the areas to be remediated and surveyed within the buildings. Contamination will be removed by cleaning or physical removal of materials from the surface until areas are below the release criteria.

Pipe Removal

Pipeline material as identified in the RI report (Shaw 2011) will be removed and handled as LLRW. A TSP will be prepared to determine the area and sampling points for the radiological surveys. Following the removal of soil, a sampling process described in Step 7 of Worksheet #11 will be conducted to determine if further removal action needs to be conducted and determine free release.

SAP Worksheet #14 – Summary of Project Tasks (Continued)

Import Fill Material

Additional soil material sources are needed for backfill of trenches and areas where soil has been removed. Soil samples will be collected at a minimum of 10 samples per source and analyzed for Cs-137 and Ra-226. One of the 10 samples will be analyzed also for total strontium and/or Sr-90 and chemical analyses listed in Worksheet #18. (Only soil material will be sampled. Rock is not required to be sampled.) If any of the analytical results exceed that criteria listed in Worksheet #15, the source will not be used for fill material and another source will be identified and sampled accordingly.

Sampling Procedures

SOPs listed in Worksheet #21 will be used for the collection of samples associated with the soil characterization borings, surfaces soils, trenches, and building surfaces.

The following procedures will be used for the collection of soil samples from import fill material:

1. Sampling personnel will don a new pair of disposable nitrile gloves immediately before collecting soil samples at each location.
2. A disposable scoop or equivalent will be used to collect soil samples into containers listed in Worksheet #19 in conjunction with analyses identified in Worksheet #18. Containers will be filled to ensure no headspace.
3. Sample numbering, labeling, documentation, and packaging procedures will be followed as described in Worksheets #18, #27, and #29.

Decontamination Procedures

In the event any nondisposable equipment is used for sampling purposes, the equipment will be decontaminated as follows:

1. **Prescreening using a hand-held alpha/beta survey meter –** If radioactive contamination exceeds the equipment release limits (identified in the Work Plan), the equipment and local area will be secured and the RSOR will be notified for further action.
2. **Washing with nonphosphate detergent and water solution –** This step will reduce the amount of gross contamination from the equipment. Use of a container, approximately 75 percent full of solution, is suggested for this step. This detergent solution will be prepared as directed by the manufacturer.
3. **Rinsing with potable water –** This step will rinse all the detergent solution away from equipment. Use of a container, approximately 75 percent full of potable water, is suggested for this step. Periodic changing of this water is required.
4. **Rinsing with potable water –** Repeat Step 2. Subsequent to this final rinse, place decontaminated equipment on a clean surface area (plastic sheeting) to air dry.
5. **Screening of equipment –** When dry, survey the decontaminated equipment using a hand-held alpha/beta survey meter. If radioactive contamination exceeds the equipment

SAP Worksheet #14 – Summary of Project Tasks (Continued)

release limits (identified in Attachment 2 of the main Work Plan), the equipment and local area will be secured and the RSOR will be notified for further action.

6. **Drumming of wastewater –** Drummed decontamination fluids will be sampled to characterize the waste for disposal as described in the wastewater characterization sampling procedure section above. Drums will be stored in a designated storage area pending receipt of the analytical data.

Data Management Tasks

Field sampling data, including field logbooks and field forms, will be maintained. The logbooks will be numbered sequentially on the cover by the Project Quality Control Manager (PQCM) and that number will be entered into a logsheet maintained by the PQCM. A copy of all field forms will be maintained in the project file.

A copy of the laboratory chains of custody (COCs) will be faxed/emailed to the Project Chemist on a daily basis for review and communication with the laboratory. The Project Chemist will maintain a copy of the COC form until submitted to the NAVFAC NW Administrative Record along with the hard-copy packages as described in Worksheet #29.

The laboratory will submit data at the turnaround time to TtEC via email. This submittal will include results and basic QC results (method blanks, laboratory control sample [LCS], surrogates, and matrix spike/matrix spike duplicates [MS/MSDs]). Following this submittal, the laboratory will be required to submit a Level III- or Level IV-equivalent data package within 30 business days of the sample collection date. For this project, 80 percent of the data will be submitted in an EPA Level III-equivalent data package, and 20 percent will be submitted in an EPA Level IV-equivalent data package as listed on the COC and described in Worksheet #29. Each sample will have a level III or IV designation on the COC. In order to meet the 20 percent requirement for level IV samples, level IV will be chosen for every fifth sample collected.

Field data from the laboratory COCs (date and time collected, sample identification, etc.) will be entered into the TtEC database by the Project Chemist. Survey data will be recorded and also entered into the database. All radiological survey locations will be surveyed using the State Plane Coordinate System (North American Datum 83) in feet, and vertical control standards will be in mean sea level (North American Vertical Datum 88) in feet. Any manual entries into the TtEC database will be 100 percent verified by the Project Chemist by checking the manual entry against the hard-copy information.

The laboratory will provide an electronic data deliverable (EDD) that will be compatible with TtEC requirements, and the EDD will be uploaded into the TtEC database. The data will be checked for required values and project-specific requirements by the database. Any discrepancies in the EDD will be corrected by TtEC or the laboratory will be notified to make corrections.

Analytical data generated by the laboratory will be validated by an independent data validation company. The validation report will include the data validation findings worksheets as described in Worksheet #29, and the validation qualifiers will be entered electronically in the laboratory EDD.

SAP Worksheet #14 – Summary of Project Tasks (Continued)

After receipt of the validated data, the validation qualifiers will be uploaded into the TtEC database. Validated analytical data will be submitted to the Naval Installation Restoration Information Solution (NIRIS) website in Navy electronic data deliverable (NEDD) format in accordance with EWI EVR.6, Environmental Data Management and Required Electronic Delivery Standards (SWDIV 2005) as required.

Hard-copy data will be stored until subsequent submittal to the NAVFAC NW Administrative Record as described in Worksheet #29. The TtEC database will be electronically backed up on data storage tapes, and the backup will be stored as an archive file.

This page intentionally left blank.

SAP Worksheet #15 – Reference Limits and Evaluation Table for Soil Samples

Matrix: Soil
Analytical Group: Cs-137 and Ra-226 (Curtis and Tompkins)

Analyte	CAS Number	Project Action Limit (pCi/g)	Project Action Limit Reference	Project MDA (pCi/g)	Laboratory-specific	
					MDAs (pCi/g)	LOD/DLs (pCi/g)
Cs-137	10045-97-3	25.63	Action Memorandum (Shaw 2013)	1	1	Not applicable [a]
Ra-226	13982-63-3	1.54	Action Memorandum (Shaw 2013)	0.7	0.7	Not applicable [a]

Matrix: Soil
Analytical Group: Sr-90 (TestAmerica-Richland)

Analyte	CAS Number	Project Action Limit (pCi/g)	Project Action Limit Reference	Project MDA (pCi/g)	Laboratory-specific	
					MDAs (pCi/g)	LOD/DLs (pCi/g)
Total Strontium [b]	7440-24-6	9.51	Action Memorandum (Shaw 2013)	3	3	Not applicable [a]
Sr-90	10098-97-2	9.51	Action Memorandum (Shaw 2013)	3	3	Not applicable [a]

SAP Worksheet #15 – Reference Limits and Evaluation Table for Soil Samples (continued)

Matrix: Soil
Analytical Group: VOCs (TestAmerica-St. Louis)

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/kg)	Laboratory-specific		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
1,1,1-Trichloroethane	71-55-6	2,000	[c]	5.0	5.0	1.0	0.43
Benzene	71-43-2	30	[c]	5.0	5.0	1.0	0.25
Ethylbenzene	100-41-4	6,000	[c]	5.0	5.0	1.0	0.30
Ethylene dibromide	106-93-4	5	[c]	5.0	5.0	1.0	0.70
Methylene chloride	75-09-2	20	[c]	10	10	5.0	1.6
Methyl tert-butyl ether	1634-04-4	100	[c]	5.0	5.0	1.0	0.48
Tetrachloroethene	127-18-4	50	[c]	5.0	5.0	1.0	0.32
Toluene	108-88-3	7,000	[c]	5.0	5.0	1.0	0.70
Trichloroethene	79-01-6	30	[c]	5.0	5.0	1.0	0.38
Xylenes (Total)	1330-20-7	9,000	[c]	10	10	5.0	0.85

SAP Worksheet #15 – Reference Limits and Evaluation Table for Soil Samples (continued)

Matrix: Soil
Analytical Group: SVOCs (TestAmerica-St. Louis)

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/kg)	Laboratory-specific		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Benzo(a)pyrene	50-32-8	100	[c]	330	330	99	33
Naphthalene	91-20-3	5,000	[c]	330	330	99	33

Matrix: Soil
Analytical Group: Pesticides (TestAmerica-St. Louis)

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/kg)	Laboratory-specific		
					LOQ (µg/kg)	LOQ (µg/kg)	DL (µg/kg)
4,4′-DDT	50-29-3	3,000	[c]	1.7	1.7	0.67	0.63
gamma-BHC (Lindane)	58-89-9	10	[c]	1.7	1.7	0.34	0.17

Matrix: Soil
Analytical Group: PCBs (TestAmerica-St. Louis)

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/kg)	Laboratory-specific		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Aroclor 1016	12674-11-2	Total PCBs = 1,000	[c]	33	33	16	8.7
Aroclor 1221	11104-28-2		[c]	33	33	16	8.7
Aroclor 1232	11141-16-5		[c]	33	33	16	8.7
Aroclor 1242	53469-21-9		[c]	33	33	16	8.7
Aroclor 1248	12672-29-6		[c]	33	33	16	8.7
Aroclor 1254	11097-69-1		[c]	33	33	10	5.5
Aroclor 1260	11096-82-5		[c]	33	33	10	5.5

SAP Worksheet #15 – Reference Limits and Evaluation Table for Soil Samples (continued)

Matrix: Soil
Analytical Group: TPH (TestAmerica-Tacoma)

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (mg/kg)	Laboratory-specific		
					LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
Gasoline range organics	STL00228	30	[c]	4.0	4.0	1.1	0.5
Diesel range organics	STL00163	2,000	[c]	25	25	6.5	5.7
Heavy oil	STL00299	2,000	[c]	50	50	25	9.1
Mineral oil	8012-95-1	4,000	[c]	50	50	50	50

Matrix: Soil
Analytical Group: Metals including mercury (TestAmerica-St. Louis)

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (mg/kg)	Laboratory-specific		
					LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
Arsenic	7440-38-2	20	[c]	1.0	1.0	0.78	0.26
Cadmium	7440-43-9	2	[c]	0.060	0.060	0.048	0.016
Chromium	7440-47-3	2,000	[c]	1.9	1.9	1.0	0.45
Lead	7439-92-1	250	[c]	0.30	0.30	0.30	0.10
Mercury	7439-97-6	2	[c]	0.04	0.04	0..03	0.011

SAP Worksheet #15 – Reference Limits and Evaluation Table for Soil Samples (continued)

Matrix: Soil
Analytical Group: Hexavalent Chromium (TestAmerica-West Sacramento)

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (mg/kg)	Laboratory-specific		
					LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
Hexavalent chromium	18540-29-9	19	[c]	0.05	0.05	0.025	0.010

Notes:

[a] Limint of detection (LOD) and detection limits (DLs) are not applicable to radiological analyses.

[b] Total strontium is analyzed first due to a quicker turnaround time by the laboratory. If the total strontium result exceeds the project action limit listed, then the sample will be analyzed for Sr-90.

[c] Limits listed are from Table 740-1 (Method A Soil Cleanup Levels for Unrestricted Land Uses) of the Model Toxics Control Act Statute and Regulation, Washington State Department of Ecology, Publication 94-06, November 2007.

SAP Worksheet #16 – Project Schedule / Timeline Table

Due to the rapidly changing timetable, the PjM will maintain and publish the schedule monthly.

This page intentionally left blank.

SAP Worksheet #17 – Sampling Design and Rationale

The following sections provide a rationale for types of surveying and sampling that will be performed during this project.

Soil Characterization Borings

During the radiological RI, Shaw identified 66 potential soil boring locations for the purpose of collecting and analyzing soil samples to define the magnitude and extent of radiological contamination. Soil samples from 24 of the 66 boring locations identified were collected and analyzed during the radiological RI. As part of this project, the remaining 42 boring locations, shown on Figure 1, will be investigated. Some boring locations may be eliminated and some may be added based on conditions encountered in the field. Gamma static scans will be performed for each boring, and up to two samples per boring may be collected as follows: If gamma static readings are detected above background from the scan of each soil characterization boring, then a soil sample will be collected at the interval with the highest reading from that boring and also from the interval below the highest reading where the activity is found to return to background. These samples will be analyzed for Cs-137, Ra-226, and Sr-90. If gamma static readings are not detected above background at a given boring location, the sample from the interval exhibiting the highest reading will be sampled and analyzed.

Surface Soils

After the surface soils identified in the RI report have been removed, the confirmation process will be conducted by scanning the soils with a Ludlum Model 2350-1 data logger (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector (or equivalent). Scan measurements are obtained by traversing a path at a maximum speed (scan rate) of approximately 0.5 meter per second and slowly moving the detector assembly in a serpentine pattern, while maintaining the detector approximately 10 centimeters (4 inches) above the area being surveyed. Areas that are determined to exceed background plus 3 sigma will be sampled and the samples sent off-site for Cs-137, Ra-226, and Sr-90 analysis. If the sample data exceeds the release criteria, the soil in the sampled area will be rescanned and the process repeated until analytical results from the area no longer exceed the release criteria.

Once the area is cleared by the scanning process, a MARSSIM-based soil sampling will be conducted. Any area where a soil sample exceeding the release criteria is identified will be removed, and a new statistical sampling will be conducted until the area meets free release criteria.

Trenches

Once the soil and piping are removed from the trenches, a full surface scan of the sidewalls and bottom will be conducted using the Ludlum Model 2350-1 data logger (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector (or equivalent).

Areas that are determined to exceed background plus 3 sigma will be sampled and the samples sent off-site for Cs-137, Ra-226, and Sr-90 analysis. If the sample data exceed the release criteria, the soil in the sampled area will be rescanned and the process repeated until analytical results from the area no longer exceed the release criteria.

SAP Worksheet #17 – Sampling Design and Rationale (Continued)

Once the area is cleared by the scanning process, a MARSSIM-based soil sampling will be conducted. Any area where a soil sample exceeding the release criteria is identified will be removed, and a new statistical sampling will be conducted until the area meets free release criteria.

Building Surfaces

Scan surveys for alpha/beta/gamma radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43 series alpha-beta gas proportional detector (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) scintillation detector (or equivalent) and a Ludlum Model 2350-1 data logger (or equivalent) with a 44-10 scintillation detector (or equivalent) on the walls, piping, and floors on the interior of Buildings 2 and 27. Any areas exceeding mean background plus 3 sigma during the gamma scans will be further investigated for subsurface contamination. Any areas exceeding the release criteria will be swipe sampled and static surveyed in accordance with NAVSTA PS-Tt-003, Radiation and Contamination Surveys. The swipe sample will be used to identify removable alpha/beta contamination.

Static surveys for alpha/beta/gamma radiation will be performed using a Ludlum Model 2360 data logger (or equivalent) equipped with either a Ludlum Model 43-68 or Model 43-37 alpha-beta gas proportional detector (or equivalent) or a Ludlum Model 43-89 or 43-93 ZnS(Ag) scintillation detector (or equivalent) and a Ludlum Model 2350-1 data logger (or equivalent) with a 44-10 scintillation detector (or equivalent).

Contamination will be remediated/removed until all areas are below the release criteria. A final MARSSIM statistical swipe and static sampling will be conducted for free release. Any areas identified as still contaminated will be remediated, and a new MARSSIM statistical swipe and static sampling will be conducted for free release.

Import Fill Material

Additional soil material sources are needed for backfill material for trenches and remediated surface soil areas. Soil samples will be collected at a minimum of 10 samples per source and analyzed for Cs-137 and Ra-226. One of the 10 samples will be analyzed also for total strontium and/or Sr-90 and chemical analyses listed in Worksheet #18. If any of the analytical results exceed that criteria listed in Worksheet #15, the source will not be used for fill material and another source will be identified and sampled accordingly. (Only soil or fine materials will be sampled. Gravel and rock will not be sampled but will be required to be cleaned, washed, free of fines, and from an approved/acceptable source certified not to contain asbestos.)

SAP Worksheet #18 – Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ ID Number	Matrix	Depth (feet)	Analytical Group	Number of Samples	Sampling SOP Reference
Soil boring characterization soil samples (Z-SC-B-SD-ED)	Soil	TBD [a]	Cs-137, Ra-226, and Sr-90	TBD [b]	Worksheet #14
Postexcavation soil samples from soil and storm drain removal (WW-EXC-SUXX-UUU)	Soil	TBD [a]	Cs-137, Ra-226, and Sr-90	TBD [b]	Worksheet #14
Reference background area (WW-BG-UUU)	Soil	Surface	Cs-137, Ra-226, and Sr-90	TBD [b]	Worksheet #14
Import fill material (WW-BACKFILL-UUU)	Soil	Random	Cs-137, Ra-226, Sr-90, and select VOCs, SVOCs, pesticides, PCBs, TPH, metals including mercury, and hexavalent chromium as indicated in SAP Worksheet #15	TBD [b]	Worksheet #14
Building walls and floors (WW-BYY-SUXX-UUU)	N/A	N/A	Alpha/beta swipe sample [c]	TBD [b]	Worksheet #14
Building ventilation ductwork (WW-BYY-UUU)	N/A	N/A	Alpha/beta swipe sample [c]	TBD [b]	Worksheet #14
Surface soil around buildings (WW-SS-UUU)	Soil	Surface	Cs-137, Ra-226, and Sr-90	TBD [b]	Worksheet #14

SAP Worksheet #18 – Sampling Locations and Methods/SOP Requirements Table (Continued)

Notes:

[a] The sample depth is listed as TBD (to be determined) since it will be based on the excavation depth.

[b] The number of samples is listed as TBD (to be determined) since it is unknown if and how many sources will be identified.

[c] The alpha/beta swipe analysis will be performed using field instruments and therefore is not discussed in worksheets that follow regarding laboratory requirements.

B – boring
BG – background
BYY – building designation, where YY = 02 or 27
ED – end depth for soil boring sample (for example, 1.0 for 1 foot)
EXC – excavation
N/A – not applicable
SC – soil characterization
SD – start depth for soil boring sample (for example, 0.5 for half a foot)
SS – surface soil
SUXX – Survey Unit designation, where X = sequential number
U – sequential number
WW – CTO number
Z – Soil boring location number

SAP Worksheet #19 – Analytical SOP Requirements Table

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference	Containers	Sample Volume	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/analysis)
Soil	Cs-137 and Ra-226 (Curtis and Tompkins)	EPA 901.1 MOD HPS SOPs Section 3.3	Gallon ziplock	~ 1000 g	None	Not applicable
Soil	Sr-90 (TestAmerica-Richland)	EPA 905 MOD/DOE SR-01-RC MOD/DOE SR-02-RC MOD SOP RL-GPC-010	One 8-oz plastic/glass jar	5 g	None	Not applicable
Soil	VOCs (TestAmerica-St. Louis)	EPA 5035A/8260C SOP ST-MS-0002	Three 5-g En Core samplers [b]	15 g	4±2°C	48 hours/14 days
Soil	SVOCs (TestAmerica-St. Louis)	EPA 3550C/8270D SOP ST-MS-0001	One 8-oz glass jar [c]	8 oz	4±2°C	14 days/40 days
Soil	Pesticides (TestAmerica-St. Louis)	EPA 3550C/8081B SOP ST-GC-0016	One 8-oz glass jar [c]	8 oz	4±2°C	14 days/40 days
Soil	PCBs (TestAmerica-St. Louis)	EPA 3550C/8082A SOP ST-GC-0015	One 8-oz glass jar [c]	8 oz	4±2°C	14 days/40 days
Soil	TPH (TestAmerica-Tacoma)	NWTPH-Gx SOP TA-MV-0376 NWTPH-Dx SOP TA-GS-0339	Three 5-g Terra Core devices used to place each 5 g of soil in a separate 40-mL VOA vial, pre-weighed with 10 mL of methanol [b] One 8-oz glass jar [c]	15 g 8 oz	4±2°C	48 hours/14 days 14 days/40 days
Soil	Metals (TestAmerica-St. Louis)	EPA 3050B/6020A SOP ST-MT-0001 EPA 7471B (mercury) SOP ST-MT-0007	One 8-oz glass jar [c]	8 oz	4±2°C	180 days (28 days for mercury)
Soil	Hexavalent chromium (TestAmerica-West Sacramento)	EPA 7196A SOP WS-WC-0020	One 4-oz glass jar	4 oz	4±2°C	30 days/24 hours

This page intentionally left blank.

SAP Worksheet #20 – Field Quality Control Sample Summary Table

Field QC samples are not applicable as described in Worksheet #12.

This page intentionally left blank.

SAP Worksheet #21 – Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
NAVSTA PS-Tt-003	Radiation and Contamination Surveys	Tetra Tech, Inc.	Radiological Instruments	Y	None
NAVSTA PS-Tt-004	Preparation of Portable Radiation and Contamination Survey Meters and Instruments for Field Use	Tetra Tech, Inc.	Radiological Instruments	Y	None
NAVSTA PS-Tt-006	Sampling Procedures for Radiological Surveys	Tetra Tech, Inc.	Radiological Instruments	Y	None
NAVSTA PS-Tt-007	Radiologically Controlled Areas Posting and Access Control	Tetra Tech, Inc.	Radiological Instruments	Y	None
NAVSTA PS-Tt-008	Control of Radioactive Material	Tetra Tech, Inc.	Radiological Instruments	Y	None
NAVSTA PS-Tt-009	Release of Materials and Equipment from Radiologically Controlled Areas	Tetra Tech, Inc.	Radiological Instruments	Y	None
NAVSTA PS-Tt-010	Decontamination of Equipment and Tools	Tetra Tech, Inc.	Radiological Instruments	Y	None

The above SOPs are included in Attachment 4 of the Work Plan.

This page intentionally left blank.

SAP Worksheet #22 – Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference	Comments
Ludlum Model 19 (or equivalent); Ludlum 2350-1 w/ 44-10 detector (or equivalent); Ludlum 2360 w/ 43-89 detector (or equivalent); Ludlum 2929 (or equivalent); SAM 940 (or equivalent)	1. Calibrate at lab featuring NIST traceable standards 2. Operational checks and verifications	1. Annually 2. Daily	1. Pass/fail 2. +/- 20% of baseline response criteria	1. If recalibration fails, then instrument combination is retained/exchanged by instrument vendor. 2. If checks and verifications fail, then instrument combination is placed out-of-service/returned to instrument vendor for repair/exchange. Subsequently, data collected with instrument since previous QC check will be reviewed.	1. Calibration by vendor annually 2. RCT under direction of RSOR	None	None

This page intentionally left blank.

SAP Worksheet #23 – Analytical SOP References Table

Lab SOP Number [a]	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
HPS SOPs Section 3.3	Determination of Radium 226 by Gamma-Ray Spectroscopy (21 day ingrowth) DOE HASL 4.5.2.3 Revision 0, 08/31/12	Definitive	Soil Cs-137 and Ra-226	EG&G Ortec Gamma Spectroscopy System	Curtis and Tompkins	N
RL-GPC-010	Separation of Strontium Revision 3, 02/07/13	Definitive	Soil Sr-90	Gas Flow Proportional Counter	TestAmerica-Richland	N
ST-MS-0002	Determination of Volatile Organics by GC/MS Revision 19, 05/08/13	Definitive	Soil VOCs	GC/MS	TestAmerica-St. Louis	N
ST-MS-0001	GC/MS Semivolatiles Analysis Revision 15, 05/06/13	Definitive	Soil SVOCs	GC/MS	TestAmerica-St. Louis	N
ST-GC-0016	Pesticide Gas Chromatographic Analysis Revision 14, 02/15/13	Definitive	Soil Pesticides	GC	TestAmerica-St. Louis	N
ST-GC-0015	PCB GC Analysis Revision 11, 02/14/13	Definitive	Soil PCBs	GC	TestAmerica-St. Louis	N
TA-MV-0376 TA-GS-0339	Gasoline Range Organics/MBTEX Analysis Revision 11, 03/13/13 Semivolatile Petroleum Products Method for Soil and Water; Revision 13, 05/28/13	Definitive	Soil TPH	GC/PID GC/FID	TestAmerica-Tacoma	N
ST-MT-0001 ST-MT-0007	Analysis of Metals by Inductively Coupled Plasma/Mass Spectrometry Revision 20, 01/20/12 Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption Spectroscopy Revision 13, 06/17/13	Definitive	Soil Metals Soil Mercury	ICP/MS Cold Vapor Atomic Absorption (CVAA)	TestAmerica-St. Louis	N

SAP Worksheet #23 – Analytical SOP References Table (Continued)

Lab SOP Number [a]	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
WS-WC-0020	Determination of Hexavalent Chromium by Manual Colorimetric Method Revision 7.4, 06/08/12	Definitive	Soil Hexavalent chromium	Spectrophotometer	TestAmerica-West Sacramento	N

Notes:

[a] Analytical SOP revision number and date listed are current as of the date this SAP was published. All analytical SOPs are provided as Appendix A of this SAP.

SAP Worksheet #24 – Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference [a]
EG&G Ortec Gamma Spectroscopy System	1. Ortec Gamma Vision-32 A66-B32 Operations Manual	Annual, after maintenance, and at the request of the lab manager	+/- 10% for the radionuclides used for calibration	• Recalibration • Instrument maintenance • Notify lab manager	Curtis and Tompkins Laboratory Supervisor	HPS SOPs Section 3.3
Gas Flow Proportional Counter	• Plateau generation and/or verification • Discriminator setting • Initial long background count • Mass attenuated efficiency calibration • Eight source dual/single calibration curves	Annual	• Plot efficiencies vs masses • Efficiency vs. mass curve $\leq$ a third degree polynomial • Remove outliers >15% deviation from theoretical values but not more than 20% of total points • Calculate coefficient of determination (R^2). R^2 must be $\geq$0.9 • Verify calibration with second source standard count – must be within 30 percent of true value and mean across all detectors <10%	• Recalibrate • Instrument maintenance • Consult with Technical Director	TestAmerica Group Leader	RL-GPC-010
GC/MS	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	%RSD<20% all compounds, Relative Response Factor meet method criteria	Repeat calibration	TestAmerica Analyst	ST-MS-0002 ST-MS-0001
GC/MS	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ±30% of expected	Rerun ICV one time, second failure requires recalibration	TestAmerica Analyst	ST-MS-0002 ST-MS-0001
GC/MS	Calibration Verification (CV)	Daily, before sample analysis, and every 12 hours of analysis time	+/- 20%D criteria for all analytes	Re-inject CV; if passes rerun previous 10 samples and continue run; if 2nd CV fails, recalibrate	TestAmerica Analyst	ST-MS-0002 ST-MS-0001

SAP Worksheet #24 – Analytical Instrument Calibration Table (Continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference [a]
GC	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	RSD for each analyte ≤ 20%	Repeat calibration	TestAmerica Analyst	ST-GC-0016
GC	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ± 20% of expected value (initial source)	Rerun ICV one time, second failure requires recalibration	TestAmerica Analyst	ST-GC-0016
GC	Calibration Verification (Initial [ICV] and continuing [CCV])	ICV: Daily, before sample analysis CCV: After every 12 hours of analysis time and at the end of the analysis sequence	All analytes within ± 20% of expected value from the ICAL	Re-inject CCV; if passes rerun previous 10 samples and continue run; if 2nd CCV fails, recalibrate	TestAmerica Analyst	ST-GC-0016
GC	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	Mean RSD for each PCB ≤ 20%	Recalibrate	TestAmerica Analyst	ST-GC-0015
GC	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ± 20% of expected value (initial source)	Rerun ICV one time, second failure requires re-calibration	TestAmerica Analyst	ST-GC-0015
GC	Calibration Verification (Initial [ICV] and continuing [CCV])	ICV: Daily, before sample analysis CCV: After every 12 hours of analysis time and at the end of the analysis sequence	All analytes within ± 20% of expected value from the ICAL	Re-inject CCV; if passes rerun previous 10 samples and continue run; if 2nd CCV fails, recalibrate	TestAmerica Analyst	ST-GC-0015
GC/PID	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	Linear-mean RSD ≤ 20%	Repeat calibration	TestAmerica Analyst	TA-MV-0376
GC/PID	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ± 15% of expected	Rerun ICV one time, second failure requires recalibration	TestAmerica Analyst	TA-MV-0376

SAP Worksheet #24 – Analytical Instrument Calibration Table (Continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference [a]
GC/PID	Calibration Verification (Initial [ICV] and continuing [CCV])	ICV: Daily, before sample analysis CCV: Every 12 hours of analysis time and at the end of the analysis sequence	All analytes within ± 15% of expected value from the ICAL	Re-inject CCV – if passes rerun previous 10 samples and continue run; if 2nd CCV fails, recalibrate	TestAmerica Analyst	TA-MV-0376
GC/FID	Initial Calibration (ICAL) – five-point ICAL	Initial calibration prior to sample analysis	Linear mean RSD ≤ 20%	Recalibrate	TestAmerica Analyst	TA-GS-0339
GC/FID	Second Source Calibration Verification	Once after each initial calibration	Value of second source for all analytes within ± 25% of expected value (initial source)	Rerun ICV one time, second failure requires recalibration	TestAmerica Analyst	TA-GS-0339
GC/FID	Calibration Verification (Initial [ICV] and continuing [CCV])	ICV: Daily, before sample analysis CCV: Every 12 hours of analysis time and at the end of the analysis sequence	All analytes within ± 15% of expected value from the ICAL	Re-inject CCV; if passes rerun previous 10 samples and continue run; if 2nd CCV fails, recalibrate	TestAmerica Analyst	TA-GS-0339
ICP/MS	Initial Calibration (ICAL) – minimum one high standard and a calibration blank	Daily initial calibration prior to sample analysis	3 standards and a blank. Correlation Coefficient of ≥ 0.998	Recalibrate	TestAmerica Analyst	ST-MT-0001
ICP/MS	Second Source Calibration Verification (ICV)	Once after each initial calibration, prior to sample analysis	Value of second source for all analyte(s) within ± 10% of expected	Recalibrate	TestAmerica Analyst	ST-MT-0001
ICP/MS	Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence	All analytes within + 10% of expected value	Recalibrate – rerun 10 samples previous to failed CCV.	TestAmerica Analyst	ST-MT-0001

SAP Worksheet #24 – Analytical Instrument Calibration Table (Continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference [a]
CVAA	Initial Calibration (ICAL)	Daily initial calibration prior to sample analysis	Correlation coefficient R>=0.995 for linear regression	Recalibrate	TestAmerica Analyst	ST-MT-0007
CVAA	Second Source Calibration Verification (ICV)	Once after each initial calibration, prior to sample analysis	Value of second source for all analyte(s) within ± 10% of expected value (second source)	Recalibrate	TestAmerica Analyst	ST-MT-0007
CVAA	Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence.	All analytes within + 20% of expected value	Recalibrate – rerun 10 samples previous to failed CCV.	TestAmerica Analyst	ST-MT-0007
Spectrophotometer	Initial Calibration (ICAL)	Daily initial calibration prior to sample analysis	Correlation coefficient R>=0.995 for linear regression	Recalibrate	TestAmerica Analyst	WS-WC-0020
Spectrophotometer	Second Source Calibration Verification (ICV)	Once after each initial calibration, prior to sample analysis	All analytes within ± 10% of expected value	Recalibrate	TestAmerica Analyst	WS-WC-0020
Spectrophotometer	Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence.	All analytes within ± 10% of expected value; value of second source for all analyte(s) within ± 10% of expected value (second source)	Recalibrate – rerun 10 samples previous to failed CCV.	TestAmerica Analyst	WS-WC-0020

Notes:

[a] Analytical SOP revision number listed is current as of the date this SAP was published.

SAP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
Gamma Spectrometer	1. Clean cave; fill dewar with N_2 2. QA check	1. Physical check 2. Background and source check	1. Physical check 2. Check deviation	1. Weekly 2. Daily	1. Acceptable background 2. Within 3 sigma of measured population	• Recalibrate • Instrument maintenance • Consult with Technical Director	TestAmerica Group Leader / Analyst	HPS SOPs Section 3.3
Gas Flow Proportional Counter	1. Clean instrument 2. Inspect windows 3. QA check	1. Physical check 2. Physical check 3. Background and source count	1. Physical check 2. Physical check 3. Check deviation	1. Daily 2. High counts and/or background 3. Daily	1. None applicable 2. No physical defects 3. Within 3 sigma of 20 day population	• Recalibrate • Instrument maintenance • Consult with Technical Director	TestAmerica Group Leader / Analyst	RL-GPC-010
GC/MS GC ICP/MS CVAA Spectrophoto-meter	Parameter Setup	Physical check	Physical check	Initially; prior to DCC	Predetermined optimum parameter settings	Reset if incorrect	TestAmerica Analyst	ST-MS-0002, ST-MS-0001, ST-GC-0016, ST-GC-0015, TA-MV-0376, TA-GS-0339, ST-MT-0001, ST-MT-0007,WS-WC-0020
GC/MS	Tune Check	Instrument Performance	Conformance to instrument tuning	Initially; prior to DCC	Compliance to ion abundance criteria	Repeat tune check to rule out standard degradation or inaccurate injection. If problem persists, retune the instrument and repeat tune check.	TestAmerica Analyst	ST-MS-0002, ST-MS-0001

SAP Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table (Continued)

Instrument Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
ICP/MS	ICS	Instrument Performance	Conformance to interference check	Prior to sample analysis	Within + 20% of expected value	Terminate analysis, reanalyze ICS to rule out standard degradation or inaccurate injection. If problem persists, perform instrument maintenance, repeat calibrations, and reanalyze all associated samples.	TestAmerica Analyst	ST-MT-0001
ICP/MS	ICB/CCB	Instrument Performance	Instrument contamination check	After every calibration verification	ICB: No analytes detected > LOQ; CCB: no analyte detected > 3X DL	Determine possible source of contamination and apply appropriate measure to correct the problem. Reanalyze calibration blank and all associated samples.	TestAmerica Analyst	ST-MT-0001
CVAA	ICB/CCB	Instrument Performance	Instrument contamination check	After every calibration verification	No analytes detected > LOQ	Determine possible source of contamination and apply appropriate measure to correct the problem. Reanalyze calibration blank and all associated samples.	TestAmerica Analyst	ST-MT-0007

Notes:

[a] Analytical SOP revision number listed is current as of the date this SAP was published.

SAP Worksheet #26 – Sample Handling System

Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Sampler / TtEC
Sample Packaging (Personnel/Organization): Sampler / TtEC
Coordination of Shipment (Personnel/Organization): Sampler / TtEC
Type of Shipment/Carrier: Courier or FedEx®
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodian / TestAmerica
Sample Custody and Storage (Personnel/Organization): Sample Custodian / TestAmerica
Sample Preparation (Personnel/Organization): Sample preparation personnel / TestAmerica
Sample Determinative Analysis (Personnel/Organization): Analyst / TestAmerica
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 90 calendar days
Sample Extract/Digestate Storage (No. of days from extraction/digestion): Not applicable
Biological Sample Storage (No. of days from sample collection): Not applicable
SAMPLE DISPOSAL/ARCHIVE
Personnel/Organization: Sample Custodian / TestAmerica
Number of Days from Analysis: Radiological soil samples submitted for analysis shall be returned to the project site as requested for archiving and disposition. Chemical samples submitted for analysis shall be held for up to 90 calendar days after sample collection, at which time the samples will be disposed of by the laboratory.

This page intentionally left blank.

SAP Worksheet #27 – Sample Custody Requirements Table

An overriding consideration for data resulting from laboratory analyses is the ability to demonstrate that the data are legally defensible, i.e., that the samples were obtained from the locations stated and that they reached the laboratory without alteration. To accomplish this, evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal will be documented through the COC record. A sample is considered to be in custody if the following conditions have been observed:

- In actual possession or in view of the person who collected the samples
- Locked in a secure area
- Placed in an area restricted to authorized personnel
- Placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal

Appendix B presents an example of the COC record. The COC record lists each sample and the individuals performing the sample collection, shipment, and receipt. Appendix B presents an example of a custody seal that will seal samples and the cooler during transportation to the laboratory.

The COC record will be the controlling document to ensure that the sample custody is maintained. Each time the sample custody is transferred, the former custodian will sign the COC on the _Relinquished By_ line, and the new custodian will sign the COC on the _Received By_ line. The date, time, and project or company affiliation will accompany each signature. When FedEx is used to ship samples to the laboratory, the waybill number and courier name will be recorded on the COC. The shipping container will be secured with two custody seals, thereby allowing for custody to be maintained by the shipping personnel until receipt by the laboratory.

Sample custody will be the responsibility of sampling personnel from the time of sample collection until the samples are accepted by the laboratory. Thereafter, the laboratory performing the analysis will maintain custody. The sample custodian will sign the COC, inventory each shipment, and note on the original COC record any discrepancy in the sample custody, temperature of the cooler for chemical samples, or broken sample containers. The laboratory will also note any discrepancies and notify the Project Chemist. The laboratory will have a system for tracking samples consistent with Section 5.8 of the Quality Systems Manual (QSM) (DoD 2010). Radiological soil samples submitted for analysis shall be returned to the project site as requested for archiving and disposition. Chemical samples submitted for analysis shall be held for up to 90 calendar days after sample collection, at which time the samples will be disposed of by the laboratory.

In addition to providing a custody exchange record for the samples, the COC record serves as a formal request for sample analyses. The COC records will be completed, signed, and distributed as follows:

SAP Worksheet #27 – Sample Custody Requirements Table (Continued)

- One copy retained on-site for inclusion in the project files
- A copy faxed/e-mailed to the Project Chemist on a daily basis to allow tracking of samples sent to the laboratory to confirm laboratory receipt of samples

SAMPLE NUMBERING

Samples will be uniquely designated using a numbering system that identifies the CTO number and a sequential number (refer to Worksheet #18). The sample number will be recorded in the field logbook, on the labels, and in the COC record at the time of sample collection. A complete description of the sample and sampling conditions will be recorded in the field logbook and referenced using the unique sample identification number.

SAMPLE PACKAGING

Immediately after sample labeling, custody seals will be affixed to each sample container except containers for radiological analysis. Each container will be placed in double-resealable plastic bags to protect the samples from moisture. Samples to be shipped by commercial carrier will be packed in a sturdy container. Preservation is not required for radiological samples. The COC record will include the air bill number, and the "Received By" box will be labeled with the commercial courier's name. The COC record will be sealed in a double-resealable bag and then taped to the inside of the sample cooler lid. The cooler will be taped shut with strapping tape. Two custody seals will be taped across the cooler lid: one seal in the front and one seal in the back. Clear tape will be applied to the custody seals to prevent accidental breakage during shipment. The pouch for the air bill will be placed on the cooler and secured with clear tape.

The air bill will be completed for priority overnight delivery and placed in the pouch. If multiple coolers are being shipped, the original air bill will be placed on the cooler with the COC record, and copies of the air bill will be placed on the other coolers. The number of packages should be included on each air bill (1 of 2, 2 of 2). Saturday deliveries, if required, should be coordinated with the laboratory in advance, and field sampling personnel or their designee must ensure that Saturday delivery stickers are placed on each cooler by the commercial courier. "Dangerous goods" declarations will also be completed as applicable.

SAP Worksheet #28 – Laboratory QC Samples Table – Soil

Matrix: Soil
Analytical Group: Cs-137 and Ra-226
Analytical Method/SOP Reference [a]: EPA 901.1 MOD / HPS SOPs Section 3.3 (Curtis and Tompkins)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Background Sample	Daily	Absolute value < MDA	[b]	Curtis and Tompkins Analyst	Accuracy	Absolute value < MDA
LCS	Weekly Weekly and may be performed 1 per preparatory batch (defined as ≤ 20 samples) for FSS samples	Gamma source check ± 20% of known activity Prepared LCS within 13 ± 6 pCi/g for radium-226	[c]	Curtis and Tompkins Analyst	Accuracy	Gamma source check ± 20% of known activity Prepared LCS within 13 ± 6 pCi/g for radium-226
Sample Duplicate	1 per preparatory batch (defined as ≤ 20 samples)	RPD ≤40% or RER ≤1	[d]	Curtis and Tompkins Analyst	Precision	RPD ≤40% or RER ≤1

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: Sr-90
Analytical Method/SOP Reference [a]: EPA 905 MOD/DOE SR-01-RC MOD/ DOE SR-02-RC MOD/SOP RL-GPC-010 (TestAmerica-Richland)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < MDA	[b]	TestAmerica Analyst	Accuracy	Analytes < MDA
LCS and/or LCD	1 per preparatory batch	70–125% RPD ≤35% and/or RER ≤3	[c]	TestAmerica Analyst	Accuracy	70–125% RPD ≤35% and/or RER ≤3
Carriers	Per sample, blank, LCS, MS, MSD	Sr and Yt carriers: 20–115%	[e]	TestAmerica Analyst	Accuracy	Sr and Yt carriers: 20–115%
Sample Duplicate	1 per preparatory batch	RPD ≤35% and/or RER ≤3	[d]	TestAmerica Analyst	Accuracy	RPD ≤35% and/or RER ≤3

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: VOCs
Analytical Method/SOP Reference [a]: EPA 8260C/SOP ST-MS-0002 (TestAmerica-St. Louis)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < ½ LOQ	[b]	TestAmerica Analyst	Accuracy	Analytes < ½ LOQ
LCS and/or LCSD	1 per preparatory batch	Benzene: 75–125% Toluene: 70–125% Trichloroethene: 75–125% RPD ≤ 30	[c]	TestAmerica Analyst	Accuracy	Benzene: 75–125% Toluene: 70–125% Trichloroethene: 75–125% RPD ≤ 30
MS/MSD	1 per preparatory batch per matrix	Benzene: 75–125% Toluene: 70–125% Trichloroethene: 75–125% RPD ≤ 30	[f]	TestAmerica Analyst	Accuracy/ Precision	Benzene: 75–125% Toluene: 70–125% Trichloroethene: 75–125% RPD ≤ 30
Surrogate	Per all field and QC samples	1,2-Dichloroethane-d_4: 71-128% 4-Bromofluorobenzene: 85–120% Toluene-d_8: 85–115%	[g]	TestAmerica Analyst	Accuracy	1,2-Dichloroethane-d_4: 71-128% 4-Bromofluorobenzene: 85–120% Toluene-d_8: 85–115%

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: SVOCs
Analytical Method/SOP Reference [a]: EPA 8270D/SOP ST-MS-0001 (TestAmerica-St. Louis)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < ½ LOQ	[b]	TestAmerica Analyst	Accuracy	Analytes < ½ LOQ
LCS and/or LCSD	1 per preparatory batch	Benzo(a)pyrene 50–110% Naphthalene 40–105% RPD ≤ 30	[c]	TestAmerica Analyst	Accuracy	Benzo(a)pyrene 50–110% Naphthalene 40–105% RPD ≤ 30
MS/MSD	1 per preparatory batch per matrix	Benzo(a)pyrene 50–110% Naphthalene 40–105% RPD ≤ 30	[f]	TestAmerica Analyst	Accuracy/ Precision	Benzo(a)pyrene 50–110% Naphthalene 40–105% RPD ≤ 30
Surrogate	Per all field and QC samples	2,4,6-Tribromophenol 35–125%	[g]	TestAmerica Analyst	Accuracy	2,4,6-Tribromophenol 35–125%

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: Pesticides
Analytical Method/SOP Reference [a]: EPA 8081B/SOP ST-GC-0016 (TestAmerica-St. Louis)

QC Sample	Frequency / Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < ½ LOQ	[b]	TestAmerica Analyst	Accuracy	Analytes < ½ LOQ
LCS and/or LCSD	1 per preparatory batch	4,4′-DDT 45–140% Gamma–BHC (Lindane) 60–125% RPD ≤ 30	[c]	TestAmerica Analyst	Accuracy	4,4′-DDT 45–140% Gamma–BHC (Lindane) 60–125% RPD ≤ 30
MS/MSD	1 per preparatory batch per matrix	4,4′-DDT 45–140% Gamma–BHC (Lindane) 60–125% RPD ≤ 30	[f]	TestAmerica Analyst	Accuracy/ Precision	4,4′-DDT 45–140% Gamma–BHC (Lindane) 60–125% RPD ≤ 30
Surrogate	Per all field and QC samples	Decachlorobiphenyl 55–130% Tetrachloro-m-xylene (TCMX) 70–125%	[g]	TestAmerica Analyst	Accuracy	Decachlorobiphenyl 55–130% Tetrachloro-m-xylene (TCMX) 70–125%

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: PCBs
Analytical Method/SOP Reference [a]: EPA 8082A/SOP ST-GC-0015 (TestAmerica-St. Louis)

QC Sample	Frequency / Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < ½ LOQ	[b]	TestAmerica Analyst	Accuracy	Analytes < ½ LOQ
LCS and/or LCSD	1 per preparatory batch	Aroclor 1016 40–140% Aroclor 1260 60–130% RPD ≤ 30	[c]	TestAmerica Analyst	Accuracy	Aroclor 1016 40–140% Aroclor 1260 60–130% RPD ≤ 30
MS/MSD	1 per preparatory batch per matrix	Aroclor 1016 40–140% Aroclor 1260 60–130% RPD ≤ 30	[f]	TestAmerica Analyst	Accuracy/ Precision	Aroclor 1016 40–140% Aroclor 1260 60–130% RPD ≤ 30
Surrogate	Per all field and QC samples	Decachlorobiphenyl 60–125%	[g]	TestAmerica Analyst	Accuracy	Decachlorobiphenyl 60–125%

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: TPH
Analytical Method/SOP Reference [a]: NWTPH-Gx and NWTPH-Dx/SOP TA-MV-0376 and TA-GS-0339 (TestAmerica-Tacoma)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < ½ LOQ	[b]	TestAmerica Analyst	Accuracy	Analytes < ½ LOQ
LCS and/or LCSD	1 per preparatory batch	68–120% RPD ≤ 25	[c]	TestAmerica Analyst	Accuracy	68–120% RPD ≤ 25
MS/MSD	1 per preparatory batch per matrix	50–150% RPD ≤ 50	[f]	TestAmerica Analyst	Accuracy/ Precision	50–150% RPD ≤ 50
Surrogate	Per all field and QC samples	4-Bromofluorobenzene: 50–150%	[g]	TestAmerica Analyst	Accuracy	4-Bromofluorobenzene: 50–150%

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: Metals including mercury
Analytical Method/SOP Reference [a]: EPA 6020A and 7471B/SOP ST-MT-0001 and SOP ST-MT-0007 (TestAmerica-St. Louis)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < ½ LOQ	[b]	TestAmerica Analyst	Accuracy	Analytes < ½ LOQ
Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence	No analytes detected > 2 × DL	[b]	TestAmerica Analyst	Accuracy	No analytes detected > 2 × DL
LCS and/or LCSD	1 per preparatory batch	80–120% RPD ≤ 20	[c]	TestAmerica Analyst	Accuracy	80–120% RPD ≤ 20
MS/MSD	1 per preparatory batch per matrix	80–120% RPD ≤ 20	[f]	TestAmerica Analyst	Accuracy/ Precision	80–120% RPD ≤ 20
Serial dilution	Each new sample matrix	1:5 dilution must agree within ±10% of original determination.	[h]	TestAmerica Analyst	Accuracy	1:5 dilution must agree within ±10% of original determination.
Post-digestion spike	When serial dilution or matrix spike fails	80–120%	[i]	TestAmerica Analyst	Accuracy	80–120%

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Matrix: Soil
Analytical Group: Hexavalent chromium
Analytical Method/SOP Reference [a]: EPA 7196A/SOP WS-WC-0020 (TestAmerica-West Sacramento)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per preparatory batch	Analytes < ½ LOQ	[b]	TestAmerica Analyst	Accuracy	Analytes < ½ LOQ
Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence	No analytes detected > 2 × DL	[b]	TestAmerica Analyst	Accuracy	No analytes detected > 2 × DL
LCS and/or LCSD	1 per preparatory batch	85–115% RPD ≤ 30	[c]	TestAmerica Analyst	Accuracy	85–115% RPD ≤ 30
MS/MSD	1 per preparatory batch per matrix	85–115% RPD ≤ 30	[f]	TestAmerica Analyst	Accuracy/ Precision	85–115% RPD ≤ 30

SAP Worksheet #28 – Laboratory QC Samples Table – Soil (Continued)

Notes:

[a] Analytical SOP revision numbers listed are current as of the date this SAP was published.

[b] Any sample associated with a blank that fails the criteria checks will be reprocessed in a subsequent preparation batch, except when the sample analysis resulted in a non-detect. If no sample volume remains for reprocessing, the results will be reported with appropriate data qualifying codes.

[c] Reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.

[d] Reprep and reanalyze the sample and duplicate in the associated preparatory batch for failed analytes if sufficient sample material is available and the sample is homogeneous. If RPD/RER still out of range, report as matrix interference confirmed and write a nonconformance. If reanalysis is in range, re-extract samples in batch.

[e] Truncate carriers/tracers above 100% recovery to eliminate low biased results. Reprep and reanalyze sample if carrier is low (indicating high biased results) if there is activity in the sample above the reporting limit. No reanalysis if matrix interference is nonconformance during sample preparation.

[f] The data will be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.

[g] Reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available.

[h] Perform post-digestion spike addition if serial dilution does not meet criteria.

[i] Reanalyze post-digestion spike.

SAP Worksheet #29 – Project Documents and Records Table

Document	Where Maintained
Work Plan and associated plans including SAP and Health and Safety Plan	Project file; NAVFAC NW Administrative Record
Field logbook	Project file
Field forms	Project file
COC	Laboratory; NAVFAC NW Administrative Record
Shipping records	Project file
Field surveillance reports	Project file
Field Change Requests	Project file
Laboratory data package including: • Copy of chain of custody • Sample receipt and login • Laboratory internal chain of custody • Instrument calibration information • Chromatograms as applicable • Sample preparation logs • Sample analysis/run logs • Nonconformance Reports including corrective actions • Laboratory signed review page	Laboratory and project file; project file copy will subsequently be sent to NAVFAC NW Administrative Record
Data validation report	Validator and project file; project file copy will subsequently be sent to NAVFAC NW Administrative Record

SAP Worksheet #29 – Project Documents and Records Table (Continued)

Field documentation associated with sampling activities includes logbooks, sample labels, COCs, sample shipping records, field surveillance reports, and FCR forms. In addition, laboratory and validator documentation will be generated during this project. These types are described in the following sections.

Field Logbook

A permanently bound field logbook with consecutively numbered pages, used for sampling activities only, will be assigned to this project. All entries will be recorded in indelible black or blue ink. At the end of each work day, the logbook pages will be signed by the responsible sampler, and any unused portions of the logbook pages will be crossed out, signed, and dated. If it is necessary to transfer the logbook to another person, the person relinquishing the logbook will sign and date the last page used, and the person receiving the logbook will sign and date the next page to be used. At a minimum, the logbook will contain the following information:

- Project name and site location
- Date and time
- Personnel in attendance
- General weather information
- Work performed
- Field observations
- Sampling performed, including specifics such as location, type of sample, type of analyses, and sample identification
- Field analyses performed, including results, instrument checks, problems, and calibration records for field instruments
- Descriptions of deviations from this SAP
- Problems encountered and corrective action taken
- Identification of field QC samples
- QC activities
- Verbal or written instructions
- Any other events that may affect the samples

Sample Labels

Sample labels will be filled out in indelible black or blue ink and affixed to sample containers at the time of sample collection. An example sample label is provided in Appendix B. Each sample label will be covered with clear tape. Each sample container will be labeled with the following, at a minimum:

SAP Worksheet #29 – Project Documents and Records Table (Continued)

- Sample identification number
- Sample collection date (month/day/year)
- Time of collection (24-hour clock) from the start of sampling
- Sampler's initials
- Preservative (if any)
- Sample weight (data completed by laboratory)

Chain of Custody

COC information is described in Worksheet #27.

Sample Shipping Records

Samples will be transported to the laboratory via FedEx. For samples shipped via FedEx, the COC will be packaged within the cooler, and the sender's copy of the airbill will serve as custody documentation and will be maintained on-site in the project file. Sample shipping procedures are detailed in Worksheet #27.

Field Surveillance Reports

Field Surveillances will be performed in accordance with the three phases of inspection as required by the QC Program. A Preparatory Inspection will be performed by the PQCM prior to the first sampling activities. This will include a general orientation for health and safety. An Initial Inspection will be conducted at the beginning of field sampling activities for project. Daily field inspections and subsequent surveillances will be performed at the discretion of the PQCM or the Quality Control Program Manager (QCPM) throughout the duration of the project. The PQCM will use the Initial Inspection Checklist during inspection.

Field Change Request

An FCR will be prepared by the Program Chemist, or a designee, if a change to the SAP occurs during sampling activities. These changes will be minor and not result in a change in scope and/or DQOs for this project. The FCR must be approved prior to field implementation. The FCR may include the revised worksheets from this SAP.

Changes to work scope affecting the original DQOs will be approved by the Program Chemist, QCPM, PjM, and RPM. The change must be approved before the sampling and analysis are concluded.

Laboratory Documentation

Laboratory data packages will include the following at a minimum:

- Sample receipt and login
- Laboratory internal COC

SAP Worksheet #29 – Project Documents and Records Table (Continued)

- Instrument calibration logs
- Sample preparation logs
- Sample analysis/run logs
- Sample results case narrative
- Sample disposal records
- Nonconformance reports including corrective actions

The laboratory will prepare analytical data packages comprising the above documentation for each sample delivery group (SDG) and provide them to TtEC. Laboratory deliverables will include a copy of the hard copy data package, submitted as either EPA Level III- or IV-equivalent packages as specified on the COC. Detailed information on the requirement of hard copy data packages is provided below. The report pages will be sequentially numbered. The report will contain a table of contents referencing individual sections in the data package, the original copy of COC records, a copy of all corrective action reports, and a narrative documenting the resolution of all corrective actions and nonconformances. All samples will be cross-referenced to the associated QC samples. The packages will be assembled in the following sequence:

- Cover page (with laboratory name, address, phone number, contact person, and SDG number, as well as the project name and project number)
- Table of contents
- Case narrative
- Sample management records, including the original, white copy of COC records (including cooler temperature and sample condition), shipping documents, and laboratory sample receipt forms
- Cross-reference table
- Analytical results and quality assurance (QA)/QC information by test as follows:
  - <u>Radiological raw data sequence</u>
    a. Sample results forms, including method blanks
    b. Sample raw data (EPA Level IV only)
    c. QC summaries
    d. Initial calibration (ICAL)
    e. Calibration checks, including all related continuing calibration verifications
    f. Instrument run log
    g. Sample preparation log

SAP Worksheet #29 – Project Documents and Records Table (Continued)

All relevant laboratory raw data and documentation including, but not limited to, logbook, data sheets, electronic files, and reports, will be maintained by the laboratory for at least 5 years. TtEC must be notified 30 days before disposal of any relevant records.

In addition to the hard copy data, an EDD will be submitted by the laboratory in a format compatible with TtEC requirements. Both the EDDs and the hard copy report will present results to two or three significant figures. For radiological results, at least three significant figures will be used for all results. Results for QC analyses (method blanks, MS/MSD, LCS, and duplicates) will be reported up to three significant figures.

When revisions to laboratory data reports are required, the revised pages (an original and copy) will be stamped with the notation "amended or revised report." If revisions affect the laboratory EDDs, the revised EDD will then be sent along with the revised hard copy pages. In addition, a hard copy or electronic copy of items submitted to the validator by the laboratory will also be submitted to the Project Chemist.

Data Validation Reports

Analytical data generated by the laboratory will be validated by an independent data validation company. The validation report will include the data validation findings worksheets. The reports will be arranged in increasing SDG numbers and grouped by the type of analysis; i.e., a group of reports will consist of SDGs with the same analysis arranged in increasing numerical order. Each SDG will be submitted as a separate data validation report. Reports covering multiple SDGs are not acceptable.

The validation reports will contain the following information:

- Title page that contains project name, sample collection date, validator subcontractor name, report date, type of analysis, laboratory, SDG, sample identifications (including MS/MSD, duplicate, reanalysis, or dilution samples), sample matrix (e.g., soil, water), and validation level (EPA Level III or IV).
- Introduction page that includes the number of samples per matrix, analytical method reference, validation guideline reference, and section references to summary qualification flags, and denotes QC samples. Statements regarding flag classification (protocol/advisory) and whether raw data check was performed will also be included.
- Section headings for each analytical method will include the following:
  - Technical holding times
  - Calibration
  - Laboratory blanks
  - Accuracy and precision data
  - Target compound identification
  - System performance checks
  - Analyte quantitation and quantitation limits (QLs)

SAP Worksheet #29 – Project Documents and Records Table (Continued)

  - Field QC samples (if not applicable, report will note)
  - Overall assessment of data
  - Assessment of compliance with statement of work requirements

- QC deviation summaries, which will include in a tabular format the following:
  - Unique identification of QC run (e.g., date/time)
  - Associated project and sample numbers (not the laboratory internal sample IDs)
  - Associated constituents
  - Actual value for noted deviation
  - Applicable QC criteria
  - Applicable qualifiers
  - Qualifier classifications (advisory or protocol)

- Validation findings worksheets
- Qualifier classification

Any revisions will be submitted within 1 week of receiving the review comments from the Project Chemist. Report revision submittal packages will include a cover page and revised pages.

In addition to a hard-copy report, the validator will receive the EDD and populate the final validation qualifiers in the EDD. The validated EDD will be returned to TtEC for upload into the database.

The data validation subcontractor will maintain validation records for at least 5 years. TtEC will be notified 30 days before disposal of any records.

SAP Worksheet #30 – Analytical Services Table

Matrix	Analytical Group	Sampling Locations/ ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/ Organization (contact information)	Backup Laboratory/ Organization (contact information)
Soil	Cs-137 and Ra-226	All	EPA 901.1 MOD	30 business days	Curtis and Tompkins Contact: Mr. Phil Smith 201A & 201B Fisher Avenue San Francisco, CA 94124 (415) 216-2768	TestAmerica Laboratory Contact: Erika Starman 13715 Rider Trail North Earth City, MO 63045 (314) 298-8566
Soil	Sr-90, VOCs, SVOCs, pesticides, PCBs, TPH, metals including mercury, hexavalent chromium	All	See Worksheet #19	30 business days	TestAmerica Laboratory Contact: Erika Starman 13715 Rider Trail North Earth City, MO 63045 (314) 298-8566	GEL Contact: Tasha Horton 2040 Savage Road Charleston, SC 29407 (843) 556-8171

SAP Worksheet #30 – Analytical Services Table (Continued)

The following sections describe analytical laboratory requirements, including qualifications, sample custody, and QC procedures.

Laboratory Qualifications

Curtis and Tompkins and TestAmerica have been selected to analyze samples for this project as indicated in Worksheet #23. Samples for TestAmerica will be sent to their St. Louis facility, and analyses will be subcontracted out to their Richland, Tacoma, and West Sacramento facilities as indicated in Worksheet #23. Curtis and Tompkins and the TestAmerica laboratories have successfully completed the DoD Environmental Laboratory Accreditation Program certification for the applicable methods listed in Worksheet #23 and will maintain current status throughout the duration of this project. These laboratories are also certified for those methods by the Washington State Deparment of Ecology.

The laboratories selected for this project must be capable of providing the project QC and data deliverables required by this SAP.

The laboratories must be capable of meeting all the requirements listed in this SAP including turnaround time, minimum detectable activity (MDA) requirements or QLs, QC criteria, data deliverables, and requirements in the Navy Installation Restoration Chemical Data Quality Manual (IRCDQM) (NFESC 1999), and the QSM for Environmental Laboratories (DoD 2010).

Laboratory Sample Custody and Documentation

The integrity and traceability of samples from the time they are collected through the time data are reported are essential in any sampling and analysis program. The handling of the samples and transferring of custody must be well-documented given the evidentiary nature of the analytical data. A sample is considered to be in one's custody if it meets any of the following criteria:

1. In actual possession or in view of the person who collected the sample
2. Locked in a secure area
3. Placed in an area restricted to authorized personnel
4. Placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal

The samples will be delivered to the person in the laboratory authorized to receive samples (referred to as the sample custodian). Upon receipt of a sample, the sample custodian will inspect the condition of the sample (including the temperature of the cooler as applicable) and the custody seal, reconcile the information on the sample label against that on the COC record, assign a unique laboratory tracking number, log the sample in the laboratory logbook, and store the sample in a secured sample storage room.

SAP Worksheet #30 – Analytical Services Table (Continued)

The TtEC Project Chemist will be informed immediately of any inconsistencies between the COC record and the sample containers received. Any deviations from accepted sample handling procedures will be documented, and the TtEC Project Chemist will be informed.

The laboratory will have a system for tracking samples that is consistent with Section 5.8 of the QSM (DoD 2010). The laboratory will archive the samples and maintain their custody up to 90 calendar days after sample collection, at which time the laboratory will contact TtEC for shipment of the samples back into the custody of TtEC.

Laboratory Quality Control Requirements

The laboratories will have written SOPs defining the instrument operation and maintenance, tuning, calibration, detection limit (DL) determination, QC acceptance criteria, blank requirements, and stepwise procedures for each analytical method. At a minimum, SOPs will be written for procedures and methods including sample receipt/control/disposal, sample preparation/extraction, sample analysis, result calculation, database management, health and safety, and corrective action. The SOPs, and all revisions, will be available to the analysts in the laboratory. The SOPs must meet the requirements of the analytical methods, the IRCDQM (NFESC 1999), and the QSM (DoD 2010), which defines the frequency, acceptance criteria, and corrective action.

The laboratory must also maintain written records of all activities that have an impact on the quality of the laboratory results.

Any portion of the method subcontracted by the laboratory to another laboratory or sent to another facility of the same network of laboratories must have the prior approval of the Project Chemist unless otherwise identified in Worksheet #23.

Laboratory Quality Control Checks

The following subsections describe in detail the laboratory QC checks required by this project.

Calibration

All instruments will be calibrated and the calibration acceptance criteria met before samples are analyzed. Calibration standards will be prepared with National Institute of Standards and Technology (NIST)-traceable standards and analyzed per method requirements. ICAL acceptance criteria documented in the laboratory SOPs will meet those of applicable guidance documents. The ICAL will meet the following requirements:

- The lowest concentration of the calibration standard is less than or equal to the QLs based on the final volume of extract or sample.
- For gamma spectroscopy analysis, the calibration standard covers a wide array of energies, and the total sample activity contains approximately 1 microcurie of

SAP Worksheet #30 – Analytical Services Table (Continued)

activity. The gamma spectroscopy standard will be of similar density and material to the samples being analyzed by this method. The typical calibration standard for gamma spectroscopy will utilize short-lived radionuclides that decay in as few as 90 days—therefore the standard will only be used for control checks and calibration for 1 year from date of certification.

- For each target analyte, at least one of the calibration standards will be at or below the regulatory limit (action level), as defined by the DQOs.
- Before samples are analyzed, ICAL will be verified with a second source standard prepared at the mid-point of the calibration curve. ICAL verification will meet the acceptance criteria expressed in the laboratory SOPs.
- Daily calibration verification will be conducted at the method-prescribed frequencies and will meet the acceptance criteria of applicable guidance documents. Daily calibration verification will not be used for quantitation of target analytes.
- Calibration data (calibration tables, chromatograms, instrument printouts, and laboratory logbooks) will be clearly labeled to identify the source and preparation of the calibration standard and therefore be traceable to the standard preparation records.

Instrument Blanks

An instrument blank is used to monitor the cleanliness of the instrument system during sample analysis. Instrument blanks are treated in the same manner as samples.

Laboratory Control Samples

Laboratory control samples are matrix-equivalent QC check samples (analyte-free water, laboratory sand, or sodium sulfate) spiked with a known quantity of specific analytes carried through the entire sample preparation and analysis process. The spiking solution used for LCS/ laboratory control sample duplicate (LCSD) preparation is of a source different from the stock used to prepare calibration standards.

The LCS is prepared and run at a frequency of 1 per 20 project samples per matrix with the associated samples, using the same reagents and volumes. If insufficient quantity of sample is available, the LCS will be prepared and analyzed in duplicates.

Laboratory Duplicates

For laboratory sample duplicate analyses, a sample is prepared and analyzed twice. Laboratory sample duplicates are prepared and analyzed with each batch of samples for most inorganic analyses. For this project, a laboratory duplicate will be prepared and analyzed for the laboratory for each batch of samples, defined as 20 samples or less.

SAP Worksheet #30 – Analytical Services Table (Continued)

Preventive Maintenance

All instruments must be maintained in accordance with the manufacturers' recommended procedures. The laboratory must define in its QA plan the frequency and type of maintenance for each instrument. The laboratory must also record all maintenance activities in an instrument logbook. The laboratory must maintain the instruments in working condition required by the methods specified for the analyses. Sufficient redundancy in equipment must be available in the laboratory to handle downtime situations. Method substitution because of instrumental failure will not be permitted without approval from the Project Chemist.

In addition to preventive maintenance, the laboratory must keep a sufficient supply of replacement parts on hand for those parts known to require frequent changes due to wear and tear or contamination. Whenever preventive or corrective maintenance is applied to an instrument, the laboratory must demonstrate the instrument's return to operating conditions and must recalibrate the instrument prior to resumption of sample analyses.

Definition of Detection and Quantitation Limits

MDA: From Multi-Agency Radiological Laboratory Analytical Protocols, the MDA can be calculated as a sample-specific value. Typically, these values assumed both a Type I (α) and Type II (β) error of 5 percent. However, for samples analyzed at the laboratory, the project will utilize the DL in calculations regarding MDA for gamma spectroscopy results. For purposes of and in discussions regarding gamma spectroscopy, any use of the term "MDA" will specifically describe the sample-specific DL.

This page intentionally left blank.

SAP Worksheet #31 – Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of Corrective Actions (Title and Organizational Affiliation)
Operational Readiness Review	Prior to mobilization of the project and prior to initiating major phases of work	Internal	TtEC	Project Manager, TtEC	Project Manager, TtEC	Project Manager, TtEC	PQCM, TtEC
Field Sampling Surveillance (conducted during sampling)	At a minimum, once at the beginning, once during, and once toward the end of the project	Internal	TtEC	PQCM, TtEC	Project Manager, TtEC	Project Manager, TtEC	Project Manager and QCPM, TtEC
Scan and Static Data Collection Surveillance	Once every 6 months during project	Internal	TtEC	RSOR, TtEC	RSO, TtEC	RSO, TtEC	Project Manager and RSO, TtEC
Data Review Surveillance	Once every 6 months during project	Internal	TtEC	Program Chemist, TtEC	Project Chemist, TtEC	Program Chemist, TtEC	QCPM, TtEC

This page intentionally left blank.

SAP Worksheet #32 – Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Title and Organizational Affiliation)	Time Frame of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Title and Organizational Affiliation)	Time Frame for Response
Field Sampling Surveillance	Surveillance Report	Project Manager, TtEC	7 days after completion of the inspection	Corrective Action Report	Project Manager and QCPM, TtEC	5 days after notification
Data Review Surveillance	Surveillance Report	QCPM, TtEC	7 days after completion of the inspection	Corrective Action Report	QCPM, TtEC	14 days after notification

This page intentionally left blank.

SAP Worksheet #33 – QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Field Sampling Surveillance Report	Once at the beginning, once during, and once towards the end of field sampling activities	Determined during the project	PQCM, TtEC	Project Manager and QCPM, TtEC
Data Review Surveillance Report	Once after all data are generated and reviewed	Determined during the project	Program Chemist, TtEC	Project Manager and QCPM, TtEC

This page intentionally left blank.

SAP Worksheet #34 – Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Title and Organizational Affiliation)
Field logbook	Field logbooks will be reviewed weekly and verified for information accuracy and completeness. The inspection will be documented in daily QC reports.	I	PQCM, TtEC
COC forms	COC forms will be reviewed daily upon their completion and verified for completeness.	I	PQCM, TtEC Project Chemist, TtEC
Sample receipt	For samples shipped via courier or FedEx, the Project Chemist will verify receipt of samples by the laboratory the day following shipment.	I	Project Chemist, TtEC
Sample logins	Sample login information will be reviewed and verified for accuracy and completeness in accordance with the requirements in this SAP.	I E	Project Chemist, TtEC Laboratory Project Manager, Curtis and Tompkins/TestAmerica
Laboratory data prior to release	Laboratory data will be reviewed to verify that the requirements in this SAP have been met. Prior to release, data will be verified as follows:	E	Laboratory Project Manager, Curtis and Tompkins/TestAmerica
	All data (100 percent) comply with the method- and project-specific requirements and any deviations or failure to meet criteria is documented for the project file.	E	Analyst, Curtis and Tompkins/TestAmerica
	All manual entries (100 percent) are free of transcription errors and manual calculations are accurate; computer calculations are spot-checked to verify program validity; data reported are compliant with method- and project-specific QC requirements; raw data and supporting materials are complete; spectral assignments are confirmed; descriptions of deviations from method or project requirements are documented; significant figures and rounding have been appropriately used; reported values include dilution factors; and results are reasonable.	E	Peer Analyst, Curtis and Tompkins/TestAmerica
	Data reported are compliant with method- and project-specific QC requirements; the reported information is complete; the information in the report narrative is complete and accurate; and results are reasonable.	E	Supervisor, Curtis and Tompkins/TestAmerica

SAP Worksheet #34 – Verification (Step I) Process Table (Continued)

Verification Input	Description	Internal/ External	Responsible for Verification (Title and Organizational Affiliation)
Laboratory data prior to release (Continued)	Data reported are compliant with method- and project-specific QC; analytical methods are performed in compliance with approved SOPs. This review may be conducted after release of data since reviews are Navy-only on 10 percent of the data.	E	Quality Assurance Manager, Curtis and Tompkins/TestAmerica
Laboratory data due at turnaround time listed on COC	Laboratory data will be verified for having been obtained following the protocols in this SAP and being of sufficient quality to satisfy DQOs.	I	Project Chemist, TtEC
Laboratory data packages	All laboratory data packages will be verified by the laboratory performing the work for completeness and technical accuracy prior to submittal. Data packages will then be reviewed by the Project Chemist for accuracy and completeness in accordance with the data package requirements described in Worksheet #29. Subsequently, data packages will be evaluated externally by undergoing third-party data validation as described in Worksheet #36.	E I I	Project Chemist, TtEC
Field and electronic data	One hundred percent of manual entries will be reviewed against the hard-copy information, and 10 percent of electronic uploads will be checked against the hard copy.	I I	Project Chemist, TtEC

SAP Worksheet #35 – Validation (Steps IIa and IIb) Process Table

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Title and Organizational Affiliation)
IIa	Field logbook	Field logbooks will be reviewed weekly for accuracy associated with each sampling event. The inspection will be documented in daily QC reports.	PQCM, TtEC
IIa	COC forms	COC forms will be reviewed daily to ensure that project information, sample analyses requested, number of field QC samples collected, and percent level III or IV validation chosen are accurate and in accordance with the requirements in this SAP.	PQCM, TtEC Project Chemist, TtEC
IIa	Sample receipt	The sample cooler will be checked for compliance with temperature and packaging requirements listed in Worksheet #27 of this SAP.	Laboratory sample custodian, Curtis and Tompkins/TestAmerica
IIa	Sample logins	Sample login will be reviewed for accuracy against the COC form.	Project Chemist, TtEC Laboratory Project Manager, Curtis and Tompkins/TestAmerica
IIa	Laboratory data prior to release	Laboratory data will be reviewed to ensure that the data are accurate and meet the requirements in this SAP. Prior to release, data will be validated as follows:	Laboratory Project Manager, Curtis and Tompkins/TestAmerica
		All data (100 percent) comply with the method- and project-specific requirements and any deviations or failure to meet criteria is documented for the project file.	Laboratory Analyst, Curtis and Tompkins/TestAmerica
		All manual entries (100 percent) are free of transcription errors and manual calculations are accurate; computer calculations are spot-checked to verify program validity; data reported are compliant with method- and project-specific QC requirements; raw data and supporting materials are complete; spectral assignments are confirmed; descriptions of deviations from method or project requirements are documented; significant figures and rounding have been appropriately used; reported values include dilution factors; and results are reasonable.	Laboratory Peer Analyst, Curtis and Tompkins/TestAmerica
		Data reported are compliant with method- and project-specific QC requirements; the reported information is complete; the information in the report narrative is complete and accurate; and results are reasonable.	Laboratory Supervisor, Curtis and Tompkins/TestAmerica
		Data reported are compliant with method- and project-specific QC; analytical methods are performed in compliance with approved SOPs. This review may be conducted after release of data since only 10 percent of the data is reviewed.	Laboratory Quality Assurance Manager, Curtis and Tompkins/TestAmerica

SAP Worksheet #35 – Validation (Steps IIa and IIb) Process Table (Continued)

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Title and Organizational Affiliation)
IIa	Laboratory data due at turnaround time listed on COC	Laboratory data will be reviewed to ensure that the data reported met the analyte list and limits listed in this SAP.	Project Chemist, TtEC
IIa	Laboratory data packages	All laboratory data packages will be validated by the laboratory performing the work for technical accuracy prior to submittal.	Laboratory Project Manager, Curtis and Tompkins/TestAmerica
		Data packages will then be reviewed for accuracy against the laboratory data that was faxed/e-mailed at the turnaround time listed on the COC.	Project Chemist, TtEC
		Data packages will be evaluated externally by undergoing data validation as described in Worksheets #29 and #36.	Third-party data validator, LDC
IIb	Data validation reports	Data validation reports will be reviewed in conjunction with the project DQOs and data usability assessment (Worksheet #37).	Project Chemist, TtEC

SAP Worksheet #36 – Analytical Data Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (Title and Organizational Affiliation)
IIa	Soil/Water	All	In accordance with SOPs listed in Worksheet #23, NAVFAC SW EWI #1, and EPA Level III and IV guidelines	Laboratory Project Manager Curtis and Tompkins/TestAmerica
IIb	Soil/Water	All	In accordance with LDC SOPs, NAVFAC SW EWI #1, and EPA Level III and IV guidelines	Third-party data validator / LDC

The following documents will be used as guidance for validating all data: Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA 540/R-99-008 (EPA 1999); Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, EPA 540-R-04-004 (EPA 2004); Test Methods for Evaluating Solid Waste, Physical Chemical Methods, SW-846, Third Edition and final updates (EPA 1986); QSM (DOD 2010); and the QC criteria specified in this SAP. Currently, there are no standards for data validation of radiological analyses. Therefore, guidance documents on validation of radiological data and modified functional guidelines will be used by the validator.

Data validation will be performed as required by an independent data validation company. For this project, 80 percent of the data will require EPA Level III-equivalent data validation and 20 percent EPA Level IV-equivalent data validation. EPA Level III-equivalent data validation includes the comparison of QC parameters to the appropriate criteria or limits. (QC parameters include holding times, tune, calibration, blanks, spikes, surrogates, and internal standards, as applicable.) EPA Level IV-equivalent data validation includes not only what is performed in a Level III-equivalent validation but also review of raw data and backup documentation (for calibrations, standards, analysis run logs, etc.). This information is used for checking calculations of quantified analytical data during a Level IV-equivalent data validation review.

Data may be qualified as protocol or advisory. Protocol violations are when the laboratory deviates from the referenced analytical methods or the project-specific QLs, QC limits, or QC criteria. Advisory violations are when technical validation criteria have not been met.

Field QC samples will be discussed in the validation reports as follows:

- **Field Duplicates** – Field duplicate identifications will be provided on the COC form for each SDG by TtEC if collected. A section showing relative percent difference (RPD) values will be included to demonstrate field duplicate precision. If the results cannot be calculated, this will be noted in the report.
- **Field Blanks** – Identifications for field blanks, including trip blanks, equipment blanks, and source blanks, will be provided on the COC forms by TtEC. Any analyte detected above the QL in field blanks will be discussed in this section of the report.

This page intentionally left blank.

SAP Worksheet #37 – Usability Assessment

After the analytical data have been reviewed, verified, and validated in accordance with Worksheets #34 to #36, a data quality assessment (DQA) report may be prepared to assess data quality and usability. The DQA will include review of the following:

- Sample collection and analytical methods to verify that these were performed as discussed in Worksheets #14 and #17
- Field QC samples to verify that these were collected in accordance with Worksheet #12
- Project-specific QLs as listed in Worksheet #15 to verify that project-specific remedial goals were met
- DQOs to determine whether they have been achieved by the data collected
- Project-specific data quality indicators for precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters as discussed below

Analytical DQOs as assessed through the PARCC parameters are as follows.

Precision

Precision is the measure of the reproducibility of a set of replicate results or the agreement among repeat observations made under the same conditions. Analytical precision is the measurement of the variability associated with duplicate or replicate analyses. Field duplicate, laboratory duplicate, MSD, and LCSD (if analyzed) samples will be used to assess field and analytical precision. The precision measurement will be determined using the RPD between the duplicate sample results as follows:

RPD = 100 × 2 × (result – duplicate result)/(result + duplicate result)

RER = (result activity – duplicate activity)/(sample uncertainty + duplicate uncertainty) using 2 sigma propogated uncertainty

The RPD limits for laboratory duplicate, MSD, and LCSD are presented in Worksheet #28, and the field duplicate limits are listed in Worksheet #12. Associated samples that do not meet the criteria will be evaluated by the validator.

Accuracy

Accuracy is defined as the nearness of a result or the mean of a set of results to the true or accepted value. Analytical accuracy is measured by comparing the percent recovery (%R) of analytes spiked into a sample against a control limit. Spiked samples (typically from wet chemical analysis and separation processes) include MS, MSD, and LCS analyzed for every batch of up to 20 samples. They serve as a measure of analytical accuracy and surrogate standards added to all samples, blanks, MS, MSD, and LCS analyzed for organic contaminants to

SAP Worksheet #37 – Usability Assessment (Continued)

evaluate the method's accuracy and help to determine matrix interferences. %R is calculated as follows:

$$\%R = 100 \times (\text{spiked sample result - unspiked sample result})/\text{amount of spike added}$$

The laboratory will review the QC samples and surrogate standard recoveries for each analysis to ensure that the %R lies within the control limits listed in Worksheet #28. Otherwise, data will be flagged.

Representativeness

Unlike precision and accuracy, which can be expressed in quantitative terms, representativeness is a qualitative parameter. Representativeness is the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. It is a qualitative parameter that depends on proper design of the sampling program.

Field personnel will be responsible for ensuring that samples are representative of field conditions by collecting and handling samples according to the procedures in this SAP. Errors in sample collection, packaging, preservation, or COC procedures may result in samples being judged non-representative and may form a basis for rejecting the data.

Completeness

Completeness is the percentage of measurements judged to be valid. The completeness goal is to generate a sufficient amount of valid data to meet project needs. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified with a rejected (R) flag. The requirement of completeness is 95 percent for samples and is determined using the following equation:

$$\%\ \text{completeness} = 100 \times (\text{number of valid analyte results/number of possible results})$$

Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another, whether it was generated by a single laboratory or during interlaboratory studies. The use of standardized field and analytical procedures ensures comparability of analytical data.

Sample collection and handling procedures will adhere to EPA-approved protocols. Laboratory procedures will follow standard analytical protocols, use standard units and standardized report formats, follow the calculations as referenced in approved analytical methods, and use a standard statistical approach for QC measurements.

REFERENCES

Argus (Argus Pacific Inc.). 2009a. Radiation Screening, Building 27, Former Sand Point Naval Facility, Seattle, Washington. April 30

_____. 2009b. Radiation Screening, Building 2 and Pump Houses, Former Sand Point Naval Facility, Seattle, Washington. May 28.

DoD (Department of Defense). 2010. Quality Systems Manual for Environmental Laboratories. Version 4.2. October.

DoD, Department of Energy, Nuclear Regulatory Commission, and U.S. Environmental Protection Agency. 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575. August.

EPA (U.S. Environmental Protection Agency). 1986. Test Methods for Evaluating Solid Waste, Physical Chemical Methods, SW-846. Third Edition and final updates.

———————. 1999. National Functional Guidelines for Organic Data Review, EPA 540/R-99/008. Contract Laboratory Program. October.

———————. 2002. Guidance for Quality Assurance Project Plans, EPA QA/G-5, QAMS. December.

———————. 2004. National Functional Guidelines for Inorganic Data Review, EPA 540/R-04/004. Contract Laboratory Program. October.

———————. 2005. Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP). March.

———————. 2006. Guidance on Systematic Planning using the Data Quality Objectives Process, EPA QA/G-4, QAMS. February.

NAVFAC SW (Naval Facilities Engineering Command Southwest). 2005. Environmental Work Instruction (EWI), EVR.6, Environmental Data Management and Required Electronic Delivery Standards.

NFESC (Naval Facilities Engineering Service Center). 1999. Navy Installation Restoration Chemical Data Quality Manual (IRCDQM). October.

Shaw (Shaw Environmental and Infrastructure, Inc.). 2011. Final Radiological Remedial Investigation Report; Former Naval Station Puget Sound. May.

_____. 2013. Final Action Memorandum for Radiological Time-Critical Removal Actions at Former Naval Station Puget Sound. May.

SWDIV (Southwest Division Naval Facilities Engineering Command). 2001. Environmental Work Instruction (EWI) #1, 3EN2.1, Chemical Data Validation. November.

URS (URS Consultants, Inc.). 1996. Environmental Baseline Survey, Naval Station Puget Sound (NAVSTA PS), Seattle, Washington, CTO 0104. January 16.

This page intentionally left blank.

FIGURES

This page intentionally left blank.

Boring #	WA State Plane (NAD83, Washington North, US Feet)	
2	1288072.89	253758.42
3	1288072.00	253738.01
4	1288063.99	253738.61
6	1288071.29	253715.59
7	1288066.39	253705.28
9	1288073.31	253700.78
10	1288073.45	253686.19
11	1288066.66	253690.07
13	1288093.80	253661.95
14	1288084.33	253644.89
15	1288129.41	253616.70
20	1288152.45	253635.19
21	1288209.19	253638.29
26	1288228.86	253616.17
27	1288251.10	253620.31
31	1288339.39	253635.20
32	1288004.93	253810.76
33	1288001.60	253821.50
34	1288016.24	253814.40
35	1287992.35	253807.72
36	1288008.55	253792.18
37	1288012.12	253774.73
38	1288023.85	253777.01
39	1287999.42	253771.20
40	1288012.03	253761.53
41	1288011.48	253747.12
42	1288024.16	253747.79
43	1288013.22	253733.81
44	1288000.17	253746.20
45	1287997.92	253648.38
46	1287981.11	253660.23
47	1288091.65	253519.81
48	1288077.55	253499.28
50	1288104.83	253501.18
52	1288195.90	253511.76
53	1288205.45	253525.76
54	1288184.38	253512.02
55	1288197.60	253497.54
57	1288382.74	253090.57
58	1288392.25	253094.62
59	1288399.90	253090.55
62	1288568.27	253106.30

LEGEND

- PLANNED SOIL REMOVAL ACTION AREAS
- PLANNED BUILDING REMOVAL ACTION AREAS
- PLANNED STORM DRAIN AND SINK DRAIN REMOVAL ACTION AREAS
- MANHOLE
- CATCH BASIN
- CONTRACTOR CONTROLLED AREA
- TRAFFIC ROUTING
- SOIL CHARACTERIZATION BORING

90 0 90 Feet

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

SAMPLING AND ANALYSIS PLAN
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 1

PLANNED REMOVAL ACTION AREAS

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: L7451.mxd

TETRA TECH EC, INC.

APPENDIX A

STANDARD OPERATING PROCEDURES
(on CD only)

This page intentionally left blank.

Curtis & Tompkins, Ltd.

Determination of Radium 226 by Gamma-Ray Spectroscopy
(21 day ingrowth) DOE HASL 4.5.2.3

Approved:

8/28/12
Laboratory Director/ Date

8/29/12
QA Director / Date

8/28/12
HPS Laboratory Supervisor/ Date

8/28/12
HPS Laboratory Supervisor/ Date

Read, Understood and Agreed:

08.28.12
Signature / Date

8/28/12
Signature / Date

8-28-12
Signature / Date

8/28/12
Signature / Date

Signature / Date

Signature / Date

Signature / Date

Signature / Date

Re-Approved:

Signature / Date

Signature / Date

Curtis & Tompkins, Ltd.

Determination of Radium 226 by Gamma-Ray Spectroscopy
(21 day ingrowth) DOE HASL 4.5.2.3/EPA 903.1
Table of Content

Curtis & Tompkins, Ltd.

Determination of Radium 226 by Gamma-Ray Spectroscopy
(21 day ingrowth) DOE HASL 4.5.2.3/EPA 903.1

SCOPE: This document describes procedures and quality control criteria for the determination of Radium 226 (Ra226) by gamma ray spectroscopy in soil/solid matrices processed by C&T Radiochemistry SOP 3.6 (Preparation of Soil Samples for Gamma Spectroscopy) after a 21 day ingrowth period. Additional isotopes can be determined in the same sample by using appropriate libraries and calibration standards. Ra226 can be determined in other matrices, Biota, Water by matching calibration standards and using appropriate geometries. This procedure describes the analysis, calculations, documentation, data assessment, quality control and acceptance criteria for Ra226 determination by Gamma Spectroscopy.

The Minimum Detectable Activity (MDA) for Ra226 using this procedure is 1.3 pCi/gr. MDA and Uncertainty can be reduced by counting samples for longer periods of time. Measurement uncertainty can be as high as 100% when the measured results are near or below the detection limit. Ra226 is determined by measuring the Ra226 decay daughter; 214Bi at 609 keV after a 21 day incubation The sample must be sealed and stored for 22 days before 214Bi reaches secular equilibrium with 226Ra. This “in growth” measurement provides an efficient determination of Ra226. More direct determinations of Ra226 by Alpha spectrometry may yield more accurate and precise results however, alpha spec procedures are more labor intensive and expensive.

Summary of the Method

Soil samples are dried, ground and sieved to #10 mesh. 300-400 gram samples are counted in 250 mL sealable metal containers. This “Tuna Can” geometry is maintained consistently for calibration and for Laboratory Control Standard (LCS). Samples and calibrations standards are placed in the gamma-ray spectroscopy systems and counted following daughter ingrowth (21+days). Results are reported in activity as pCi (picoCurie) or pCi/g (picoCurie per gram).

Isotopes and Detection Limits

Isotope	CAS #	MDA (pCi/gr)
Americium-241	86954-36-1	0.9
Cesium-137	10045-97-3	0.07
Cobalt-60	10198-40-0	0.03
Europium-152	14683-23-9	0.1
Europium-154	15585-10-1	0.2
Radium-226	13982-63-3	1.3
Thorium-232	7440-29-1	0.9
Uranium-235	15117-96-1	0.18

REFERENCES

US-EPA Method 901.1 and/or 903.1 Gamma Spectroscopy
DoE HASL 300 Sec 4.5.2.3 Ga-01-R Gamma Radioassay 2/97

Curtis & Tompkins, Ltd.

MultiAgency Radiological Analytical Protocols Manual (MARLAP) Volume II Chapter 15 Section 15.6 Gamma Detection Methods
DoD Quality Systems Manual, Version 4.2, October 2010
Volume 1 TNI NELAC Standard, EL-V1-2009, September 2009

HPS Sampling and Analysis Plan (HPS-SAP) Revision 1 July 2011
HPS SOP 3.6 Preparation of Soil Samples for Gamma Spectroscopy
HPS SOP 2.3 Radiological Data Review

C1402-98 Standard Guide for High-Resolution Gamma-ray Spectrometry
Ortec Solid-State Photon Detector Operator's Manual GEM Series HpGe (High-Purity Germanium) Coaxial Detector System

Ortec GammaVision-32 A66-B32. Global Value Productivity Add-On for GammaVision-32 Software User's Manual, Version 2.2
Gamma Vision-32, "Gamma-Ray Spectrum Analysis and MCA Emulator for Microsoft Windows 98, 2000, NT, and XP." Software User's Manual A66-B32. Version 6.09.

Maestro-32, "MCA Emulator for Microsoft Windows 98 SE, 2000 Pro, and XP Pro." User's Manual A65-B32. Version 6.0.

Practical Gamma-Ray Spectroscopy, Gordon Gilmore, Second Edition, (2008) Wiley

SAMPLE STORAGE PRESERVATION & HOLDING TIME

All samples are collected by client field technicians and provided with a chain of custody.
No sample preservation is required for gamma-ray spectroscopy.
Appropriate sample containers: plastic bags or jars, and once prepared, tuna cans
Samples are delivered, shipped, and stored at ambient temperature
There is no maximum holding time for preparation or analysis. When determining 226-Radium using progeny ingrowth, a hold time before counting of 21 days is required.
All samples in process are stored and secured in the sample storage or sample preparation Conex(s). Following analysis, all samples are secured in archive storage at ambient temperature and held until authorization is received from the client for disposal.

QC REQUIREMENTS

Instrument Calibration procedures, specifications and acceptance criteria with corrective actions are established. Method performance is monitored through the use of laboratory control standards (LCS), duplicate sample analysis, and participation in a proficiency sample program. Issues related to low level environmental radiochemical testing as well as waste disposal costs preclude the use of tracers, spikes, and other QC samples.

The following QC samples are required per batch of 20 samples, more samples are allowed in the batch if the samples were prepared and analyzed for the GS186 product and allowed to

incubate for the ingrowth period to achieve a more reliable measurement for Ra-226:

a) Prep Blank
b) One LCS
c) One sample duplicate

Prep Blanks

Prep Blanks are reference blank soil processed by Radiochemistry SOP 3.6 Dried, milled/crushed to pass #10 sieves, and canned with other samples in the batch. The can is labeled prep blank and counted under the same conditions and settings as samples. C&T QC Department has access to the source and preparation of blank soil.

Prep Blank results are evaluated against the weekly background measurement and updated as appropriate.

Frequency: One per batch of 20 samples or One daily if sample was prepared and screened by the GS186 product.
Acceptance Criteria: Absolute value less than analyte RL
Corrective Action: Any sample associated with a blank that fails the criteria checks will be reprocessed in a subsequent preparation batch, except when the sample analysis resulted in a non-detect. If no sample volume remains for reprocessing, the results will be reported with appropriate data qualifying codes.

Duplicate Samples

Frequency: 1 per prep batch, max 20 samples per batch or one daily if sample was prepared and screened by the GS186 product.
Acceptance Criteria: Relative percent difference (RPD) ≤40% or relative error ratio (RER) ≤1
Corrective Action: Re-prepare and reanalyze the sample and duplicate in the associated preparatory batch for failed target analytes if sufficient sample material is available and the sample is homogeneous. If RPD/RER still out of range, report as matrix interference confirmed and write a nonconformance. If reanalysis is in range, re-prepare samples in the batch provided sufficient sample exists to do so. Evaluate the data to determine the source of difference and if there is a matrix effect or analytical error.

Laboratory Control Samples (LCS)

Suitable LCS material is not commercially available; an LCS was prepared in November of 2011 at the HPS laboratory containing approximately 10 pCi/gr Ra226. This is the LCS material used to control this analysis. C&T QC Department has access to the source and preparation of the LCS material described in other documents as “Magic Dirt”.

LCS Criteria

Frequency: One per batch or one daily if sample was prepared and screened by the GS186 product.
Acceptance Criteria: Within establish internal control limits: +/- 20% of known activity
Corrective Action: If the LCS fails perform troubleshooting and instrument maintenance as

needed and reanalyze the LCS and all samples affected by the changes made to the instrument.

Minimum Detectable Activity (MDA)/Minimum Detectable Concentration (MDC)/Lower Level of Detection (LLD)

See Isotopes and Detection Limits table above

Sample weight should be 300g to 400g in the Tuna Can. Soil sample counting time is typically 45 Minutes (2700 seconds) to achieve detection limits for all isotopes of concern.

If less than 300g of soil is present in the tuna can, the counting period may change as informed by data quality objectives and approved by the HPS Laboratory Director or Lab supervisor.

The detection limit for remediation is based on a Critical Level Calculation. Ortec GammaVision-32 software, used in this procedure, provides a Critical Level MDA process, sometimes referred to as the Method Detection Limit (MDL). The Critical Level is 2.33 times the square root of the isotope of concern's background level in the spectrum. For purposes of this procedure, the terms MDA and MDL may be utilized interchangeably.

Matrix Spike (MS)
MS/MSD's are not analyzed because no suitable comparable radioactive material or tracer is commercially available at a relevant (low) activity level.

Initial Calibration QC Specifications
Frequency: as needed for detectors being brought back from maintenance or failed CCV's, or once annually per detector.
Acceptance criteria: +/- 10% of the true value of the nuclides used for the calibration.
Corrective actions: 1) Recalibration, 2) Instrument maintenance, 3) Notify Lab Director
All ICAL events must be documented in the instrument maintenance logs

Continuing Calibration Verification (Performance Checks)
CCV checks are performed on each detector daily prior to use using a CCV check source calibration standard
Acceptance criteria: +/- 10% of the true value of the nuclides used for the calibration.
Corrective actions are: 1) Recalibration, 2) Instrument maintenance, 3) Notify Lab Director

Background Measurement
Frequency: Daily
Acceptance Criteria: Absolute value less than analyte RL
Corrective Action: Any sample associated with a prep blank that fails the criteria checks will be reprocessed in a subsequent preparation batch, except when the sample analysis resulted in a

non-detect. If no sample volume remains for reprocessing, the results will be reported with appropriate data qualifying codes.

In addition to the daily background checks, a long background check (14,000sec) is performed at the end of each week for background correction for the following week.

Instrument Contamination Monitoring
Instrument contamination is monitored by background checks see Background Measurement above and Daily Background Check and 6 month Instrumentation Background Check below.

SAFETY

Laboratory safety procedures shall be implemented as required in accordance with the specifications stated in C&T's Health and Safety Manual. At the HPS lab, the procedures and requirements of the Tetra Tech safety manual, "Accident Prevention/Site Safety and Health Plan", Latest Version apply as well and the procedures and specifications stated in, "Hunter's Point Radiation Protection Plan and Attachments", Latest Version.

There is no eating or drinking in the prep or counting labs at either HPS or Berkeley facilities

All work areas shall be kept as clean as possible at all times and the entire work area shall be cleaned at the conclusion of the last shift of the day.

Promptly clean any spills that occur using the guidance contained in the Health and Safety Manuals and support of the Radiation Safety Officer and Health and Safety Officer if necessary.

INTERFERENCES

Electrical noise is a common interference. Line conditioners are used to minimize electrical surges.

Background interference is also a concern, and appropriate corrective action for this interference is to increase counting times.

Precautions

- Keep HpGe (High Purity Germanium) detectors cold. Minimizing the number of times the detectors are allowed to get to room temperature will extend the life of the crystal/detector.
- For Liquid Nitrogen cooled detectors, ensure the detector cold-finger is submerged in liquid nitrogen at least 8 hours before applying any voltage to the crystal.
- For mechanical cooled detectors, check air filter cleanliness at 2 week intervals, clean

with water rinse and/or replace with new as needed

- In cases where the detector is removed from the liquid nitrogen source, or when a detector shutdown signal is triggered due to increasing temperature, the cold finger should be stabilized at room temperature for a minimum of 24 hours prior to re-submerging in liquid nitrogen.
- Never exceed the manufacturer's recommended operating voltage for the detector. Operate detectors using the correct polarity.
- For detectors that do not have the Detector Interface Module (DIM) hardwired to the detector, ensure N-type detectors are connected to a Negative DIM and P-type detectors are connected to a Positive DIM.
- Do not open the detector shielding during counting operations.

Instrument high voltages and gains are established using the procedures described in Ortec Solid-State Photon Detector Operator's Manual GEM Series HpGe (High-Purity Germanium) Coaxial Detector System.

EQUIPMENT AND SUPPLIES

Ortec Gamma Radiation Counting Equipment
EG&G Ortec Beryllium Window HPGe Gamma Spectroscopy System
High Purity Germanium detector with built in preamplifier and lead shield
Dewar flask with fill collar (30 Liter); Linear amplifier; Detector Interface Module (DIM)
Ethernet transceiver with cable or UBS connection
Multi-channel Analyzer with DSP(Digital Signal Processing) system & WinTel Computers
GammaVision for Windows Model A66-B32 Version 6.09; Global Value Version 2.2

Supplies
250ml plastic jar: ESS Part# 0250, SKS Part# 5786
250ml seam sealable metal can: Wells Can Company Part #BP307, Part #BP307EE
Liquid Nitrogen (LIN) Airgas Industrial Grade

Maintenance Activities
Maintenance procedures for Gamma spectroscopy equipment it is in APPENDIX 4: INSTRUMENT MAINTENANCE of this SOP.

PROCEDURE

Note: This procedure is only valid for the tuna can geometry. If a different geometry is used, separate calibrations must be performed using the different detector-source geometries.

Curtis & Tompkins, Ltd.

Initial Calibration Procedure

The calibration procedure is specified in the Ortec Gamma Vision-32 A66-B32 Operations Manual, abstracted below.

The energy calibration data is used to define the energies of the peaks in the spectrum. These adjustments allow the calculated energies to correspond to the correct library entry, to correctly identify the peak and attribute it to the corresponding nuclide.

Calibrating the detector efficiency relates the number of gamma rays emitted from a source to the number of gamma rays collected in the full-energy peak by the detector. Efficiency calibration data includes effects from the detector itself, the detector source geometry, the materials surrounding the detector, and the absorption in the source material or matrix. Incorrect efficiency calibrations will cause the nuclide activity to be incorrectly reported.

Calibration Standards see APPENDIX 2: CALIBRATION STANDARDS

Tuna Can Soil Standard (Density: 1.5 g/cc)

23.5 mm Diameter Multi-energy Button Source. Isotope Eu-152

Energy and Efficiency Calibrations

1. Place the Eu-152 multi-energy button source on top of two stacked empty tuna can geometries.
2. Open GammaVision and Click on ACQUIRE then click on MCB PROPERTIES using the menu bar displayed on GammaVision opening screen.
3. Click on the amplifier tab displayed on the MCB PROPERTIES screen, then click on START AUTO in the OPTIMIZE BLOCK to commence peak optimization.
4. Remove the EU-152 button source and replace with the mixed gamma TUNA CAN standard upon completion of peak optimization. Click on GO displayed in the menu bar of the opening screen of Gamma Vision to initiate a count.
5. Set the cursor at channel 10,660 during the accumulation of counts and adjust the 1332.5 keV Co-60 energy peak to center on the cursor using the ALT+SHIFT+ (+ or -) keys. Once the 1332.5 keV peak is centered at channel 10,660, secure the count by clicking on the STOP button in the menu bar.
6. Acquire a tuna can specific geometry calibration spectrum using the opening screen of Gamma Vision by clicking on ANALYZE then SETTINGS in the menu bar to display the Sample Type Settings screen. Click on PRESETS to view the LIVE TIME block to ensure 10,000 seconds is displayed. Close window and return to opening screen. Click on GO to start the spectrum accumulation. A typical calibration spectrum will contain each peak with at least 10,000 net area counts. Pb-210 at 46.54 keV peak energy is considered the most limiting parameter. Once 10,000 net counts have accumulated in the Pb-210 channel, the count can be stopped.

7. Save the calibration spectrum to the path “C\User\Cal\Spetra\DetX\X_GEOMETRY SOURCENUM.spc” where:

   X = Detector Number

   GEOMETRY = Geometry Description

   SOURCENUM = Source number (i.e,

   C\User\Cal\Det1\1_250 ml Bottle U603.clb)

8. Close all Detector Windows returning to Gamma Vision opening window and click on BUFFER in the Detector ID window. Click on FILE then click on RECALL. Scroll thru the “Look in” window to find the USER FOLDER. Click on USER FOLDER to open folder. Click on CAL folder to open the folder, then, click on SPECTRA to locate the saved calibration spectrum. Click on the saved spectrum to load into BUFFER.
9. Click on Analyze then click on Settings then click on Sample Type. Select the Browse button next to “File:” field and open the file “C:\User\SDF\Cal.Sdf”. Click the OK button.
10. If a previously applicable Calibration File exists click on Calibrate then select Recall Calibration. Select the calibration file and Click the Open button. Select CALIBRATE, then, CALIBRATION WIZARD from the BUFFER menu bar.

    Select the option CREATE NEW ENERGY and EFFICIENCY CALIBRATIONS. The TCC Calibration option should remain at the current setting. Select the NEXT button.

    In the ENERGY CALIBRATION WIZARD page, select the library file“C\User\Lib\EfficiencyCalibration.Lib” for mixed gamma using the Browse button. Click on the NEXT button.

    In the EFFICIENY CALIBRATION WIZARD page, select the appropriate CERTIFICATE file in the CERTIFICATE file window. If a certificate file for the applicable source does not exist, then create a Certificate file for the source as follows:

    Click on the Certificate File Browse Button and select the file to edit from the directory “C:\User\Efficiency Tables,” then click on the open button. (Note: If a file for the applicable source does not exist, then any of the existing file may be copied and renamed as necessary to create a logical name for the source using geometry and source identification.)

    Select the Certificate File Edit button to edit/review the source data.

    Verify or modify the source data as applicable. If any changes are made to any peak data, then select UPGRADE to apply those changes to the data grid before moving to another peak in the grid.

    After all changes are made to the data grid, select the SAVE AS button and save the Efficiency Table/Certificate File to the “C:\User\Efficiency Tables” directory with an

appropriate name including the geometry and source identification.

Select the OK button to close Certificate File Editor.

Energy, FWHM, and Efficiency Calibrations

1. Click on NEXT to perform the Energy, FWHM, and Efficiency Calibrations.
2. Select the EDIT ENERGY button to review the Energy and FWHM Calibrations.
3. Verify that at least the 46.54 keV peak and the 1836.01 peak are present in the table for a mixed gamma source as these points are at the low and high extremes for measurement and verify that at least 3 points exist between those extremes.
4. Verify that all delta values in the table for the energy calibration are within +/- 0.2%.
5. On the ENERY CALIBRATION sidebar window select FWHM option in the FIT section. Verify that all delta values in the table for the FWHM calibration are within +/- 5%. Delete any points that have a delta > +/- 5%.
6. Close the ENERGY CALIBRATION sidebar.
7. Select the EDIT EFFICIENCY button to review the EFFICIENCY calibration fit.
    a. Verify the FIT TYPE (or MODE) is appropriate for the detector type, i.e., P-type detectors or N-type with Aluminium end cap most commonly use POLYNOMIAL BELOW the knee. N-type detectors without an Aluminium end cap most commonly use QUADRADIC ABOVE and BELOW the KNEE fit with the knee set at 150 keV.
    b. Verify that all delta values in the table for the efficiency calibration are within +/- 5% with the following clarifications:
8. Hg-203 may be deleted from the efficiency table if the calibration spectrum was acquired more than a few months after the assay date. This is due to the increased error associated with the decay correction using a nuclide with a relatively short half-life.
9. Some geometries in close proximity to the detector will experience more coincidence summing of the Y-88 and Co-60 peaks. As a result, the 661.66 keV peak and the 898.01 keV peak may have delta values greater than the 5%. For those two peaks, a maximum delta up to 10% is generally accepted. This results in a conservative activity calculation in samples for Cs-137 and a more accurate assessment of other peaks in this energy range.
10. Peaks with nearby interferences that result in a high delta should be removed from the calibration. For example, the 511 keV peak may interfere with the 514 keV peak

depending on the count time and geometry resulting in an erroneous efficiency value for the 514 keV peak in the calibration.

11. The Knee value may need to be adjusted to ensure a smooth curve fit at the transition point. For geometries that are very close proximity to the detector (i.e. Filter Paper), the knee value may provide a better curve fit at approximately 160 kev rather than 150 kev. The user may use trial and error to determine the best fit.

12. When using the Quadratic fit the knee may be adjusted to improve the calibration fit if necessary. Verify that the fitted line is smooth in the transition point near the knee.

13. Close the Efficiency Calibration sidebar window.

14. Select the SAVE CALIBRATION button and save the calibration to "C;\User\Cal\X_GEOMETRY.clb." where X is the detector and GEOMETRY is an appropriate geometry name (i.e., 1_250mlBottle.clb). If the Interpolative Fit was used as a result of the selected spectrum source being used for QC, then the calibration file name must be X_QC.clb where X is the detector number.

(Note: Except for the detector number all calibration names must be consistent for the automation routines to properly select the specified files!Refer to the GVSampleDataSC Software Manual for more detail related to file identification.)

Enter the calibration description in the format "Detector #X GEOMETRY" where X is the detector number and GEOMETRY is appropriate for Tuna Can when prompted.

Select the FINISH button to close calibration wizard.

Print the calibration report from the menu "Calibration\Print Calibration…"

Close the spectrum BUFFER window and save the spectrum when prompted.

Run the efficiency VERIFICATION AUTOMATION routine from the GVQUICKSTART to verify that the calibration is accurate and all related files were updated successfully. (For the QC calibration, an EFFICIENCY VERIFICATION is not necessary. Run the normal QC to verify the calibration accuracy).

Place the Eu-152 multi-energy button source on top of two stacked empty tuna can geometries.

Acquire a QC calibration spectrum using the opening screen of Gamma Vision by clicking on ANALYZE then SETTINGS in the menu bar to display the Sample Type Settings screen. Click on PRESETS to view the LIVE TIME block to ensure 600 seconds is displayed. Close window and return to opening screen. Click on GO to start the spectrum accumulation. Repeat steps 5.1.8 through 5.1.23 to create a QC calibration file.

Curtis & Tompkins, Ltd.

QC Criteria for Gamma Spectroscopy Calibrations

Total Source Activity
Efficiency and Energy calibrations will be performed annually, and/or following maintenance, power supply anomalies such as power surge spectrum shifts, and failure of control chart parameters 2 sigma warning and 3 sigma control provided by Gamma Vision software.

Energy Calibration
A valid NIST traceable source will be used for all energy calibrations. Two sets of parameters will be accumulated: energy verses channel number and peak shape, i.e., FWHM versus energy. The inputs to this function are a spectrum with isolated peaks distributed over the energy range of interest and a library of peak energies. The formula for energy versus channel number is:

$$E = a_1 + a_2C + a_3C^2$$

Where:
E = energy
a_i = coefficients
C = channel number

The formula for FWHM vs. channels is:

$$F = b_1 + b_2C + b_3C^2$$

Where:
F = FWHM
b_i = coefficients
C = channels

The calculation for FWHM in energy:

$$F(e) = F(c)\ (a_2 + 2a_3 + C)$$

Where:
F(e) = FWHM in energy
F(c) = FWHM in channels at channel C
a_2 = energy calibration slope defined by Eq.1
a_3 = energy calibration quadratic coefficient defined in Eq.1
C = channel number

When the FWHM fit is made, the fit is checked for validity. If the FWHM curve is negative at any part of the spectrum or the curve bends over (has a maximum and then goes down), a warning message, “NON-PHYSICAL FWHM FIT” will be displayed. The FWHM curve can be displayed to see why the fit is incorrect or if the delta between data points and FWHM fit is greater than 25%. The curve may be accepted if the warning is due to the fit outside the energy of interest, or some of the data points need to be deleted. The calibration spectrum should have good

resolution peaks with a minimum of 1,000 counts (preferably 10,000 counts), so, counting longer may remedy the poor fit. In the event Pb-210 is utilized for efficiency calibrations, the Pb-210 peak may be less than 1,000 counts and ignored if desired.

Efficiency Calibration

A valid NIST traceable source that contains isolated singlet peaks over the entire energy range of interest is used for efficiency calibrations.

The polynomial efficiency/energy formula is:

$$\epsilon = e^{\{\Sigma a_i E2\text{-}i\}}$$

Where:
ϵ = efficiency at energy E
a_i = fitting coefficients
E = energy in Mev

The result of an efficiency calibration calculation is one or two sets of coefficients (one for the fit above the maximum and one for below) and a set of energy-efficiency pairs. The energy-efficiency pairs are used for the interpolative fit.

Continuing Calibration Verification & Second Source Calibration Verification

1. Continuing Calibration Verifications (CCV) using calibration standards from a different source or lot number from the same source can be considered laboratory control standards (LCS) to verify the efficiency and energy calibrations established in the ICAL and check the general operating parameters of the system.
2. CCV checks are performed on each detector daily prior to use using a CCV check source calibration standard which should be from a different source or lot number from those used to calibrate the ICAL the detector.
3. A second source standard or Laboratory Control Standard (LCS) is used to verify the primary calibration standard following initial detector calibration and weekly thereafter during detector operation. The LCS contains isotopes encompassing the full energy range in the gamma-ray spectrum measurement. The acceptance criteria for LCS is +/- 20% of the known value for isotopes in the LCS. The corrective action for a failing LCS requires re-analysis or an explanation in the narrative portion of the data report.

Efficiency Verification

An Efficiency Verification is performed after the initial calibration. The steps for running an Efficiency Verification are as follows:

1) Place the Mixed Gamma Source on the detector
2) In the Global Value window initiate the Efficiency Verification Job
3) Enter the technician's name and password performing the Job

4) Enter the Source Reference Number when prompted
5) Click OK to start the count
6) At the end of the count an Excel file is automatically populated with results. Using the Source Certificate of Calibration enter the referenced γps for all the radionuclides.
7) If the percent difference is within 20% for all the nuclides listed then the detector is operating normally.

Daily Background Check

1. Perform a daily background check on each Gamma Detector to monitor detector contamination and power supply anomalies.
2. A daily background report is automatically generated after completing this test.
3. The daily background is not subtracted from the reported sample results, and serves as a quality control check for changes in background for an individual detector.

6 month Instrumentation Background Check

1. Perform a system component background check for each detector and shield every six months, and/or after a new detector is installed and/or returned to service after maintenance. Record these checks in the detector maintenance log.
2. Check pre-determined parameters (background counts, background count rate) and verify results are within acceptable limits. If the result is less than two standard deviations from the mean, no action is necessary.
3. If the result is between two and three standard deviations from the mean, note the result in the instrument maintenance log.
4. If the result is greater than three standard deviations from the mean, notify the lab supervisor or Lab Manager and the detector must be taken out of service until corrective action is completed. Note these activities in the detector maintenance log.

Gamma Counting Procedure

1. The following steps are to be followed after completing the Daily Background Check, Daily Quality Control Check, and Weekly Laboratory Control Standard Check have been performed as required in accordance with procedures above.
2. Enter sample information into Global Values as follows.
3. Start the gamma-ray spectroscopy counting routine by opening "GLOBAL VALUE", then "GLOBAL VALUE QUICK START". Ensure the proper detector is selected for counting. From "GLOBAL VALUE QUICK START" "AUTOMATION GROUPS" screen, open "ANALYZE SAMPLES" file, then from "AUTOMATION JOBS" screen, open "COUNT SAMPLE". Scan the barcode attached to the sample.
4. From the "GV SAMPLE DATA TETRA TECH" automated pop-up screen "SAMPLE DATA" section, verify that the "SAMPLE ID", "CONTRACT", "SAMPLE DATE/TIME", "UNIT NUMBER", are properly populated. Enter sample description into the "SAMPLE DESCRIPTION" field (if necessary). Enter the “INGROWTH SEAL DATE”

5. From the "GV SAMPLE DATA TETRA TECH" automated pop-up screen "ANALYSIS DATA" section, verify the following fields:
    a. "ANALYSIS METHOD" is appropriate for the sample.
    b. "GEOMETRY" is appropriate for the sample (i.e., Smear 47 mm Disk, Soil 250ml Plastic Bottle, Soil 250ml Tuna Can) to ensure an appropriate efficiency is used.
    c. "LIBRARY" is appropriate for the sample (i.e., Efficiency Calibration, Efficiency Verification, Generic Analysis No Decay, Null, or QC). Note that the typical library for analysis is "Generic Analysis No Decay".
    d. "ACTIVITY UNITS" is appropriate for the sample (i.e.,pCi, Ci, Bq, or DPM). Note that the activity units are typically "pCi".
    e. "COUNT TIME" is appropriate for the sample. Note that the typical count time is 2700 seconds.
6. From the "GV SAMPLE DATA" automated pop-up screen "ANALYSIS DATA" section, enter the sample quantity in the "SAMPLE QUANTITY" field. Note that for a soil sample this should be in the range of 300 to 400 grams. We're working on a LIMS application to automate this entry based on sample ID and capture weight data.
7. Place sample to be counted onto high purity Germanium crystal (HpGe).
8. Select "CONTINUE" to start the spectral analysis and collection. Notify the Lab Director for guidance if a FAILURE NOTIFICATION" window appears at any point in the sample analysis set up process.
9. Upon completion of the gamma-ray spectroscopy analysis, click on "SAMPLES" on the "GLOBAL VALUE QUICK START" at HPS or equivalent Gamma Vision window at Berkeley. Enter USERNAME and PASSWORD, and select "OK". Select the spectrum for the sample analyzed from the "SPECTRUM" field drop down menu. Review the completed gamma-ray spectroscopy analytical report to ensure that the following report attributes are satisfactory:
    f. Sample description
    g. Live time equals the selected count time
    h. Efficiency selected is appropriate to the sample
    i. Radionuclide Library selected is appropriate for the sample
    j. Minimum Detectable Activity (MDA) for respective radionuclides meets the criteria listed in the Sampling Analysis Plan

<u>Duplicate Sample Analysis</u>

1. One laboratory duplicate sample will be analyzed once per twenty samples utilized for unrestricted release. Samples prepared for the GS186 product at HPS may be batched with more than 20 samples, in these cases SOP is to count selected samples after the 21 day ingrowth process has occurred LIMS will track the preparation batch and if possible the duplicate sample assigned to the larger batch can be counted to related the appropriate prep duplicate to the sample.
2. Samples are to be run on the same detector, preferably not in consecutive order. In the

event that the samples are run consecutively, the sample container will be physically removed from the shielding housing, relocated to the sample storage location, prior to replacing the sample on the detector. This process ensures that the likelihood of a sample returning to the same geometry on the detector face is random, as would normally be during sample analysis.

3. The acceptable criterion for the duplicate pairs stated in the HPS SAP is a relative percent difference (RPD) of <40%. Additional requirements may be imposed through other work documents. The formula for RPD is:

RPD = 100x2(result -duplicate result) / (result + duplicate result)

Blank Sample Analysis

Blanks are performed at the beginning of every workday before a QC sample is run. The steps for running a Blank are as follows:

1) Place the soil prep blank sample on top of the detector
2) In the Global Value (HPS) of Gamma Vision (BRK) window, initiate the Background Check Job. Enter the technician's name and password
3) Click OK to start the count
4) At the end of the count a LIMS file is automatically populated with results for the condition of the detector.
5) Review the conditions and acceptance criteria for the Background check.
6) If the Background check passes then the detector is operating normally and the QC check can be initiated. If the Background check does not pass notify the Supervisor or his/her designee.
7) If no deviation is found then reference 6.3 Troubleshooting in the Ortec Solid-State Photon Detector Operator's Manual for possible causes.
8) When the corrective action is completed perform the QC check again and make an entry in the detector maintenance log.
9) If the detector performance cannot be remedied, the Supervisor or his/her designee will need to determine further corrective action.

LCS Analysis

LCS are not easily performed given the requirements for radioactive materials for these tests. The steps for running an LCS are the same as a Continuing Calibration/Efficiency Verification except the LCS Job is selected in the Global Value (HPS) or Gamma Vision (BRK) Window.

C&T has prepared LCS material at a nominal activity of 10 pCi Ra226 per gram. The material (Magic Dirt) is available for use at both labs and should be employed when the SAP or client specifications require this determination.

Sample Result Review & Evaluation

Samples are counted and reviewed by Lab Technicians and automatically reviewed for compliance to rules for Gamma Spectroscopy determinations by LIMS. (Gamma Spectroscopy Data Review SOP). Samples that are compliant to all the rules are automatically reported by LIMS. Samples that fail to meet one or more to the rules are automatically queued for supervisory review by LIMS. Data reviewed by supervisors or Lab Managers or their designees are "published" after passing corrective action determined as a result of review effort.

The data review procedure is specified in HPS SOP 2.3 Gamma Spectroscopy Data Review.

Once samples are reviewed an email is sent to the TtEC point of contact stating that all samples have been reviewed and published to the C&T LabLine internet portal alternatively, they're sent to the project manager for project level review and reporting.

DOCUMENTATION

All initial calibrations, any maintenance event, changes to the instrumentation, or changes to associated hardware and software must be documented in the maintenance benchbooks for each detector.

WASTE DISPOSAL

All laboratory activities associated with this procedure will be performed in a fashion designed to generate the least amount of waste possible using ALARA (as low as reasonably acceptable) necessary to achieve the data quality objectives.

Samples in Tuna cans shall be stored in the counting lab at Berkeley and in the sample control Conex at HPS for 30 days after completion of the work. Samples with no detectable radiation above background levels can be disposed of in the dumpster. Samples with detectable radiation require disposal as low level waste or can be returned to the customer using appropriate shipping procedures. HPS has a long term sample storage facility that is used to archive samples until the appropriate disposition has been determined.

Expired sources are stored in secure containment until disposition. Some sources can be returned to their manufacturer for credit against the cost of a new standard, alternatively they can be disposed of as low level radioactive waste using appropriate procedures at each lab facility.

Materials used for preparation of samples (Masslinn, bench diapers etc.) and those used for decontamination should be disposed in labeled radioactive waste bags. These bags are collected weekly and transferred to the waste facilities at each location.

Low level radioactive waste (materials, extracts, byproducts) shall be stored in appropriate

containers as directed by the "HPS Waste Management Plan" and the SOP for Lab Waste Disposal at Berkeley.

POLLUTION PREVENTION
All HPS laboratory activities will be performed in accordance with the base wide "Hunter's Point Shipyard Pollution Prevention Plan".

REVISION HISTORY
This SOP is Revision 0 the first version of this SOP

Curtis & Tompkins, Ltd.

APPENDIX_1:CALCULATIONS

The ***background determination*** calculates the first pass background on the low-energy side of the peak using a 5-point average of the channel contents for the region from the peak-centroid channel to the channel which is 6 times the library match width (normally 0.5) times the calculated FWHM (from the calibration) below the centroid. The 5-point average data at a given point is the sum of the data from two channels below the point to two channels above the point divided by 5. This is equivalent to smoothing the data with a smoothing width of 5 and coefficients of 0.2 for all points. The background value is the minimum value of the moving 5-point average and the background channel number is the center channel of the 5. If the minimum average value is within one sigma (counting statistics) of the actual channel value at the assigned channel point, this 5-point average is the low energy background value for this peak. If the average value is not within one sigma of the actual data, a 3-point average is used instead of the 5-point average to calculate a new minimum value. This 3-point average minimum value is compared with the actual data at the assigned channel and is accepted if it is within 1 sigma of the actual data. If the 3-point average also fails this test, the data value at the assigned channel is used for the background. The same process is repeated for the high-energy side of the peak to calculate the background value above the peak. The background under the peak is the straight line between these two values. The net peak area and background are calculated from this first pass.

The ***peak area calculation***, to obtain the library peak area for a particular energy, is to fit the spectrum region with a background plus peak shape function. This so-called "directed fit" can be applied to peaks and has the ability to produce negative peak areas. The negative peak area will produce a negative activity and this will be replotted. Negative activities are required by some reporting agencies for statistical purposes. The fit is iterated until the reduced chi square for the fit changes by less than 1% from the previous iteration up to a maximum of 10 iterations. Most cases will converge in 3 to 4 iterations. Since these values are derived from a fitting process, it is difficult to redo the calculations manually.

The ***counting statistical uncertainty*** is the uncertainty in the gross area and the uncertainty in the background added in quadrature. The uncertainty in the gross area is the square root of the area. The uncertainty in the background is not as simple because the background is a calculated number. The background area uncertainty is the uncertainty in the channels used to calculate the end points of the background multiplied by the ratio of the number of channels in the peak to the number of channels used to calculate the background. For wide peaks and low counts per channel, there is high uncertainty in the calculated background.

$$bkg\ error = \left(\frac{(background\ area)\,(peakwidth)}{(width\ of\ low\ average + width\ of\ high\ average)} \right)^{1/2}$$

$$gross\ area\ error = \sqrt{gross\ area}$$

$$net\ area\ error = \sqrt{(gross\ area\ error)^2 + (background\ error)^2}$$

The peak width is calculated at the half maximum, tenth maximum, and twenty-fifth maximum for the net peak shape. The peak width points are linearly interpolated between the two channels that bracket the respective height value.

The ***peak centroid channel*** in total summation is the center-of-moment of the peak and is calculated as the weighted channel number of the peak. That is, the peak centroid is the sum of the net channel contents times the channel number divided by the sum of the channel contents. The centroid is calculated as:

Where: *l, h* = the peak low and high channels i= the channel number
Ci = net contents of channel i

For the directed fit method, the centroid can be refined from the fitting process.

Fraction Limit is used to verify the identification of a particular nuclide in a spectrum, the number of located peaks is compared to the number of possible peaks. This value gives more weight to the more intense peaks. It is expressed as follows:

where *BranchingRatio* is the branching ratio for the peak for the given nuclide, *1*is the sum over the located peaks, and *p* is the sum over the possible peaks. This fraction is between 100 for all peaks located and 0 for no peaks located. This value is compared to a limit value to determine whether this nuclide's peaks are present in sufficient measure to say the nuclide is present. The*fraction limit test* is passed if the fraction is above the selected value

The ***uncertainty*** printed on the report can be either counting or total uncertainty. They can be printed at 1,2, or 3 sigma. The counting uncertainty is the uncertainty of the peak area due to statistical uncertainty. For a peak net area, the counting uncertainty can be expressed in percent of the peak area. This same percent is used to express the percent counting uncertainty in the activity values. The total uncertainty estimate (1 sigma) is determined by summing in quadrature

Curtis & Tompkins, Ltd.

the individual uncertainties from the various analysis components.

$$\sigma_t = \sqrt{\sigma_{count}^2 + \sigma_{nor}^2 + \sigma_{rsum}^2 + \sigma_{abs}^2 + \sigma_{nuc}^2 + \sigma_{eff}^2 + \sigma_{geo}^2 + \frac{\sigma_{uni}^2}{3}}$$

Where:
σ_t =total uncertainty estimate
σ_{count} = counting uncertainty estimate
σ_{nor} = additional normally distributed uncertainty estimate
σ_{rsum} = random summing uncertainty estimate
σ_{abs} = absorption uncertainty estimate
σ_{nuc} = nuclide uncertainty estimate
σ_{eff} = efficiency uncertainty estimate
σ_{geo} = geometry uncertainty estimate
σ_{uni} = uniformly distributed uncertainty estimate

All components of uncertainty estimates except are computed at the I-sigma level.
The uncertainty estimate for a uniformly distributed error is used at the full range. If a collection factor is not used, the uncertainty estimate is zero for that component.

The ***nuclide activity*** is calculated for all peaks in the library whose energy is between the energy limits selected for the analysis (in-range). There are several methods of determining if a nuclide is present or not, and if MDA should be reported. The nuclide is reported as present if one of the following is true:

1. The first in-range peak of the nuclide in the library is present in the spectrum, and the counting uncertainty is below the peak cutoff.
2. All of the peaks marked as key lines are present.
3. The fraction limit test is passed.

The nuclide activity (in becquerels), based on the peak at energy, *E,* is given by:

$$A_{Ei} = \frac{N_{Ei}}{\varepsilon_E * t * \gamma_d}$$

Where: A_{Ei} = the activity of nuclide i based on energy *E*
N_{Ei} = the net peak area for peak at energy *E*
$\mathcal{E}_E$ = the detector efficiency at energy *E*
t = the livetime
Y_d = the gamma-rays/disintegration for energy *E* of this nuclide

Curtis & Tompkins, Ltd.

The gamma-rays/disintegration value is in the library and the efficiency factor is stored in the calibration file.

This "peak activity" is reported in the nuclide peak matrix. If there is more than one peak in the energy analysis range for a nuclide, then an attempt to average the peak activities is made. The result of the average is the average nuclide activity.

APPENDIX_2: CALIBRATION STANDARDS

NIST Traceable Standards: Eckert & Ziegler Part #85624-918 Total Activity 2.0 µCi in Tuna Can geometry.

Radionuclide	Quantity in Microcuries
Cd-109	0.85
Co-57	0.019
Ce-139	0.029
Hg-203	0.062
Sn-113	0.049
Cs-137	0.024
Y-88	0.082
Co-60	0.038
Am-241	0.061
Sr-85	0.061
Pb-210	0.77

Put the LCS specifications and identity here

Curtis & Tompkins, Ltd.

APPENDIX_3:INSTRUMENT CONDITIONS

Instrument conditions can vary slightly between instruments. All specific instrument conditions are found with each instrument's method file at each instrument's workstation.

APPENDIX_4:INSTRUMENT MAINTENANCE

As defined by HPS SAP Worksheet #25, page 160

Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person
Clean cave; fill LNO2	Physical check	Physical check	Weekly	Acceptable background	-Recalibrate -Instrument maintenance -Consult lab manager	HPS Laboratory Manager
Background check/Check deviation	Physical check	Physical check	Prior to use and at minimum daily	Within 3 sigma of measured population	-Recalibrate -Instrument maintenance -Consult lab manager	-Recalibrate -Instrument maintenance -Consult lab manager
Source check/Check deviation	Physical check	Physical check	Prior to use and at minimum daily	Within 3 sigma of measured population	-Recalibrate -Instrument maintenance -Consult lab manager	-Recalibrate -Instrument maintenance -Consult lab manager

Curtis & Tompkins, Ltd.

APPENDIX_5: DEFINITIONS

Calibration Check - is a standard in the mid range of the energy range that is used to verify the calibration on a daily basis. This is equivalent to continuing calibration verification (CCV) per NELAC.

Laboratory Control Sample (LCS) is a NIST traceable standard from a different lot or if available different vendor than the primary calibration standard. The LCS must include the high, middle and low energy ranges of the isotopes being measured. It serves as an independent check of the calibration. It is run when a new curve is generated.

Prep Blank/Method Background Sample -is an empty tuna can allowed to sit open in the sample prep Conex 250ml jar counted for the same time as a sample and used to assess background contamination.

Efficiency -the percent of decay events from a certified standard radioactive source, in a specific reproducible geometry that are seen and measured by a detector.

Traceable Calibration Standard -A certified calibrated radioactive source prepared as or from a standard reference material traceable to the National Institute of Standards & Technology (NIST), Eckert & Ziegler Isotope Products and others.

ADC -analog to digital converter.

Full Width Maximum (FWHM) -the full width of a gamma-ray peak distribution measured at half the maximum peak height measured above the continuum (background).

Dead Time -the time while the pre amplifier is collecting an electrical pulse generated by photon/detector interaction and is unable to collect another pulse.

Geometry -a standard sample or source counting configuration (i.e. 250 ml polypropylene jar) and its relationship to the detector.

In growth-the expected amount of a decay product that will exist at a later time because of ingrowth from a specified ancestor.

Title: Separation of Strontium

Approvals (Signature/Date):

Kenneth Miller Technical Manager	2/7/2013 Date	Dave Harbinson Health & Safety Coordinator	2/7/2013 Date
Sarah Nagel Quality Assurance Manager	2/07/2013 Date	Jodie Carnes Laboratory Director	2/7/13 Date

RL-GPC-010

REVISION 3

Facility Distribution No. _____ **Distributed To:_____**

1.0 Scope and Application

1.1 Analytes, Matrix(s), and Reporting Limits

This procedure describes a method for the separation and measurement of strontium. The method allows for running of the method in tandem with the actinide separations by extraction chromatography.

On occasion clients may request modifications to this SOP. These modifications are handled following the procedures outlined in Section 12 in the Quality Assurance Manual.

Refer to Policy P-R-01 for method detection limits

2.0 Summary of Method

Radioactive strontium is separated using a strontium specific extraction chromatographic resin prior to gas flow proportional counting. Initial load conditions will vary depending on whether the sample is performed sequentially with actinides or not. Stable strontium is used to monitor method yields.

3.0 Definitions

Refer to Quality Assurance Manual, Appendix 2 for definitions.

4.0 Interferences

4.1 The presence of elemental strontium in the sample may bias the gravimetric yield determination. If it is suspected that natural strontium is present in the sample, its concentration should be determined by a suitable means and the yield calculation appropriately modified.

4.2 Strontium must be separated from interfering isotopes of other elements to enable measurement by beta counting.

4.3 Sr Resin with an 8M HNO_3 load solution is used to effectively remove barium-140 and potassium-40 isotopes as well as other matrix interferences. Tetravalent plutonium, neptunium, cerium and ruthenium, however are not removed using nitric acid. If necessary, these isotopes can be effectively removed by including an additional rinse of approximately four free column volumes of 3 M HNO_3 - 0.05 M oxalic acid.

5.0 Safety

Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001), Radiation Safety Manual and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.1 Specific Safety Concerns or Requirements

All work must be stopped in the event of a known or potential compromise to the health and safety of an associate. The situation must be reported immediately to a laboratory supervisor.

Eye protection that satisfies ANSI Z87.1, laboratory coat, and appropriate gloves must be worn while samples, standards, solvents and reagents are being handled. Disposable gloves that have become contaminated will be removed and discarded; other gloves will be cleaned immediately.

Exposure to chemicals must be maintained as low as reasonably achievable; therefore, unless they are known to be non-hazardous, all samples should be opened, transferred and prepared in a fume hood, or under other means of mechanical ventilation.

5.2 Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. **Note: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table.** A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Nitric Acid	Corrosive Oxidizer Poison	2 ppm-TWA 4 ppm-STEL	Nitric acid is extremely hazardous; it is corrosive, reactive, an oxidizer, and a poison. Inhalation of vapors can cause breathing difficulties and lead to pneumonia and pulmonary edema, which may be fatal. Other symptoms may include coughing, choking, and irritation of the nose, throat, and respiratory tract. Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and stain skin a yellow or yellow-brown color. Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			

6.0 Equipment and Supplies

6.1 Equipment

- Analytical balance – 0.0001 g sensitivity
- Column/ cartridge rack
- Fume hood
- Heat lamp
- Hotplate

6.2 Supplies

- Column reservoirs - 25 mL
- Column reservoirs – 250 mL to 1 liter
- Ion exchange column – 1 to 1.5 cm diameter column with 10 mL resin volume
- Stainless steel planchets – 50.8 mm diameter, 6.4 mm deep flat bottom, cupped planchet
- Syringe filters

7.0 Reagents and Standards

Unless otherwise indicated, all references to water should be understood to mean reagent grade water.

7.1 Cation exchange resin - hydrogen form, 100 to 200 mesh
7.2 Nitric acid (15.7 M) - concentrated nitric acid
7.3 Nitric acid (3 M) - Add 191 mL of concentrated HNO_3 to 800 mL of water and dilute to 1 liter with water.
7.4 Nitric acid (3 M) - oxalic acid solution (0.05 M)- Add 191 mL of concentrated HNO_3 and add 6.3 grams of oxalic acid dihydrate to 800 mL of water and dilute to 1 liter with water.
7.5 Nitric acid solution (0.05 M) - Add 3.2 mL of concentrated nitric acid to 900 mL of water and dilute to 1 liter with water.
7.6 Nitric acid solution (0.1 M) - Add 6.4 mL of concentrated nitric acid to 900 mL of water and dilute to 1 liter with water.

7.7 Nitric acid solution (8 M) - Add 510 mL of concentrated nitric acid to 400 mL of water and dilute to 1 liter with water.

7.8 Sr Resin - prepacked column, 0.7 grams resin, or small particle size (50-100 μm) in appropriate size column. Pre-packed cartridges may also be used.

7.9 Sr-85 tracer and/or standards

7.10 Strontium (Sr) carrier (5 mg/mL), gravimetric - Dissolve 12.1 grams $Sr(NO_3)_2$ in water and dilute to 1 liter with water.

8.0 Sample Collection, Preservation, Shipment and Storage

Sample container, preservation techniques and holding times may vary and are dependent on sample matrix, method of choice, regulatory compliance, and/or specific contract or client requests. Listed below are the holding times and the references that include preservation requirements.

8.1 The sample may be collected in glass or plastic containers. Storage of the sample prior to analysis should not exceed six months.

8.2 It is recommended that water samples be preserved at the time of collection by adding enough 1 M HNO_3 to the sample to adjust it to pH 2.

9.0 Quality Control

9.1 All quality control data shall be maintained and available for easy reference.

9.2 Yield monitors (carriers and tracers) and QC spikes are prepared with a pre-set mass and/or activity and distributed appropriately in coded vials for use during sample analysis. Consult the latest version of the client specific Quality Assurance Summary (QAS) for the appropriate yield monitors, spikes, carriers, and/or tracers to use.

9.3 Consult the Quality Assurance Summary for client specific information regarding QC frequency.

9.4 Refer to SOP RL-DR-001 for QC acceptance criteria and corrective action.

10.0 Calibration

Refer to appropriate detector calibration SOP.

11.0 Procedure

NOTE: To resolve problems with the instrumentation or support equipment when the solution is not contained in this SOP, refer to SOP RL-QA-005 Troubleshooting Guide.

11.1 Sr Resin Column Preparation:

NOTE: The method can be run with either columns or cartridges. The term column will be used throughout the procedure and it applies to both forms of the Sr resin.

11.1.1 For cartridges the setup and operation of the vacuum box is found in procedure RL-ALP-017.

11.1.2 For each sample, place a Sr cartridge on the vacuum box. Label each cartridge with the appropriate sample ID. Place the waste collecting container in the box.

11.1.3 Just prior to loading the sample, add 5 mL of 8 M HNO_3 (3 M HNO_3 if a sequential analysis is being performed with other extraction chromatographic materials.) into each reservoir (to condition the resin) and pass through the cartridge with vacuum at approximately 3 mL/minute.

11.2 Sr Resin Column Separation:

11.2.1 Refer to the appropriate SOP for sample preparation as specified by client specific requirements. .

11.2.2 Dissolve the sample residue in 10 mL 8 M HNO_3, check the solution for undissolved solids and filter if necessary.

Note: An alternative to this is the combined loads and rinses from the Actinide Separations Procedure RL-ALP-001. While the molarity of the nitric acid is lower than optimum, the difference is insignificant. This permits the sequential separation of various actinides and strontium.

11.2.3 Transfer the sample solution into the appropriate Sr Resin column and let the solution drain through at < 1mL/minute.

11.2.4 Add 5 mL of 8 M HNO_3 to rinse each tube/beaker and transfer each solution into the each column and allow to drain.

Note: If the samples have been previously loaded onto cartridges while running RL-ALP-001 set up the cartridges and add this rinse directly to the reservoir.

11.2.5 If Pu^{+4}, Np^{+4} or Ce^{+4} may be present, add 5 mL of 3 M HNO_3 - 0.05 M oxalic acid into each column and allow to drain.

Note: The 3 M HNO_3 - 0.05 M oxalic acid removes Pu^{+4}, Np^{+4} or Ce^{+4}, which are retained by Sr Resin. If these interferences are known to be absent, this step may be skipped. If the analysis was preceded by the actinide separation procedure RL-ALP-001, these interferences will be absent.

11.2.6 Add 10 mL of 8 M HNO_3 to each column and allow the rinse solution to drain through each column. Note: This additional 8 M HNO_3 rinse removes any residual oxalic acid and ensures full removal of K^+ and Ba^{+2} that may be present.

11.2.7 Record the time when the last rinse completely drains through each column as the start of yttrium ingrowth.

11.2.8 Ensure that labeled containers are below each column.

11.2.9 Elute the strontium by adding 10 mL of 0.05 M HNO_3 into each column and allowing it to drain.

11.2.10 Place a tared planchet under a heat lamp for each sample.

11.2.11 Evaporate the solution onto each planchet in successive portions.

11.2.12 Allow each portion to evaporate to near dryness between additions.

11.2.13 Rinse the container containing the column strip with 2 mL of 0.05 M HNO_3 and transfer to the planchet.

11.2.14 After all the solution has evaporated to dryness, cool each dish.

11.2.15 Weigh each planchet to determine the gravimetric yield

11.2.16 Submit the sample to the counting room for gas flow proportional counting. Count for sufficient time to achieve the desired minimum detectable concentration.

11.2.17 After total Strontiumhas been couned, set planchets aside in a safe palce during the Y-90 ingrowth period

11.3 Y-90 separation

11.3.1 Redissolve the residue from the planchet using approximately 15 ml of 8M HNO_3.

11.3.2 Set up a vacuum box with SR resin cartridges following RL-ALP-017 (Cromatagraphic Column Prep)

11.3.3 Condition the column with 5 ml of 8M HNO_3

11.3.4 Once the condition has completely drained place clean labeled collection tubes into the vacuum box and load the dissolved samples into the appropriate columns and allow to drain.

11.3.5 Rinse the beaker with 5 ml of 8M HNO_3 add the rinse to the appropriate column reservoir and allow to drain.

11.3.6 Record tha Separation time once the columns have completely drained.

11.3.7 Remove the tubes from the vacuum box Place a tared planchet under a heat lamp for each sample. Evaporate the solution onto each planchet in successive portions.

11.3.8 Allow each portion to evaporate to near dryness between additions.

11.3.9 Rinse the container containing the solution with 2 mL of 0.05 M HNO_3 and transfer to the planchet.

11.3.10 After all the solution has evaporated to dryness, cool each dish.

11.3.11 Weigh each planchet and record the weight in the bench sheets.

12.0 Calculations / Data Reduction

12.1 For computer calculation of the strontium-90 concentration, consult the RadCalc Users Guide.

12.2 Gravimetric Sr carrier yield = $\frac{R-T}{C}$

where R = residue + dish, mg; T = tare weight of dish, mg; C = $Sr(NO_3)_2$ added

13.0 Method Performance

13.1 Demonstration of Capabilities

See section 19 of Quality Assurance Manual.

13.2 Training Requirements

See section 17 of Quality Assurance Manual.

14.0 Pollution Control

It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity needed, preparation of reagents based on anticipated usage and reagent stability). Employees must abide by the policies in Section 13 of the Corporate Environmental Health and Safety Manual (CW-E-M-001) for "Waste Management and Pollution Prevention."

15.0 Waste Management

Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes are disposed of in an accepted manner. Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to RL-HS-001. The following waste streams are produced when this method is carried out.

- Aqueous acidic waste pH< 2. Waste is collected in an appropriate container and transferred into an acid waste container color coded with yellow tape and a yellow cap.
- Aqueous Basic waste with a pH >2. Waste is collected in an appropriate container and transferred into a neutral waste container color coded with green tape and a green cap.

16.0 References / Cross-References

16.1 ASTM Volume 11.02, 2009, "Standard Test Method for Sr-90 in Water," D5811-08, ASTMI, PA
16.2 Eichrom Technologies, Inc. Strontium 89,90 in Water, SRW01, Rev. 1.4, February 25, 2003
16.3 RadCalc DB, Users Guide, TestAmerica Richland
16.4 RL-QAM-001 Quality Assurance Manual, latest revision
16.5 RL-ALP-001 Determination of Actinides by Extraction Chromatography, latest revision
16.6 RL-DR-001 Review of Environmental and Bioassay Data, latest revision
16.7 RL-HS-001 Accumulation and Disposal of All Waste Generated, latest revision
16.8 RL-PRP-001 Preparation of Urine and Blood Samples, latest revision
16.9 RL-PRP-010 Urine and Water Preparation by Calcium Phosphate Precipitation, latest revision
16.10 RL-QA-005 Troubleshooting Guide, latest revision.
16.11 P-R-01 Minimum Detectable Concentration Determination, latest revision
16.12 CW-E-M-001 Corporate Environmental Health and Safety Manual, latest revision

17.0 Method Modifications:

Item	Method	Modification
1	SRW01	Urine matrix included in SOP
2	SRW01	Matrix limitation removed

18.0 Attachments

N/A

19.0 Miscellaneous

19.1 Responsibilities

Analyst: Implements SOP as written.
Counting Room: Performs review on raw instrument data.
Technical Data Reviewer: Performs final data review.
Project Manager: Confirms final review and prepares data for reporting to client.
QA Manager: Performs product quality assessments as defined in the Quality Assurance policies.

19.2 Records Management/Documentation

All records generated by this analysis will be filed and kept in accordance with the Richland facility of TestAmerica QA policies for records management and maintenance.

20.0 Revision History

- Revision 0, 1/4/2010
  - SOP established
- Revision 1, 9/06/2011
  - Referenced RL-QA-005.
- Revision 2, 01/27/2012
  - Removed ethyl alcohol from reagents and standards.
  - Step 11.2.3 defined flow rate for sample load.
  - Clarified wording.
- Revision 3, 02/06/2013
  - Added yttrium separation section 11.3
  - Removed matrix limitations to allow all matrices

Title: DETERMINATION OF VOLATILE ORGANICS BY GC/MS [SW-846 8260; EPA 624; DW 524.2]

Approvals (Signature/Date):

Ben Hicks 5/7/13 Ben Hicks Date Organics Manager	Michael Ridenhower 5/7/13 Michael Ridenhower Date Health & Safety Manager / Coordinator
Marti Ward 5-7-13 Marti Ward Date Quality Assurance Manager	Elaine Wild 5/7/13 Elaine Wild Date Laboratory Director

This SOP was previously identified as SOP No. ST-MS-0002 Rev. 18

Facility Distribution No.: 0 **Distributed To:** See Electronic Distribution Sheet

1.0 SCOPE AND APPLICATION

1.1 This SOP is applicable to the determination of Volatile Organic Compounds in waters, wastewater, soils, sludges and other solid matrices.

1.2 This SOP is applicable to SW-846 method 8000B, 8000C, 8260B, 8260C, Drinking water method 524.2, and EPA 624.

1.3 This method can be used to quantify most volatile organic compounds that have boiling points below 200 °C and are insoluble or slightly soluble in water. Volatile water soluble compounds can be included in this analytical technique; however, for more soluble compounds, quantitation limits are approximately ten times higher because of poor purging efficiency.

1.4 The method is based upon a purge and trap, gas chromatograph/mass spectrometric (GC/MS) procedure. The approximate working range is 1 to 200 µg/L for 5 mL waters, 0.5 to 40 µg/L for 25 mL purge waters, 5 to 200 µg/kg for low-level soils, and 250 to 25,000 µg/kg for high-level soils.

1.5 The laboratory target analytes supported by this method, the reporting limits, method detection limits and QC limits are maintained in the Laboratory Information Management System (LIMS).

1.5.1 Additional compounds may be amenable to this method. The minimum requirement for non-standard analytes is that the reporting limit be set at the lowest required concentration that can actually be detected by the instrument, and when an MDL study can not be conducted, the MDL be set equal to the reporting limit.

2.0 SUMMARY OF METHOD

2.1 Volatile compounds are introduced into the gas chromatograph by the purge and trap method. The components are separated via the chromatograph and detected using a mass spectrometer, which is used to provide both qualitative and quantitative information.

2.2 In the purge and trap process, an inert gas is bubbled through the solution at ambient temperature or at 40^{o}C (40^{o}C required for low level soils) and the volatile components are efficiently transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbant column where the volatile components are trapped. After purging is completed, the sorbant column (trap) is heated and flushed with inert gas to desorb the components onto a gas chromatographic column. The gas chromatographic column is then heated to elute the components that are detected with a mass spectrometer.

2.3 Qualitative identification of the parameters in the extract is performed using the retention time and the relative abundance of characteristic ions. Quantitative analysis is performed using the internal standard technique with a single characteristic ion.

2.4 The use of selected ion monitoring (SIM) is acceptable for applications requiring quantitation limits below the normal range of electro impact mass spectrometry. However, SIM may provide a lesser degree of confidence in the compound identification, since less mass spectral information is available. Instead of scanning everything in a retention time range, SIM looks for specific ions (qualitative and quantitative) that are placed in retention time groups. The ions used for qualitative and quantitative purposes are the same for scan and SIM analysis. The laboratory currently only runs a SIM method for 1,4 dioxane. Details are available in Appendix 1 of this SOP.

3.0 DEFINITIONS

3.1 See the TestAmerica St. Louis Quality Assurance Manual (ST-QAM) for a glossary of common laboratory terms and data reporting qualifiers.

3.2 SIM – selected ion monitoring

4.0 INTERFERENCES

4.1 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other processing apparatus that lead to discrete artifacts. All of these materials must be routinely demonstrated to be free from interferences under conditions of the analysis by running laboratory method blanks as described in the Quality Control section. The use of ultra high purity gases, pre-purged purified reagent water or purchased HPLC water, and approved lots of purge and trap grade methanol will greatly reduce introduction of contaminants.

4.2 Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) into the sample through the septum seal during shipment and storage. A field blank prepared from reagent water and carried through the sampling and handling protocol can serve as a check on such contamination. Trip Blanks, prepared from reagent water, can serve as a check on conditions during transportation from the field to the laboratory.

4.3 Matrix interferences may be caused by non-target contaminants that are coextracted from the sample. The extent of matrix interferences will vary considerably from source to source depending upon the nature and diversity of the site being sampled.

4.4 Cross-contamination can occur whenever high-level and low-level samples are analyzed sequentially or in the same purge position on an autosampler. Whenever an unusually concentrated sample is analyzed, it should be followed by one or more blanks to check for cross-contamination. The purge and trap system may require extensive bake-out and cleaning after a high-level sample.

4.5 Some samples may foam when purged due to surfactants present in the sample. When this kind of sample is encountered an antifoaming agent can be used. A blank spiked with this agent must be analyzed with the sample because of the non-target interferences associated with the agent.

4.6 Methylene Chloride, Acetone, and 2-Butanone are potential laboratory contaminants. Concentrations up to five times the level observed in the method blank, in associated laboratory samples, may be attributed to the presence of these compounds in the laboratory.

5.0 SAFETY

5.1 Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001), Radiation Safety Manual and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.2 **SPECIFIC SAFETY CONCERNS OR REQUIREMENTS**

5.2.1 The gas chromatograph and mass spectrometer contain zones that have elevated temperatures. The analyst needs to be aware of the locations of those zones, and must cool them to room temperature prior to working on them.

5.2.2 The mass spectrometer is under deep vacuum. The mass spectrometer must be brought to atmospheric pressure prior to working on the source.

5.2.3 There are areas of high voltage in both the gas chromatograph and the mass spectrometer. Depending on the type of work involved, either turn the power to the instrument off, or disconnect it from its source of power.

5.3 **PRIMARY MATERIALS USED**

5.3.1 The following is a list of the materials used in this method, which have a serious or significant hazard rating. NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Methanol	Flammable Poison Irritant	200 ppm (TWA)	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			
TWA – Time Weighted Average			

6.0 EQUIPMENT AND SUPPLIES

6.1 Micro syringes- 1.0 µL, 10 µL, 25 µL, 50 µL, 100 µL, 250 µL, 500 µL, 1000 µL. Hamilton 1700 series

6.2 Volumetric flasks, Class A

6.3 Analytical Balance, capable of weighing ± 0.001 g

6.4 Syringe: 5 or 25 mL glass with Luerlok tip, if applicable to the purging device.

6.5 Vials: 20 and 40 mL with Teflon lined screw caps

6.6 Spatula: Disposable wooden tongue depressors

6.7 Disposable pipettes

6.8 pH paper: Wide range and 0.3 to 2.3

6.9 Glass beads: Store in a drying oven.

6.10 Gas Chromatograph/Mass Spectrometer System:
- 6.10.1 Gas Chromatograph: Hewlett Packard GC 5890 and Agilent 6890 system with temperature programming.
- 6.10.2 Purge and Trap Device: The purge and trap device consists of the sample purger, the trap, and the desorb heater.
- 6.10.3 Gas Chromatographic Capillary Columns:
  - 6.10.3.1 Mass Spectrometer: Hewlett Packard 5970, 5972 and 5973 mass spectrometers capable of scanning 35-300 AMU every two seconds or less, using 70 volts electron energy in the electron impact mode.
- 6.10.4 GC/MS interface: In general split/splitless injector are used but any interface (including direct introduction to the mass spectrometer) that achieves all acceptance criteria may be used.
- 6.10.5 Data System:
  - 6.10.5.1 ChemStation software system that allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program.
  - 6.10.5.2 Target software system allows searching any GC/MS data file for ions of a specified mass and plotting such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP). Software allows integrating the abundances in any EICP between for a specified time or scan-number limit. Also, for the non-target compounds, software a mass spectrum that meets the required criteria when 50ng of 4-Bromofluorobenzene (BFB) are must be available that allows for the comparison of sample spectra against reference library spectra. The most recent release of the NIST/EPA mass spectral library should be used as the reference library.
    - 6.10.5.2.1 Data Library: NIST 98

6.11 Carrier gas: Ultra high purity helium

6.12 Make up gas: Ultra high purity helium

7.0 REAGENTS AND STANDARDS

7.1 All standards and reagent preparation, documentation and labeling must follow the requirements of SOP ST-QA-0002, current revision.

7.2 Methanol: Purge and Trap Grade

7.3 Water: HPLC grade or equivalent.

7.4 See recipes for standards and QC samples in the Standards Log program.

7.5 Calibration Standards and Surrogates
- 7.5.1 Stock Solutions: Stock solutions may be purchased as certified solutions from commercial sources or prepared from pure standard materials as appropriate. These standards are prepared in methanol and stored in Teflon-sealed screw-cap bottles with minimal headspace at 0 to -20 °C.
- 7.5.2 Working standards: A working solution containing the compounds of interest prepared from the stock solution(s) in methanol. These standards are stored in the freezer or as recommended by the manufacturer.
  - 7.5.2.1 See SOP: ST-QA-0002 for expiration date criteria.

7.6 Initial calibration verification (ICV) standards are similar to calibration standards, but are from a completely different source.

7.7 Internal standards: Internal standards are added to all samples, standards, and blank analyses.

7.8 Tuning standard: A 25 ng/µL 4-Bromofluorobenzene standard is made up that will deliver 50 ng (or 25 ng) on column upon injection.

7.9 Sodium bisulfate, crystal

7.10 Ascorbic acid, ACS Reagent Grade, granular

7.11 Sodium Thiosulfate, ACS Reagent Grade, granular

8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1 TestAmerica St. Louis supplies sample containers and chemical preservatives in accordance with the method. TestAmerica St. Louis does not perform sample collection. Samplers should review the methods referenced and other applicable sample collection documents for detailed collection procedures. Sample volumes and preservative information is given in ST-PM-0002.

8.2 Aromatic volatiles water samples are preserved with 1:1 HCl and stored at 4 ± 2 °C. Analysis hold time is 14 days from collection.

8.3 Aqueous samples are stored in glass containers with Teflon lined septa at 4 ± 2 °C, with minimum headspace.

8.4 Soil samples are refrigerated at 4 ± 2 °C. Analysis hold time is 14 days from collection.

8.4.1 Medium level solid extracts are aliquoted into 2 - 5 mL glass vials with Teflon lined caps and stored at 4 ±2 °C. The extracts are stored with minimum headspace.

8.5 For 5035 analysis

8.5.1 Solid samples, for low level analysis, may be field preserved with sodium bisulfate solution, or collected unpreserved using the Encore™ (or equivalent) sampler and shipped to the laboratory within 48 hours of sampling.

8.5.1.1 Following shipment back to the lab the soil is preserved with sodium bisulfate or the sample is extruded into an empty, clean sealed vial and frozen within 48 hours of sampling.

8.5.1.2 It is recommended that two Encore (or equivalent) samplers be used for each field sample position, to allow for any reruns than may be necessary.

8.5.2 Solid samples, for medium level analysis, may be field extracted with methanol, or collected unpreserved using the Encore (or equivalent)™ sampler and shipped to the laboratory within 48 hours of sampling.

8.5.2.1 It is recommended that two Encore (or equivalent) samplers be used for each field sample position, to allow for any reruns than may be necessary.

8.5.2.2 Solid samples – field extracted with methanol

8.5.2.2.1. Prepare a 2 oz sample container by adding 25 mL purge and trap grade methanol. (If a 5 g sample is to be used, add 5 mL methanol to a 2 oz container or VOA vial).

8.5.2.2.2. Seal the bottle and attach a label.

8.5.2.2.3. Weigh the bottle to the nearest 0.01 g and note the weight on the label.

8.5.2.2.4. Ship with appropriate sampling instructions.

8.5.2.2.4.1. At client request, the methanol addition and weighing may also be performed in the field.

8.5.2.2.4.2. When the samples are returned to the lab, obtain the weight of the soil added to the vial and note on the label.

8.5.2.3 Solid samples – field extracted with methanol

8.5.2.3.1. When the samples are returned to the lab, extrude the (nominal) 5 g (or 25 g) sample into a pre-weighed VOA vial containing 5 mL methanol (25 mL methanol for the 25 g sampler). Obtain the weight of the soil added to the vial and note on the label.

8.6 An additional sample is collected for percent moisture determination.

8.7 EPA 524.2 Sample Dechlorination and Preservation

8.7.1 If specified by the client that actual drinking water samples containing residual chlorine are to be analyzed by the laboratory, the following procedure shall be used:

8.7.1.1 Finished drinking water samples suspected of containing residual chlorine shall have 25 mg of ascorbic acid added to each 40 mL VOA vial prior to filling. If the requested target analytes are not gases at room temperature or are not listed in Table 7 of EPA Method 524.2, sodium thiosulfate is recommended to reduce residual chlorine (3 mg sodium thiosulfate for each 40 mL VOA vial).

8.7.1.2 If the sample containers are prepared by the laboratory for filling by the sample collector, the ascorbic acid or sodium thiosulfate will be placed into unpreserved VOA vials (do not mix the ascorbic acid or sodium thiosulfate with the HCl used for preservation).

8.7.1.3 It will be the sample collector's responsibility to add additional ascorbic acid or sodium thiosulfate if a diethyl-p-phenylenediamine (DPD) test kit indicates residual chlorine in excess of 5 mg/L (25 mg ascorbic acid or 3 mg sodium thiosulfate per each 5 mg/L of residual chlorine).

8.7.1.4 After filling the VOA vial, the sample collector should adjust the sample to pH < 2 by carefully adding two drops of 1:1 HCl for each 40 mL of sample. Samples should be sealed and mixed for one minute. (Note: If the sample is to be analyzed for trihalomethanes (THMs) only, the HCl preservation step may be omitted if sodium thiosulfate was used for dechlorination.)

8.7.1.5 If a sample foams vigorously when HCl is added, the sample should be discarded. Fill fresh VOA vials containing ascorbic acid or sodium thiosulfate, but do not acidify. A note should be placed on the chain-of-custody that is submitted with the samples that they were "not acidified". These samples have a 24 hold time if target analytes other than THMs are to be analyzed.

8.7.1.6 Samples should be maintained at $4 \pm 2\ ^{o}C$ until analysis.

8.8 At specific client request, unpreserved soils packed into glass jars or brass tubes may be accepted and sub-sampled in the lab.

8.8.1 This is an older procedure based on method 5030.

9.0 QUALITY CONTROL

9.1 **Batch**

9.1.1 A sample batch is a maximum of 20 environmental samples, which are prepared together using the same process and same lot(s) of reagents. A preparation batch is composed of one to 20 environmental samples of a similar matrix, meeting the above mentioned criteria. Where no preparation method exists (example, volatile organics, water) the batch

is defined as environmental samples that are analyzed together with the same process and personnel, using the same lots of reagents, not to exceed 20 environmental samples. An analytical batch is composed of prepared environmental samples, extracts, digestates or concentrates that are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples.

9.1.2 Instrument conditions must be the same for all standards, samples and QC samples.

9.1.3 For this analysis, batch QC consists of a method blank, a Laboratory Control Sample (LCS), Matrix Spike (MS) and Matrix Spike Duplicate (MSD). In the event that there is insufficient sample to analyze a MS/MSD, an LCS Duplicate (LCSD) is prepared and analyzed.

9.1.4 Samples having different QC codes, due to non-standard client specific QC requirements, must be batched separately in the LIMS. A method blank and LCS may be shared across QC codes provided the actual "sample batch" does not exceed 20 environmental samples. MS/MSD must be performed for each separate QC code.

9.1.5 Unless medium level (i.e. an extraction batch) the blank, LCS and MS/MSD MUST run in the same 12 hour clock. The definition of a non-extraction batch is a maximum of 20 samples run in a 12 hr clock.

9.2 **Method Blank**

9.2.1 A method blank is a blank matrix processed simultaneously with, and under the same conditions as, samples through all steps of the procedure.

9.2.2 For Water analyses, the method blank is comprised of HPLC water.

9.2.3 For Soil analyses, the method blank is comprised of glass beads.

9.2.4 **For water and low soil method 8260 and 524.2 analyses**

9.2.4.1 A method blank must be analyzed with every 12 hour analytical clock and/or with each batch of 20 samples, whichever occurs first.

9.2.5 **For water method 624 analyses**

9.2.5.1 A method blank must be analyzed with every 24 hour analytical clock and with each batch of 20 samples, whichever occurs first..

9.2.6 **For medium level soil method 8260 analyses**

9.2.6.1 A method blank must be prepared with every medium level soil batch (20 or fewer samples of the same matrix). The medium level method blank is tied to an extraction and does not require repeated analysis with each sample analysis batch.

9.2.7 Method blank population studies shall be performed periodically. The data from such studies shall be used to identify systemic contamination issues.

9.3 **Laboratory Control Sample**

9.3.1 An LCS is a blank matrix spiked with a known amount of analyte(s), processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.3.2 For Water analyses, the LCS is comprised of HPLC water fortified with Volatiles.

9.3.2.1 Under current methodology, the CCV may also serve as the LCS; however, due to limitations in the LIMS, the CCV and LCS should **never** be generated from the same injection.

9.3.3 For Soil analyses, the LCS is comprised of glass beads fortified with Volatiles.

9.3.4 **For method 8260 and 524.2 analyses**

9.3.4.1 A LCS must be analyzed with every 12 hour analytical clock and with each batch of 20 samples, whichever occurs first..

9.3.5 **For method 624 analyses**

9.3.5.1 A LCS must be analyzed with every 24 hour analytical clock and with each batch of 20 samples.

9.3.5.2 A LCS must be prepared with every high level soil batch (20 or fewer samples of the same matrix).

9.3.6 **For medium level soil method 8260 analyses**

9.3.7 An LCS must be prepared with every medium level soil batch (20 or fewer samples of the same matrix).

9.3.7.1 The medium level LCS is tied to an extraction and does not require repeated analysis with each sample analysis batch.

9.4 **Matrix Spike/Matrix Spike Duplicate**

9.4.1 A Matrix Spike is an aliquot of a field sample to which a known amount of target analyte(s) is added, and is processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.4.2 **8260** – A MS/MSD must be analyzed with every 12 hour analytical clock and with each batch of 20 samples, whichever occurs first..

9.4.3 **524.2** – Method 524.2 does not require a MS/MSD be performed though it may be requested by the client. In the absence of client QC criteria for this MS/MSD, the laboratory will use 70 – 130% recovery limits, and RPD of 20%, as advisory criteria.

9.4.4 **624** - A MS/MSD must be analyzed with every 24 hour analytical clock and with each batch of 20 samples, whichever occurs first.

9.5 **Surrogate**

9.5.1 A surrogate is a non-target analyte similar in chemical composition and behavior, which mimics the target analytes during preparation, extraction and analysis.

9.5.2 Surrogate(s) is added to every field sample, method blank, LCS and MS/MSD for analysis at the beginning of the sample preparation process.

9.6 **Procedural Variations/ Nonconformance and Corrective Action**

9.6.1 Any variation shall be completely documented using a Nonconformance Memo and approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

9.6.2 Any deviations from QC procedures must be documented as a nonconformance, with applicable cause and corrective action approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Internal standard calibration is used.

10.1.1 Internal standard calibration is used. The internal standards are listed in this SOP. Target compounds should reference the nearest internal standard. Each calibration standard is analyzed and the response factor (RF) for each compound is calculated using the area response of the characteristic ions against the concentration for each compound and internal standard.

10.2 **Instrument Tuning**

10.2.1 Each GC/MS system must be hardware-tuned to meet the abundance criteria, listed in this SOP, for a maximum of a 50 ng (8260 and 624) and 25 ng (524.2) injection or purging of BFB. These criteria must be met

10.2.1.1 **8260** – for each 12 hour time period

10.2.1.2 **524.2** – for each 12 hour time period

10.2.1.3 **624** – for each 24 hour time period

10.2.1.3.1. The time period begins at the moment of injection of BFB.

10.2.2 Inject the method appropriate amount of GC/MS tuning standard into the GC/MS system. Obtain a background-corrected mass spectra of BFB and confirm that all the key m/z criteria in Table 2 are achieved. If all the criteria are not achieved, the analyst must retune the mass spectrometer and repeat the test until all criteria are achieved. The performance criteria must be achieved before any samples, blanks, or standards are analyzed.

10.3 **Initial Calibration**

10.3.1 Prepare a multi-point calibration curve by fortifying 5 mL of HPLC water with incrementing concentrations of Volatiles standard.

10.3.2 The initial calibration contains a minimum of 5 points, for each target analyte (6 points are required for a quadratic fit). The low level standard must be at or below the reporting limit. The other standards define the working range of the detector, with the highest level standard establishing the linear range of the instrument.

10.3.2.1 Note 624 requires a minimum 3 point calibration. The low level standard must be at or below the reporting limit. The other standards define the working range of the detector, with the highest level standard establishing the linear range of the instrument.

10.3.3 A new calibration curve must be generated after major changes to the system or when the continuing calibration criteria cannot be met. Major changes include new columns, any significant changes in instrument operating parameters, and major instrument maintenance.

10.3.4 Except in specific instances, it is NOT acceptable to remove points from a calibration curve for the purpose of meeting criteria. Refer to the TestAmerica Policy CA-T-P-0002, Selection of Calibration Points

10.3.5 Sample peak areas are compared to peak areas of the standards. The ratio of the detector response to the amount concentration of analyte in the calibration standard is defined as the response factor (RF) or calibration factor (CF).

10.3.6 **Initial Calibration Criteria (SW 8000B/8260B)**:

10.3.6.1 The % RSD of the calibration check compounds (CCC) must be less than 30%. CCC are as follows:

- Vinyl Chloride
- 1,1-Dichloroethene
- Chloroform
- 1,2-Dichloropropane
- Toluene
- Ethylbenzene

10.3.6.2 If none of the CCCs are required analytes, project specific calibration specifications must be agreed with the client.

10.3.6.3 The average RF must be calculated for each compound. A system performance check is made prior to using the calibration curve. The five system performance check compounds (SPCC) are checked for a minimum average response factor.

10.3.6.3.1. A **minimum response factor of 0.01** must be achieved for all other volatile target analytes.

Compound	Min. RF
Chloromethane	0.100
1,1-Dichloroethane	0.100
Bromoform	>0.100
1,1,2,2-Tetrachloroethane	0.300
Chlorobenzene	0.300

10.3.6.4 If all %RSDs in the initial calibration are $\leq$ 15%, then all analytes may use average response factor for calibration.

10.3.6.5 The analyst should evaluate analytes with %RSD > 15%.

10.3.6.5.1. Evaluate whether the problem is related to the analytical range. The low standard or the high standard having a response that is out of line with the others typically expresses this. For criteria regarding the removing calibration points from the curve, refer to STL policy P-T-001, Selection of Calibration Points.

10.3.6.6 For SW846 Method 8000B

10.3.6.6.1. If the average of all %RSDs in the calibration is > 15%, the analyst should consider instrument maintenance to improve the linearity of response.

10.3.6.6.2. When a linear regression curve is used, the intercept of the curve at zero response must be less than ± the reporting limit for the analyte. Client requirements may be tighter.(see Section 10.3.7.6.1).

10.3.6.6.3. If a linear regression curve is used, r must be ≥ 0.995.

10.3.6.6.4. When a linear model is employed use of $1/Concentration^2$ weighting is recommended to improve the accuracy of quantitation at the low end of the curve and to better control the intercept at zero response.

10.3.6.6.5. The regression may be forced through zero when using a linear model. See specific client requirements to determine if this technique is allowed for specific sample groups.

10.3.7 **Initial Calibration criteria (8000C/8260C and 524.2)**:

10.3.7.1 Minimum Response Factors (SW 8260C only)

10.3.7.1.1. See Table 4 in this SOP for recommended minimum response factors prescribed by method 8260. For analytes not given a minimum response factor by the method, TestAmerica St. Louis has established a default of 0.01 and 0.001 depending on the nature of the compound.

10.3.7.2 SW-846 8260C and 524.2 chromatographic methods allow the use of both linear and non-linear models for the calibration data.

10.3.7.3 The first way is to begin with the simplest approach, the linear model through the origin, and then progress through other options until the calibration acceptance criteria are met. The second way is to use technical knowledge of the detector response to the target compound to choose the calibration model.

10.3.7.4 The option for non-linear calibration may be necessary to address specific instrumental techniques. However, it is not EPA's intent to allow non-linear calibration to be used to compensate for detector saturation or to avoid proper instrument maintenance.

10.3.7.5 **Linear calibration using the average response factor**

10.3.7.5.1. The Relative Standard Deviation (RSD) of the calibration points from the curve used must be ≤ 20% for each target analyte.

10.3.7.5.2. If the %RSD in the initial calibration is > 20%, then calibration using a linear regression may be employed.

10.3.7.6 **Linear calibration using a least squares regression**

10.3.7.6.1. The intercept of a linear calibration at zero response (i.e. the y-intercept) must have an absolute value less than the reporting limit for each analyte. Client requirements may be tighter, please check Client Requirement Memorandum (CRM) if identified in comments.

Note, for analyses utilizing an internal standard the Target variable "b" does NOT equal the y-intercept. For analyses utilizing an internal standard, the Target variable "b" must be multiplied by the associated internal standard concentration to derive the concentration at the y-intercept.

10.3.7.6.2. r (correlation coefficient) must be ≥ 0.995 OR r^2 (coefficient of difference) must be ≥ 0.990.

10.3.7.6.3. When calculating the calibration curves using the linear regression model, a minimum quantitation check on the viability of the lowest calibration point should be performed by re-fitting the response from the low concentration calibration standard back into the curve.

10.3.7.6.4. It is not necessary to re-analyze a low concentration standard, rather the data system can recalculate the concentrations.

10.3.7.6.5. The recalculated concentration of the low calibration point should be within ± 30% of the standard's true concentration.

10.3.7.6.5.1. Analytes which do not meet the minimum quantitation calibration re-fitting criteria should be considered "out of control" and corrective action should be taken.

10.3.7.7 **Linear calibration using a least squares regression, forcing thru zero**

10.3.7.7.1. Forcing the curve through zero is not the same as including the origin as a fictitious point in the calibration. In essence, if the curve is forced through zero, the intercept is set to 0 *before* the regression is calculated, thereby setting the bias to favor the low end of the calibration range by "pivoting" the function around the origin to find the best fit and resulting in one less degree of freedom. It may be appropriate to force the regression though zero for some calibrations.

10.3.7.7.2. Curve must still meet criteria in 10.3.7.6.1 and 10.3.7.6.2

10.3.7.8 **Linear calibration using a least squares regression, weighting of data points**

10.3.7.8.1. In a linear model, the points at the lower end of the calibration curve have less absolute variance than points at the high concentration end of the curve. This can cause severe errors in quantitation at the low end of the calibration. For this reason it may preferable to increase the weighting of the lower concentration points. $1/Concentration^2$ weighting (often called $1/X^2$ weighting) to improve accuracy at the low end of the curve.

10.3.7.8.2. Curve must still meet criteria in 10.3.7.6.1 and 10.3.7.6.2.

10.3.7.9 **Non-linear calibration**

10.3.7.9.1. In situations where the analyst knows that the instrument response does not follow a linear model over a sufficiently wide working range, or when the other approaches have not met the acceptance criteria, a quadratic model may be employed. All quadratic curves require a minimum of 6 pts.

10.3.7.9.2. It is not EPA's intent to allow non-linear calibration to be used to compensate for detector saturation or to avoid proper instrument maintenance. Thus, non-linear calibrations are not be employed for analytes shown to consistently exhibit linear calibration for the analytes of interest.

10.3.7.9.3. The intercept of the curve at zero response must be less than ± the reporting limit for the analyte. (Some clients may have tighter criteria; check Client Requirement Memos)

10.3.7.9.4. r (correlation coefficient) must be ≥ 0.995 OR r^2 (coefficient of difference) must be ≥ 0.990.

10.3.8 **624 Criteria**

10.3.8.1 Method 624 only requires a 3 point calibration. We routinely perform a 5 point calibration; however, 2 points may be removed from the curve if necessary to meet 624 calibration criteria. Refer to the TestAmerica Policy CA-T-P-0002, Selection of Calibration Points

10.3.8.2 The Relative Standard Deviation (RSD) of the calibration points from the curve used must be ≤ 35%.

10.3.8.3 If the %RSD in the initial calibration is > 35%, then calibration using a linear regression may be employed.

10.3.8.3.1. If a linear regression curve is used, the intercept of the curve at small zero response must be less than ± the reporting limit for the analyte. It is recommended that for linear regression curves the line be set through the origin.

10.3.8.4 Use of 1/Concentration^2 weighting is recommended to improve the accuracy of quantitation at the low end of the curve. The analyst should consider instrument maintenance to improve the linearity of response.

10.3.8.4.1. Weighting of data points

10.3.8.4.2. The points at the lower end of the calibration curve have less weight in determining the curve generated than points at the high concentration end of the curve. However, in environmental analysis, accuracy at the low end of the curve is very important. For this reason it is preferable to increase the weighting of the lower concentration points. 1/Concentration^2 weighting (often called 1/X^2 weighting) will improve accuracy at the low end of the curve and should be used if the data system has this capability.

10.4 **Initial Calibration Verification (ICV)**

10.4.1 The initial calibration verification standard is a different standard source than the one used for the initial calibration

10.4.2 An ICV must be performed with each initial calibration.

10.4.3 The ICV performance must be within ± 30% D criteria for each analyte.

10.4.3.1 Not meeting this requirement may be indicative of serious system malfunction or inaccuracies in the standards used for the initial calibration curve or ICV standard.

10.4.4 Corrective action must be taken (including reanalysis of the ICV or analysis of a different ICV).

10.4.4.1 Any decision to proceed with analysis of samples when the ICV is out-of-control must be taken with great care and in consultation with the QA department and the laboratory director. Any such action must be documented in an NCM.

10.4.4.2 Variance among vendor supplied standards for a few compounds is not atypical for long analyte lists. All ICV failures that cannot be associated to laboratory error will require the immediate analysis of a third standard in an attempt to characterize the bias. If a third standard is not in the laboratory it must be ordered immediately.

10.5 **Continuing Calibration Verification.(CCV)**

10.5.1 At the start of each 12 hour period (8260) or 24 hour period (624) the GC/MS tuning standard must be analyzed. A 50ng injection of BFB must result in a mass spectrum for BFB which meets the criteria. See Table 2 in this SOP.

10.5.2 Following a successful BFB analysis, the continuing calibration standard(s) are analyzed. The standards must contain all volatile analytes, including all required surrogates. A mid level calibration standard is used for the continuing calibration

10.5.3 A CCV standard is analyzed every analysis tune clock immediately following the BFB tune.

10.5.3.1 **8260 and 524.2** – for each 12-hour tune time period

10.5.3.2 **624** – for each 24-hour tune time period

10.5.4 The CCV can be the same source or a second source from the calibration.

10.5.5 The internal standard response must be within -50 – 100% of the response in the mid level of the initial calibration. The internal standard retention times must be within 30 seconds of the retention times in the mid-level of the initial calibration.

10.5.6 8000B/8260B criteria:

10.5.6.1 The SPCC compounds must have a minimum response factor (see Initial Calibration SPCC criteria)

10.5.6.2 The percent difference of the CCC compounds from the initial calibration must be ≤ 20%.

10.5.6.3 In addition, the percent difference or drift of all analytes must be ≤ 60%, with allowance being made for up to six target compounds to have percent drift greater than 20%. Due to poor responses, the following compounds are allowed to have a %D > 60%, but less than 100%: Cyclohexane, 2-Chloroethyl vinyl ether, 2-Nitropropane, 1,4-Dioxane, Tetrahydrofuran, n-butanol and Isobutanol.

10.5.6.4 In addition, if any target analyte's %D is > 20%, the entire target analyte list must be averaged. The average %D must be ≤ 20%.

10.5.6.5 If none of the identified CCCs are in the special calibration, the project specific target analytes %D must be < 20% or a maximum %D as agreed with the client. If there is a special project/client %D criteria it is noted on the client requirement sheet; otherwise a maximum 20% D is applied.

10.5.6.6 There are instances where a small subset of the routinely calibrated analytes are needed for analysis (e.g. dilutions or project with abbreviated target analyte lists). In cases where the target analytes for analysis constitutes less than half of the total number of analytes in the calibration standard, apply the following:

10.5.6.6.1. The SPCC compounds must have a response factor (see initial calibration SPCC criteria) if the SPCC is a target of interest.

10.5.6.6.2. The percent difference of the CCC compounds from the initial calibration must be ≤ 20%, if the CCC is a target of interest. In addition, the percent difference or drift of all analytes of concern must be ≤ 60%, with allowance being made for, Cyclohexane, 2-Chloroethyl vinyl ether, 2-Nitropropane, 1,4-Dioxan, Tetrahydrofuran, n-butanol and Isobutanol. These compounds are allowed to have a %D > 60% but less than 100%.

10.5.6.6.3. For target analyte lists with more than 20 compounds: if any target analyte's %D is > 15%, the entire target analyte list must be averaged. The average %D must be ≤ 15%.

10.5.6.6.4. For target analyte lists with less than 20 compounds: each target analyte %D must be < 15% or a maximum %D as agreed with the client.

10.5.7 **8260C criteria:**

10.5.7.1 The CCV performance must be with ± 20% D criteria.

10.5.7.2 If a CCV has failed and the analyst can document the reason for failure (e.g. broken vial, carryover from the previous sample etc.) then a second CCV may be analyzed without any adjustments to the instrument. If this CCV meets criteria then sample analysis may continue. If this second CCV does not meet criteria, the analysis run is terminated. Instrument maintenance is performed and the instrument may require re-calibration (i.e. initial calibration)

10.5.8 **624 criteria**

10.5.8.1 Continuing calibration %D criteria is given in Table 5 of the Method. The column "Range for Q" is used to determine if CCV target analytes meet acceptance.

10.5.8.2 All target analytes must be within the limits prescribed.

10.5.9 **524.2 criteria**

10.5.9.1 For each target analyte %D must be less than or equal to 30%.

10.5.10 Calibration excursions are to be documented via a NCM.

10.6 Retention Time (RT) windows

10.6.1 Relative Retention Time (RRT)

10.6.1.1 In addition to normalizing the response (peak area) of the target compound to the response of the internal standard in that sample or extract for that injection, the retention times of the target compound and the internal standard may be used to calculate the relative retention time (RRT) of the target compound.

10.6.1.2 The RRT is expressed as a unit-less quantity:

$$RRT = \frac{\text{Retention time of the analyte}}{\text{Retention time of the internal standard}}$$

10.6.1.3 The RRT of each target analyte in each calibration standard should agree within ± 0.06 RRT units.

10.6.1.4 It is recognized here that with increasing retention times of the internal standard, target analytes will be able to more easily meet this criterion. Thus, care should be exercised when selecting the appropriate internal standards by retention times. The process of selecting internal standards to quantify target analytes should also include consideration of retention times as they should be similar.

10.6.1.5 If this criterion is not met and unless there are no other indicators of a component's identification such as a very unique but a high probability mass spectral match then that component may not be considered as identified by relative retention time.

10.6.1.6 The RRT evaluation allows the analyst to compensate for modest shifts in the chromatographic conditions that can occur due to interferences and simple day-to-day instrument variability. Many methods that employ internal standard calibration use more than one internal standard, and the target compounds are related to the internal standards on the basis of the similarity of their respective chromatographic retention times.

10.6.2 Retention Time Windows

10.6.2.1 The maximum retention time window is ± 0.45 minutes from the established retention time of the target analyte in the initial calibration.

10.6.2.1.1. Establishing this maximum retention time window, ensures that the RRT criteria of RRT ± 0.06 is achieved.

10.6.3 Internal standard retention time

10.6.3.1 The retention times of the internal standards in the calibration verification standard must be evaluated immediately after or during data acquisition. If the retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard level of the most recent initial calibration sequence, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

10.6.4 Retention Time Criteria

10.6.4.1 The retention times of all compounds in each continuing calibration must be within the retention time windows established.

11.0 PROCEDURE

11.1 Screening

11.1.1 Screening samples is a semi-quantitative determination and is not intended to be use as a reportable analytical result.

11.1.2 Screening may be performed on either a GC-FID or GC/MS instrument. The instrument should be capable of detecting the compounds of concern but does not adhere to any method calibration criteria or analysis tune clock times, nor are there any batch QC (eg method blanks, LCS) requirements for screening samples.

11.1.3 Water samples are screened using a minimum 0.5 mL of samples and diluting with target analyte free water to a final volume of 5 mL. Greater dilutions may be taken if the sample is suspected to have significantly high concentration of target analytes or interferents.

11.1.4 For soil samples, 1 g of sample is place in a 40 mL VOA vial with 5 mL of target analyte free water. Greater dilutions may be taken if the sample is suspected to have significantly high concentration of target analytes or interferents.

11.1.5 Sample screening may be performed utilizing a heated or non-heated purging vessel.

11.2 Allow standards, samples and sample extracts to reach ambient temperature before analysis.

11.3 All analysis conditions and injection volumes for samples must be the same for the calibration standards (including purge time and flow, desorb time and temperature, column temperatures, multiplier setting etc.).

11.3.1 Water, soil and medium level extract analyses are routinely performed by heated purge.

11.3.1.1 If desired, water, TCLP and methanol extracts may be performed using a non-heated purge.

11.3.1.2 If non-heated purge is desired, the calibration and all QC samples must also be performed utilizing a non-heated purge.

11.4 **Water Sample Preparation (5030B method)**

11.4.1 Transfer 5 mL or 25 mL sample to a VOA vial.

11.4.2 Transfer the 5 mL sample into an empty labeled 40 mL VOA vial.

11.4.3 Add 250 ng of each internal and surrogate standard (10 µL of a 25 µg/mL solution)

11.4.3.1 For routine TCLP samples use 0.5 mL of TCLP sample leachate with 4.5 mL reagent water and spike with surrogate and internal standards.

11.4.3.1.1.1 Note that TCLP reporting limits will be 10 times higher than the corresponding aqueous limits)

11.4.3.2 For low level TCLP samples, use 5 mL of TCLP sample leachate and spike with surrogate and internal standard.

11.4.4 Prepare a method blank with 5 mL or 25 mL of HPLC water. Add 250 ng of each internal and surrogate standard (10 µL of a 25 µg/mL solution)

11.4.5 Prepare a LCS with 5 mLor 25 mL of HPLC water. Add 250 ng of each internal and surrogate standard (10 µL of a 25 µg/mL solution). Add 10 µL of 25 µg/mL spiking solution

11.4.5.1 For samples designated for MS/MSD analysis, add 10 µL of 25 µg/mL of spiking solution.

11.4.6 Check and document the pH the remaining sample.

11.4.6.1 Do not check pH prior to taking aliquot for analysis.

11.5 **Low-Level Soil Preparation (5035A method)**

11.5.1 If samples arrive unpreserved, the laboratory must, within 48 hours of collection, preserve samples with sodium bisulfate or extrude sample into a clean, empty, sealed VOA vial and freeze.

11.5.1.1 Check the preparation method code to determine preservation.

11.5.2 If samples arrive in the Encore (or equivalent) sampler and require Sodium bisulfate preservation:

11.5.2.1 Pre-weigh a labeled 40 mL VOA vial.

11.5.2.1.1 Label with an indelible marker rather than a paper label, since paper labels may cause the autosampler to bind and malfunction.

11.5.2.2 Extrude the soil sample from the Encore (or equivalent) sampler into the VOA vial.

11.5.2.3 Weigh the vial to the nearest 0.01 g.

11.5.2.4 Record weight on the label and runlog.

11.5.2.5 Add a magnetic stir bar, approximately 1 g of sodium bisulfate and 5 mL of HPLC water.

11.5.2.5.1 Soils containing carbonates may effervesce when adding the sodium bisulfate solution. If this is the case, retrieve a second Encore sample plug, add 5 mL of water instead, and freeze at < 10 ^{o}C until analysis.

11.5.2.6 Seal the vial.

11.5.2.7 Add 10 µL of surrogate through the septum to each sample and QC.

11.5.2.7.1 For samples designated for MS/MSD analysis, add 10 µL of spiking solution to the vials.

11.5.2.7.2 Prepare a Method Blank using 5.0 g of glass beads and 5 mL of HPLC grade water. Add 10µL of surrogate to the vial.

11.5.2.7.3 Prepare a LCS using 5.0 g glass beads, and 5 mL HPLC water. Add 10 µL of surrogate and 10 µL of spiking solution.

11.5.3 <u>If samples arrive 40 mL VOA vial already preserved with Sodium bisulfate</u>:

11.5.3.1 Add 5 ul of surrogate through the septum to each sample and QC.

11.5.3.1.1 For samples designated for MS/MSD analysis, add 10 µL of spiking solution to the vials.

11.5.3.1.2 Prepare a Method Blank using 5.0 g of glass beads and 5 mL of HPLC grade water. Add 5 µL of surrogate to the vial.

11.5.3.1.3 Prepare a LCS using 5.0 g glass beads, and 5 mL HPLC water. Add 10 µL of surrogate and 10 µL of spiking solution.

11.5.4 <u>If samples arrive in the Encore (or equivalent) sampler and require freezing as preservation:</u>

11.5.4.1 Pre-weigh a labeled 40 mL VOA vial.

11.5.4.1.1 Label with an indelible marker rather than a paper label, since paper labels may cause the autosampler to bind and malfunction.

11.5.4.2 Extrude the soil sample from the Encore (or equivalent) sampler into the VOA vial.

11.5.4.3 Weigh the vial to the nearest 0.01 g

11.5.4.4 Record weight on the label and runlog.

11.5.4.5 Freeze sample until time of analysis.

11.5.4.6 Seal the vial.

11.5.4.7 Add 10 µL of surrogate through the septum to each sample and QC.

11.5.4.7.1 For samples designated for MS/MSD analysis, add 10 µL of spiking solution to the vials.

11.5.4.7.2 Prepare a Method Blank using 5.0 g of glass beads and 5mL of HPLC grade water. Add 10 µL of surrogate to the vial.

11.5.4.7.3 Prepare a LCS using 5.0 g glass beads, and 5 mL HPLC water. Add 10 µL of surrogate and 10 µL of spiking solution.

11.5.5 <u>If samples arrive in 40 mL VOA vial and require freezing as preservation</u>:

11.5.5.1 Freeze sample until time of analysis.

11.5.5.2 Add 5 mL of HPLC water

11.5.5.3 Seal the vial.

11.5.5.4 Add 10 µL of surrogate through the septum to each sample and QC.

11.5.5.4.1 For samples designated for MS/MSD analysis, add 10 µL of spiking solution to the vials.

11.5.5.4.2 Prepare a Method Blank using 5.0g of glass beads and 5mL of HPLC grade water. Add 10 µL of surrogate to the vial.

11.5.5.4.3 Prepare a LCS using 5.0 g glass beads, and 5 mL HPLC water. Add 5 µL of surrogate and 10 µL of spiking solution.

11.6 **Low-Level Soil Preparation (superceded 5030 method)**

11.6.1 See SOP ST-QA-0038 for the procedure for sub sampling.
11.6.2 Weigh 5 ± 0.05 g of the sample into a pre-weighed 40 mL glass labeled vial.
11.6.2.1 If the sample is suspected or known to have high concentrations of analytes, reduce the sample aliquot to 1.0 g
11.6.3 Record the weight.
11.6.4 Add 5 mL HPLC water
11.6.5 Seal the vial.
11.6.6 The above steps should be performed rapidly and without interruption to avoid loss of volatile organics.
11.6.7 Add 10 µL of surrogate standard through the septum.
11.6.7.1 Prepare a Method Blank using 5.0 g of glass beads and 5 mL of HPLC grade water. Add 10 µL of surrogate to the vial.
11.6.7.2 Prepare a LCS using 5.0g glass beads, 10 µL of surrogate and 10 µL of spiking solution.
11.6.7.3 For samples designated as for MS/MSD, add 10 µL of spiking solution.

11.7 **Methanol Extraction of Soils (5035A method)**

11.7.1 Extrude the (nominal) 5 g sample into a pre-weighed VOA vial containing 5mL methanol (25mL methanol for the 25 g sampler).
11.7.2 Obtain the weight of the soil added to the vial and note in preplog (Attachment 1).
11.7.3 Add 5 µL medium level surrogate to each sample and QC samples.
11.7.3.1 Prepare a Method Blank using 5.0 g of glass beads and 5 mL methanol. Add 5 µL of parent surrogate to the vial.
11.7.3.2 Prepare a LCS using 5.0 g glass beads, 5 mL of methanol , 5 µL of parent surrogate and 10 µL of spiking solution.
11.7.3.3 For the LCS and MS/MSD, add 100 µL medium level spike mix.
11.7.4 Using a vortex mixer, agitate sample for at least half a minute.

11.8 **Methanol Extraction of Soils (superceded 5030 method)**

11.8.1 See SOP ST-QA-0038 for the procedure for sub sampling.
11.8.2 Weigh 5 ± 0.05 g of the sample into a pre-weighed 40 mL glass labeled vial.
11.8.2.1 If the sample is suspected or known to have high concentrations of analytes, reduce the sample aliquot to 1.0 g
11.8.3 Record the weight in prep log (Attachment 1).
11.8.4 Seal the vial.
11.8.5 Add 5 mL of purge and trap methanol.
11.8.6 Add 5 µL medium level surrogate to each sample and QC samples.
11.8.6.1 Prepare a Method Blank using 5.0 g of glass beads and 5 mL methanol. Add 5µL of surrogate to the vial.
11.8.6.2 Prepare a LCS using 5.0 g glass beads, 5 mL methanol, 5 µL of surrogate and 20 µL of spiking solution.
11.8.6.3 For the MS/MSD, add 100 µL medium level spike mix.
11.8.7 Using a vortex mixer, agitate sample for at least half a minute.

11.9 **Volatile Analysis**:

11.9.1 Load each 40 mL VOA sample vial (and QC) in the purge and trap autosampler.
11.9.1.1 Medium Level Analysis
11.9.1.1.1 Rinse a glass-tight syringe with organic free water and fill the syringe with water. Bring volume to 5 mL add 5 µL of internal standards.

11.9.1.1.2 Add sample methanol extract to the syringe (no more than 100 µL for a 5 mL purge).
11.9.1.1.3 If less than 1 µL of methanol extract is to be added to the water, dilute the methanol extract using a serial dilution.
11.9.1.1.4 Transfer methanol extract/HPLC water in syringe to a labeled 40 mL VOA vial.

11.9.2 Record autosampler sample analysis sequence in logbook.
11.9.3 Start analysis.
11.9.4 After purging is complete, desorb the sample, start the GC temperature program, and begin data acquisition.
11.9.4.1 For method 524.2 the desorb time should be a minimum of 2 minutes.
11.9.5 After desorption, bake the trap for 5 – 10 minutes to condition it for the next analysis. When the trap is cool, it is ready for the next sample.
11.9.6 When the standards and extracts are not being used, refrigerate them at 4 $\pm$ 2 ^{o}C, protected from light in screw cap vials equipped with unpierced Teflon lined septa.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 Commonly used calculations (e.g. % recovery and RPD) and standard instrument software calculations are given in the TestAmerica ST-QAM.

12.2 Internal Standards
12.2.1 Samples that exhibit low IS recoveries < 50% or high IS recoveries > 100% are reanalyzed once to confirm matrix effect.

12.3 Manual Integrations
12.3.1 Identified compounds are reviewed for proper integration. Integrations are performed automatically by the data system. If necessary, manual integrations are performed and are documented by the analyst. Manual integrations are denoted with an "M" flag on the Target quantitation report. See TestAmerica Policy CA-Q-S-002, Acceptable Manual Integration Practices

12.4 Qualitative identification
12.4.1 An analyte is identified by retention time and by comparison of the sample mass spectrum with the mass spectrum of a standard of the suspected compound (standard reference spectrum). Mass spectra for standard reference may be obtained on the user's GC/MS by analysis of the calibration standards or from the NIST Library. Two criteria must be satisfied to verify identification:
12.4.1.1 Elution of sample component at the same GC retention time as the standard component; and
12.4.1.2 Correspondence of the sample component and the standard component characteristic ions.
12.4.1.2.1Note: Care must be taken to ensure that spectral distortion due to co-elution is evaluated.
12.4.2 The sample component retention time must compare to within ± 0.2 minutes. of the retention time of the standard component. For reference, the standard must be run within the same twelve hours as the sample.
12.4.3 All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) should be present in the sample spectrum.
12.4.4 The relative intensities of ions should agree to within ± 30% between the standard and sample spectra. (Example: For an ion with an abundance of 50% in the standard spectra, the corresponding sample abundance should be between 20 and 80%.)

12.4.5 If a compound cannot be verified by all the above criteria, but in the technical judgment of the analyst, the identification is correct, then the analyst shall report that identification and proceed with quantitation.

12.5 Retention time criteria for samples

12.5.1 If the retention time for any internal standard changes by more than 0.5 minutes from the last continuing calibration standard, the chromatographic system must be inspected for malfunctions and corrected. Reanalysis of samples analyzed while the system was malfunctioning is required.

12.5.2 If the retention time of any internal standard in any sample varies by more than 0.1 minute from the preceding continuing calibration standard, the data must be carefully evaluated to ensure that no analytes have shifted outside their retention time windows.

12.6 Tentatively Identified Compounds (TICs)

12.6.1 If the client requests components not associated with the calibration standards, a search of the NIST library may be made for the purpose of tentative identification. Guidelines are:

12.6.1.1 Relative intensities of major ions in the reference spectrum (ions > 10% of the most abundant ion) should be present in the sample spectrum.

12.6.1.2 The relative intensities of the major ions should agree to within 20%. (Example: If an ion shows an abundance of 50% in the standard spectrum, the corresponding sample ion abundance should be between 30% and 70%).

12.6.1.3 Molecular ions present in the reference spectrum should be present in the sample spectrum.

12.6.1.4 Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of co-eluting compounds.

12.6.1.5 Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the spectrum because of background contamination or co-eluting peaks. (Data system reduction programs can sometimes create these discrepancies.)

12.6.1.6 Computer-generated library search routines should not use normalization routines that would misrepresent the library or unknown spectra when compared to each other. Only after visual inspection of the sample with the nearest library searches should the analyst assign a tentative identification. Library searches of peaks present in the chromatogram that are not target compounds (Tentatively Identified Compounds, TIC) may be performed if required by the client.

12.6.1.7 The first 20 TICs will be identified in a sample, unless a different number is specified by the client. See client requirement sheet.

12.7 Dilutions

12.7.1 If the concentrations of any analytes exceed the working range as defined by the calibration standards, then the sample must be diluted and reanalyzed.

12.7.2 A dilution should target the most concentrated analyte in the upper half (over 50% of the high level standard) of the client specific project requirements.

12.7.2.1 Aqueous samples requiring less than a 1:1000 dilution can be diluted directly using a 5 mL syringe

12.7.2.2 Aqueous samples requiring less than a 1:5000 dilution can be diluted directly using a 25 mL syringe

12.7.2.3 Low level soil samples may re-analyzed using a 1 g sample aliquot or utilizing the methanol extraction technique.

12.8 Carryover

12.8.1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.
12.8.1.1 If a sample analyzed after a sample with high concentrations has negative results, carryover did not occur.
12.8.1.2 If a sample analyzed after a sample with high concentrations has positive results for the same analyses, carryover may have occurred.
12.8.1.2.1 This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred
12.8.1.3 If the chromatographic profile resembles the previous sample, the results are questionable.
12.8.1.3.1 This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

13.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA; CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

13.1 The data assessment and corrective action process is detailed through the LIMS Nonconformance Memorandum (NCM) process. The NCM process is described in SOP: ST-QA-0036..

13.2 Method Blank
13.2.1 Acceptance Criteria:
13.2.1.1 No target analytes may be present in the method blank above the reporting limit.
13.2.1.2 The method blank must have acceptable surrogate recoveries.
13.2.1.3 Corrective Action for Method Blanks not meeting acceptance criteria:
13.2.1.3.1 Method Blank Contamination – Blank contamination above the RL (>1/2 RL for some programs – see specific Client Requirement Memos for details) requires re-prep of batch unless all associated samples are < RL or greater than 10 times the amount detected in the method blank.
13.2.1.3.2 Method Blank Surrogate excursion – If excursion is limited to the blank, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-anlaysis is required. In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM.

13.3 Laboratory Control Sample (LCS)
13.3.1 Acceptance Criteria: All control analytes must be within established control limits for accuracy (%Recovery) and precision (RPD).
13.3.1.1 For long analyte spike list, marginal exceedances (ME) are allowed as follows:
13.3.1.2 less than 11 analytes in LCS, no analytes allowed in ME of the LCS control limit.
13.3.1.3 11-30 analytes in LCS, 1 analytes allowed in ME of the LCS control limit.
13.3.1.4 31-50 analytes in LCS, 2 analytes allowed in ME of the LCS control limit.
13.3.1.5 51-70 analytes in LCS, 3 analytes allowed in ME of the LCS control limit.
13.3.1.6 71-90 analytes in LCS, 4 analytes allowed in ME of the LCS control limit.
13.3.1.7 More than 90 analytes in LCS, 5 analytes allowed in ME of the LCS control limit.
13.3.1.8 No LCS recoveries may be outside the Marginal Exceedance limit.
13.3.1.9 Marginal exceedances must be random. If the same LCS analyte exceeds the control limit repeatedly, it is an indication of a systemic problem. The source of the error must be located and corrective action taken.
13.3.2 The LCS should have acceptable surrogate recoveries.
13.3.3 Corrective Action for LCS not meeting acceptance criteria:
13.3.3.1 LCS Spike Recovery excursion (high) – Samples that are non-detect may be reported with an NCM (unless prohibited by client requirements). Samples with detects for the analyte recovered high in the LCS are re-prepped and re-analyzed. .

In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM

13.3.3.2 LCS Spike Recovery excursion (low) – batch is re-prepped and re-analyzed.

13.3.3.3 LCS Surrogate Recovery excursion – If excursion is limited to the LCS, data may be reported with an NCM. If target analytes are in control in the LCS, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-analysis is required.

13.3.3.4 RPD excursion for LCS/LCSD – If target analytes recoveries are in control, data may be reported with an NCM

13.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

13.4.1 All analytes should be within established control limits for accuracy (%Recovery) and precision (RPD).

13.4.2 Corrective Action for MS/MSD not meeting acceptance criteria:

13.4.2.1 MS/MSD Spike Rec. excursion may not necessarily warrant corrective action other than narration. If affected analyte concentration in the original sample is greater than four times the amount spiked, percent recovery information is ineffective. Data is reported with an NCM. If the excursion is due to a physically evident matrix interference, the data is reported with an NCM (the physical interference must be described in the NCM). If there is no evidence of interference and the RPD as well as spike recoveries out outside limits out, sample re-prep and re-analysis are required.

13.5 Sample result evaluation

13.5.1 Dilutions

13.5.1.1 If the response for any compound exceeds the working range of the analytical system, a dilution of the extract is prepared and analyzed. An appropriate dilution should be in the upper half of the calibration range.

13.5.1.2 Dilution: Sample– An NCM is created when dilutions are required.

13.5.1.3 Dilution: Surrogate(s)/spikes diluted out– An NCM is generated to document the surrogates/spikes being diluted out.

13.5.2 Carryover

13.5.2.1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.

13.5.2.2 If a sample analyzed after a sample with high concentrations is non-detect for the high concentration analyted, carryover did not occur.

13.5.2.3 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, or if the chromatographic profile resembles the previous sample, the results are questionable. This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

13.5.3 Internal Standards

13.5.3.1 Acceptance Criteria:

13.5.3.1.1 If the EICP area for any of the internal standards in the calibration verification standard changes by a factor of two (-50% to +100%) from that in the mid-point standard level of the most recent initial calibration sequence.

13.5.3.1.2 If the EICP area for any of the internal standards in samples, spikes and blanks changes by a factor of two (-50% to +100%) from the areas determined in the continuing calibration analyzed that day, corrective action must be taken. The samples, spikes or blanks should be reanalyzed or the data should be qualified. (Some programs may require that the midpoint of the initial calibration be used for ISTD monitoring. See the project CRM for specifics.)

13.5.3.2 Corrective Action for Internal Standards not meeting acceptance criteria:

13.5.3.2.1 Internal Standard excursion – high – High ISTD recovery indicates a potential low bias to analytical results. Instrument maintenance, if required, is done and affected samples are reanalyzed. If ISTDs are outside criteria on the re-analysis, a matrix interference is suspected and data reported with an NCM.

13.5.3.3 Internal Standard excursion – low – Low ISTD recovery indicates the potential for a high bias to analytical results. Samples that are non-detect for affected analytes may be reported with an NCM. Samples with positive hits above the RL for analytes associated with the poor ISTD recovery require re-analysis. Instrument maintenance, if required, is done. If ISTDs are outside criteria on the re-analysis, a matrix interference is suspected and data reported with an NCM.

13.6 Insufficient Sample

13.6.1 For each prescribed re-preparation corrective action, if there is insufficient sample to repeat the analysis, an NCM is created and a narrative comment stating such is included in the report's Case Narrative.

14.0 METHOD PERFORMANCE AND DEMONSTRATION OF CAPABILITY

14.1 Method performance data, Reporting Limits, and QC acceptance limits, are maintained in the LIMS.

14.2 Demonstration of Capability

14.2.1 Initial and continuing demonstrations of capability requirements are established in the ST-QAM.

14.3 Training Qualification

14.3.1 The manager/supervisor has the responsibility to ensure that this procedure is performed by an analyst who has been properly trained in its use and has the required experience.

14.3.2 The analyst must have successfully completed the initial demonstration capability requirements prior to working independently. See requirements in the ST-QAM.

14.4 Annually, the analyst must successfully demonstrate proficiency to continue to perform this analysis. See requirements in the ST-QAM.

15.0 VALIDATION

15.1 Laboratory SOPs are based on published methods (EPA, DOE, ASTM, Eichrom, Standard Methods) and do not require validation by the laboratory. The requirements for laboratory demonstration of capability are included in the ST-ST-QAM. Laboratory validation data would be appropriate for performance based measurement systems, non-standard methods and significant modifications to published methods. Data from said validations is held in the QA department.

16.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

16.1 All waste will be disposed of in accordance with Federal, State and Local regulations. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in section 13 of the Corporate Safety Manual for "Waste Management and Pollution Prevention."

16.2 Waste Streams Produced by the Method

16.2.1 The following waste streams are produced when this method is carried out.

16.2.1.1 Acidic sample waste generated. All acidic waste will be accumulated in the appropriate waste accumulation container, labeled as Drum Type "A" or "B".

16.2.1.2 Solvent waste generated. Solvent waste must be accumulated in the appropriate waste accumulation container, labeled as Drum Type "D".

16.2.1.3 Contaminated disposable glass or plastic materials utilized in the analysis are disposed of in the sanitary trash. If the labware was used for the analysis of radioactive samples and contains radioactivity at a level of 100 cpm over background as determined by a GM meter, the labware will be collected in waste barrels designated for solid rad waste for disposal by the EH&S Coordinator.

17.0 REFERENCES

17.1 SW846, Test Methods for Evaluating Solid Waste, Third Edition, Gas Chromatography/Mass Spectrometry for Volatile Organics, Method 8000B, 8000C, 8260B and 8260C

17.2 40CFR Part 136: "Guidelines Establishing Test Procedures for the Analysis of Pollutants, Appendix A, "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", Code of Federal Regulations, Revised July1, 1995, Method 624

17.3 USEPA Drinking Water method 524.2

17.4 TestAmerica St. Louis Quality Assurance Manual (ST-QAM), current revision.

17.5 TestAmerica Corporate Environmental Health and Safety Manual (CW-E-M-001) and St. Louis Facility Addendum (ST-HS-0002), current revisions

17.6 TestAmerica Policy CA-Q-S-002, Acceptable Manual Integration Practices

13.7 TestAmerica Policy CA-T-P-002, Selection of Calibration Points

17.7 Associated SOPs

17.7.1 ST-OP-0001, Organic Labware Cleaning Procedure
17.7.2 ST-PM-0002, Sample Receipt and Chain of Custody
17.7.3 ST-QA-0002, Standard and Reagent Preparation
17.7.4 ST-QA-0005, Calibration and Verification Procedure for Thermometers, Balances, Weights and Pipettes.
17.7.5 ST-QA-0014, Evaluation of Analytical Accuracy and Precision Through the Use of Control Charts
17.7.6 ST-QA-0016, IDL/MDL Determination
17.7.7 ST-QA-0031, VOA Holding Blank Analysis
17.7.8 ST-QA-0036, Non-conformance Memorandum (NCM) Process

18.0 CLARIFICATIONS, MODIFICATIONS OF PREVIOUS REFERENCE METHOD

18.1 Modification to Reference Method 624

18.1.1 Ion 119 is used as the quantitation ion for chlorobenzene-d5 for 25 mL purge tests.
18.1.2 A retention time window of 0.2 minutes is used for all components, since some data systems do not have the capability of using the relative retention time units specified in the reference method.
18.1.3 The quantitation and qualifier ions for some compounds have been changed from those recommended in SW-846 in order to improve the reliability of qualitative identification.
18.1.4 Method 624 Section 5.2.2 of the source method describes the trap packing materials as Tenax GC, Methyl silicone, silica gel and coconut charcoal. TestAmerica routinely employs the Supelco K trap.

18.2 Modifications required for drinking water analysis by method 524.2

18.2.1 Only one internal standard — Fluorobenzene — is required for this method. The lab uses 3 ISTDs.

18.2.2 The same analysis run may be used to satisfy the requirements for an LCS (also known as a laboratory fortified blank, LFB) and a continuing calibration verification sample. The LCS/CCV does not need to be a second source standard.

18.2.3 524.2 Section 7.1 of the source method requires that the trap packing materials be Tenax GC, Methyl silicone, silica gel and coconut charcoal. TestAmerica routinely uses Supleco K trap

18.2.4 524.2 Section 7.8.2 of the source method requires that each calibration standard be prepared by diluting the appropriate volume of the working standard with organic-free water adjusted to pH < 2 in a volumetric flask. TestAmerica prepares calibration standards by diluting the appropriate volume of the working standard with organic-free water at neutral pH.

19.0 CHANGES FROM PREVIOUS REVISION

19.1 Section 9.1.5: Blank, LCS & MS/MSD must be run in same clock for non-medium level samples
19.2 Section 10.3.2: The number of calibration points required for curves is clarified
19.3 Section 10.3.6.6: notes added to address client requirements and y-intercept
19.4 Section 10.3.7.9.1: added six point requirement for all quadratic curves
19.5 Section 10.4.4.2: Added corrective action for ICV failure (use of third standard)
19.6 Section 10.3.7.9.3: added note addressing client specific requirements
19.7 Section 12.7.1.1: added CLP allowance for reporting data within 10% of upper standard without dilution
19.8 Table 2: added allowance of other published BFB Tune criteria (i.e. EPA CLP)
19.9 Added Attachment 1 – example page from VOA Medium Level Extraction log.
19.10 Revision 17:

19.10.1 Fixed grammatical errors throughout SOP
19.10.2 Updated section 9.1 regarding MS/MSD duplicates being performed for separate QC codes.
19.10.3 Updated section 10.5.7 regarding CCV criteria testing.
19.10.4 Removed section 10.5.8.3 regarding passing CCV percentage calibration points in the initial calibration curve.
19.10.5 Updated section 11.7 and 11.8 regarding volumes of medium level surrogate and medium level spike mix used.

19.11 Rev 18:

19.11.1 Added information for Select Ion Monitoring Procedure to Sections 2, 3 and Appendix 1

19.12 Rev 19:

19.12.1 Section 3, updated SIM definition
19.12.2 Clarified Section 9.3 stating that the LCS and CCV can be from the same source
19.12.3 References to QuantIMS and Clouseau were removed and replaced with “LIMS”
19.12.4 Section 12, updated Corp. SOP reference
19.12.5 Section 12.7.1.1: removed the CLP allowance for reporting data within 10% of upper standard without dilution
19.12.6 Section 13 was re-written to include specific corrective action scenarios.
19.12.7 Section 17, updated Corp. SOP reference
19.12.8 Formatting and grammatical corrections

Table 1

Internal Standards

	Standard Concentration µg/mL	Quantitation ion (5 mL purge)	Quantitation ion (25 mL purge)
Fluorobenzene	25	96	96
Chlorobenzene-d5	25	117	117
1,4-Dichlorobenzene-d4	25	152	152

Notes:

1) 10 µL of the internal standard is added to the sample. This results in a concentration of each internal in the sample of 50µg/L for a 5 mL purge or 10 µg/L for a 25 mL purge.
2) Surrogate and internal standards may be combined in one solution.

Surrogate and Spike concentrations are listed on the Structure and Analysis Codes, which are in the attachment to this SOP.

Table 2

BFB Key Ion Abundance Criteria

Mass	Ion Abundance Criteria
50	15% to 40% of Mass 95
75	30% to 60% of Mass 95
95	Base Peak, 100% Relative Abundance
96	5% to 9% of Mass 95
173	Less Than 2% of Mass 174
174	Greater Than 50% of Mass 95
175	5% to 9% of Mass 174
176	Greater Than 95%, But Less Than 101% of Mass 174
177	5% to 9% of Mass 176

- BFB tuning criteria for mass 75 are 30 – 80% of mass 95 for method 524.2
- Alternatively, other documented tuning criteria (e.g. EPA CLP) may be used provided method performance is not aversely affected

Table 3

Characteristic ions

Compound	Primary*	Secondary	Tertiary
1,2-Dichloroethane-d_4 (Surrogate)	67*	102*	65
Dichlorodifluoromethane	85	87	50, 101,103
Chloromethane	50	52	49
Vinyl chloride	62	64	61
Bromomethane	94	96	79
Chloroethane	64	66	49
Trichlorofluoromethane	101*	103*	66
1,1-Dichloroethene	96	61	63, 98

Characteristic ions

Compound	Primary*	Secondary	Tertiary
Acrolein	56	55	58
Iodomethane	142	127	141
Carbon disulfide	76	78	—
Trichlorotrifluoroethane	151	101	153
Acetone	58	43	—
Methylene chloride	84	86	49
tert-Butyl alcohol	59	74	—
trans-1,2-Dichloroethene	96	61	98
Acrylonitrile	53	52	51
Methyl *tert* butyl ether	73	57	—
Hexane	57	43	—
1,1-Dichloroethane	63	65	83
cis-1,2-Dichloroethene	96	61	98
2-Butanone	43*	72*	—
Tetrahydrofuran	71	42	72
Chloroform	83	85	47
1,2-Dichloroethane	62	98	64
Dibromomethane	93	95	172, 174, 176
1,4-Dioxane	88	58	43, 57
Vinyl acetate	43	86	—
1,1,1-Trichloroethane	97	99	117*
Carbon tetrachloride	117	119	121
Benzene	78	52	77
Trichloroethene	130*	95*	132
Methylcyclohexane	55	83	98
1,2-Dichloropropane	63	41*	—
Bromodichloromethane	83	85	129*
2-Chloroethyl vinyl ether	63	65	106
cis-1,3-Dichloropropene	75	77	39
trans-1,3-Dichloropropene	75	77	39
1,1,2-Trichloroethane	97*	83*	85
Chlorodibromomethane	129	127*	131*
Bromoform	173	171*	175*, 254
1,2,3-Trichloropropane	110*	77	75
Toluene-d_8 (Surrogate)	98	100	—
4-Bromofluorobenzene (Surrogate)	95	174	176
Toluene	91*	92*	65
4-Methyl-2-pentanone	43*	58*	85, 100
Tetrachloroethene	164	129	131, 166
Ethyl methacrylate	69	41	99, 86, 114

Characteristic ions

Compound	Primary*	Secondary	Tertiary
2-Hexanone	43	58	57, 100
Chlorobenzene	112	114	77
Ethylbenzene	91	106	—
Xylenes	106	91	—
Styrene	104	78	103
Dibromofluoromethane	113	111	192
Dichlorobenzene (all isomers)	146	111	148
trans 1,4-Dichloro-2-butene	53	88	75
1,1,2,2-Tetrachloroethane	83	85	131,133
Allyl Chloride	76	41	39, 78
Acetonitrile	41	40	39
Dichlorofluoromethane	67	69	—
Isopropyl ether	87	59	45
Chloroprene	53	88	90
n-Butanol	56	41	42, 43
Propionitrile	54	52	55
Methacrylonitrile	41	52	39
Isobutanol	43	42	74
Methyl methacrylate	41	69	39
1,1,1,2-Tetrachloroethane	131	133	119
1,2-Dibromo-3-chloropropane	157	155	75
Ethyl ether	59	74	—
Ethyl Acetate	43*	61*	88*
2-Nitropropane	46	43	—
Cyclohexanone	55	42	98
Isopropylbenzene	105	120	77
1,2-Dichlorobenzene	111	146	148
1,3-Dichlorobenzene	111	146	148
1,4-Dichlorobenzene	111	146	148
Nonanol	57	98	41
t-Butyl alcohol	59	41	—
1-Chlorohexane	91	55	43
Ethanol	45	46	—
TAME	73	87	43
ETBE	59	87	41
DIPE (Diisopropyl ether)	45	87	59
2,2-Dimethylpentane	45	46	—
2,4-Dimethylpentane	57	85	43
2,2,3-Trimethylbutane	57	43	85
3,3-Dimethylpentane	43	71	85

Characteristic ions

Compound	Primary*	Secondary	Tertiary
2-Methylhexane	43	57	85
2,3-Dimethylpentane	56	71	43
3-Methylhexane	43	57	71
3-Ethylpentane	43	71	55
Heptane	43	57	71
Dimethylsulfide	94	79	45
1,3,5-Trichlorbenzene	180	182	145

The primary ion should be used for quantitation unless interferences are present, in which case a secondary ion may be used.
*****Primary/secondary and/or tertiary ions are switched from order in Method based on signal intensity and co-elutions.

TABLE 4

RECOMMENDED MINIMUM RELATIVE RESPONSE FACTOR CRITERIA FOR INITIAL AND CONTINUING CALIBRATION VERIFICATION

Volatile Compounds	Minimum Response Factor
Dichlorodifluoromethane	0.100
Chloromethane	0.100
Vinyl chloride	0.100
Bromomethane	0.100
Chloroethane	0.100
Trichlorofluoromethane	0.100
1,1-Dichloroethene	0.100
1,1,2-Trichloro-1,2,2-trifluoroethane	0.100
Acetone	0.100
Carbon disulfide	0.100
Methyl Acetate	0.100
Methylene chloride	0.100
trans-1,2-Dichloroethene	0.100
cis-1,2-Dichloroethene	0.100
Methyl tert-Butyl Ether	0.100
1,1-Dichloroethane	0.200
2-Butanone	0.100
Chloroform	0.200
1,1,1-Trichloroethane	0.100
Cyclohexane	0.100
Carbon tetrachloride	0.100
Benzene	0.500
1,2-Dichloroethane	0.100
Trichloroethene	0.200
Methylcyclohexane	0.100
1,2-Dichloropropane	0.100
Bromodichloromethane	0.200
cis-1,3-Dichloropropene	0.200
trans-1,3-Dichloropropene	0.100
4-Methyl-2-pentanone	0.100
Toluene	0.400
1,1,2-Trichloroethane	0.100
Tetrachloroethene	0.200
2-Hexanone	0.100
Dibromochloromethane	0.100
1,2-Dibromoethane	0.100
Chlorobenzene	0.500
Ethylbenzene	0.100
meta-/para-Xylene	0.100
ortho-Xylene	0.300
Styrene	0.300
Bromoform	0.100
Isopropylbenzene	0.100
1,1,2,2-Tetrachloroethane	0.300
1,3-Dichlorobenzene	0.600
1,4-Dichlorobenzene	0.500
1,2-Dichlorobenzene	0.400
1,2-Dibromo-3-chloropropane	0.050
1,2,4-Trichlorobenzene	0.200

TestAmerica St. Louis has established a default minimum response factor of 0.01 for compounds not identified in this table, except for Acrolein, Acetonitrile, Isobutanol, Tetrahydrofuran, Propionitrile, n-butanol, 1,4-Dioxane, 2-

chloroethyl vinyl ether, Cyclohexanone, nonanol (25 mL purge) and Acrolein, Acetonitrile, Tetrahydrofuran, Propionitrile, Isobutanoln-butanol, 1,4-Dioxane, Cyclohexanone (5 mL purge), which have a minimum response factor of 0.001.

Table 5
Assigned Surrogates/Internal Standards for Instruments using Instrument MSG

Compound	Assigned Surrogate	Assigned Internal Standard
Dichlorodifluoromethane	Dibromofluoromethane	Fluorobenzene
Freon-114	Dibromofluoromethane	Fluorobenzene
Chloromethane	Dibromofluoromethane	Fluorobenzene
Vinyl Chloride	Dibromofluoromethane	Fluorobenzene
Bromomethane	Dibromofluoromethane	Fluorobenzene
Chloroethane	Dibromofluoromethane	Fluorobenzene
Trichlorofluoromethane	Dibromofluoromethane	Fluorobenzene
Diethyl Ether	Dibromofluoromethane	Fluorobenzene
1,1,2-Trichlorofluoroethane	Dibromofluoromethane	Fluorobenzene
Acrolein	Dibromofluoromethane	Fluorobenzene
Acetone	Dibromofluoromethane	Fluorobenzene
1,1-Dichloroethene	Dibromofluoromethane	Fluorobenzene
Acetonitrile	Dibromofluoromethane	Fluorobenzene
Iodomethane	Dibromofluoromethane	Fluorobenzene
Methyl Acetate	Dibromofluoromethane	Fluorobenzene
Allyl chloride	Dibromofluoromethane	Fluorobenzene
Carbon Disulfide	Dibromofluoromethane	Fluorobenzene
Methylene Chloride	Dibromofluoromethane	Fluorobenzene
Acrylonitrile	Dibromofluoromethane	Fluorobenzene
MTBE	Dibromofluoromethane	Fluorobenzene
trans-1,2-Dichloroethene	Dibromofluoromethane	Fluorobenzene
n-Hexane	Dibromofluoromethane	Fluorobenzene
1,1-Dichloroethane	Dibromofluoromethane	Fluorobenzene
1,2-Dichloroethene (total)	Dibromofluoromethane	Fluorobenzene
Vinyl acetate	Dibromofluoromethane	Fluorobenzene
2-Chloro-1,3-butadiene	Dibromofluoromethane	Fluorobenzene
2-Butoxyethanol	Dibromofluoromethane	Fluorobenzene
2-Butanone	Dibromofluoromethane	Fluorobenzene
Propionitrile	Dibromofluoromethane	Fluorobenzene
2,2-Dichloropropane	Dibromofluoromethane	Fluorobenzene
cis-1,2-Dichloroethene	Dibromofluoromethane	Fluorobenzene
Isobutanol	Dibromofluoromethane	Fluorobenzene
Ethyl Acetate	Dibromofluoromethane	Fluorobenzene

Compound	Assigned Surrogate	Assigned Internal Standard
Methacrylonitrile	Dibromofluoromethane	Fluorobenzene
Chloroform	Dibromofluoromethane	Fluorobenzene
Bromochloromethane	Dibromofluoromethane	Fluorobenzene
Tetrahydrofuran	Dibromofluoromethane	Fluorobenzene
n-butanol	1,2-Dichloroethane-d4	Fluorobenzene
1,1,1-Trichloroethane	1,2-Dichloroethane-d4	Fluorobenzene
Cyclohexane	1,2-Dichloroethane-d4	Fluorobenzene
1,1-Dichloropropene	1,2-Dichloroethane-d4	Fluorobenzene
Carbon Tetrachloride	1,2-Dichloroethane-d4	Fluorobenzene
Heptane	1,2-Dichloroethane-d4	Fluorobenzene
Benzene	1,2-Dichloroethane-d4	Fluorobenzene
1,2-Dichloroethane	1,2-Dichloroethane-d4	Fluorobenzene
Trichloroethene	1,2-Dichloroethane-d4	Fluorobenzene
Methyl cyclohexane	1,2-Dichloroethane-d4	Fluorobenzene
1,2-Dichloropropane	1,2-Dichloroethane-d4	Fluorobenzene
Methyl methacrylate	1,2-Dichloroethane-d4	Fluorobenzene
Bromodichloromethane	1,2-Dichloroethane-d4	Fluorobenzene
Dibromomethane	1,2-Dichloroethane-d4	Fluorobenzene
1,4-Dioxane	1,2-Dichloroethane-d4	Fluorobenzene
4-Methyl-2-pentanone (MIBK)	1,2-Dichloroethane-d4	Fluorobenzene
2-Chloroethyl vinyl ether	1,2-Dichloroethane-d4	Fluorobenzene
Cis-1,3-Dichloropropene	1,2-Dichloroethane-d4	Fluorobenzene
Dimethyl disulfide	1,2-Dichloroethane-d4	Fluorobenzene
2-Nitropropane	1,2-Dichloroethane-d4	Fluorobenzene
Toluene	Toluene-d8	Chlorobenzene-d5
trans-1,3-Dichloropropene	Toluene-d8	Chlorobenzene-d5
Ethyl methacrylate	Toluene-d8	Chlorobenzene-d5
1,1,2-Trichloroethane	Toluene-d8	Chlorobenzene-d5
2-Hexanone	Toluene-d8	Chlorobenzene-d5
1,3-Dichloropropane	Toluene-d8	Chlorobenzene-d5
Tetrachloroethene	Toluene-d8	Chlorobenzene-d5
Chlorodibromomethane	Toluene-d8	Chlorobenzene-d5
1,2-Dibromoethane	Toluene-d8	Chlorobenzene-d5
Chlorobenzene	Toluene-d8	Chlorobenzene-d5
1,1,1,2-Tetrachloroethane	Toluene-d8	Chlorobenzene-d5
Ethylbenzene	Toluene-d8	Chlorobenzene-d5
m,p-Xylenes	Toluene-d8	Chlorobenzene-d5
o-Xylenes	Toluene-d8	Chlorobenzene-d5
Styrene	Toluene-d8	Chlorobenzene-d5

Compound	Assigned Surrogate	Assigned Internal Standard
Bromoform	Toluene-d8	Chlorobenzene-d5
Isopropylbenzene	Toluene-d8	Chlorobenzene-d5
Cyclohexanone	Toluene-d8	Chlorobenzene-d5
1,1,2,2-Tetrachloroethane	Toluene-d8	Chlorobenzene-d5
1,2,3-Trichloropropane	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Bromobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
n-Propylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
trans-1,4-dichlorobenzene-2-butene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
2-Chlorotoluene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,3,5-Trimethylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
4-Chlorotoluene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
t-Butylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Pentachloroethane	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2,4-Trimethylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
sec-Butylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
4-Isopropyltoluene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,3-Dichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,4-Dichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
n-Butylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2-Dichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Nonanal	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2-Dibromo-3-chloropropane	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,3,5-trichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2,4-Trichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Hexachlorobutadiene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Naphthalene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2,3-Trichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
4-Chlorophenyl methyl sulfide	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4

Assigned Surrogates/Internal Standards for Instruments using Instruments MSF, MSL, MSM, MSN

Compound	Assigned Surrogate	Assigned Internal Standard
Dichlorodifluoromethane	Dibromofluoromethane	Fluorobenzene
Freon-114	Dibromofluoromethane	Fluorobenzene
Chloromethane	Dibromofluoromethane	Fluorobenzene

Compound	Assigned Surrogate	Assigned Internal Standard
Vinyl Chloride	Dibromofluoromethane	Fluorobenzene
Bromomethane	Dibromofluoromethane	Fluorobenzene
Chloroethane	Dibromofluoromethane	Fluorobenzene
Trichlorofluoromethane	Dibromofluoromethane	Fluorobenzene
Diethyl Ether	Dibromofluoromethane	Fluorobenzene
1,1-Dichloroethene	Dibromofluoromethane	Fluorobenzene
1,1,2-Trichlorofluoroethane	Dibromofluoromethane	Fluorobenzene
Carbon Disulfide	Dibromofluoromethane	Fluorobenzene
Iodomethane	Dibromofluoromethane	Fluorobenzene
Acrolein	Dibromofluoromethane	Fluorobenzene
Allyl chloride	Dibromofluoromethane	Fluorobenzene
Methylene Chloride	Dibromofluoromethane	Fluorobenzene
Acetone	Dibromofluoromethane	Fluorobenzene
Methyl Acetate	Dibromofluoromethane	Fluorobenzene
trans-1,2-Dichloroethene	Dibromofluoromethane	Fluorobenzene
n-Hexane	Dibromofluoromethane	Fluorobenzene
Acetonitrile	Dibromofluoromethane	Fluorobenzene
MTBE	Dibromofluoromethane	Fluorobenzene
2-Chloro-1,3-butadiene	Dibromofluoromethane	Fluorobenzene
1,1-Dichloroethane	Dibromofluoromethane	Fluorobenzene
1,2-Dichloroethene (total)	Dibromofluoromethane	Fluorobenzene
Acrylonitrile	Dibromofluoromethane	Fluorobenzene
Vinyl acetate	Dibromofluoromethane	Fluorobenzene
cis-1,2-Dichloroethene	Dibromofluoromethane	Fluorobenzene
2,2-Dichloropropane	Dibromofluoromethane	Fluorobenzene
Bromochloromethane	Dibromofluoromethane	Fluorobenzene
2-Butoxyethanol	Dibromofluoromethane	Fluorobenzene
Cyclohexane	Dibromofluoromethane	Fluorobenzene
Chloroform	Dibromofluoromethane	Fluorobenzene
t-Butyl Alcohol	Dibromofluoromethane	Fluorobenzene
Diisopropyl Ether	Dibromofluoromethane	Fluorobenzene
ETBE	Dibromofluoromethane	Fluorobenzene
Ethanol	Dibromofluoromethane	Fluorobenzene
2,2-Dimethylpentane	Dibromofluoromethane	Fluorobenzene
2,4-Dimethylpentane	Dibromofluoromethane	Fluorobenzene
2,2,3-Trimethylbutane	Dibromofluoromethane	Fluorobenzene
3,3-Dimethylpentane	Dibromofluoromethane	Fluorobenzene
Ethyl Acetate	Dibromofluoromethane	Fluorobenzene
Carbon Tetrachloride	Dibromofluoromethane	Fluorobenzene

Compound	Assigned Surrogate	Assigned Internal Standard
Tetrahydrofuran	Dibromofluoromethane	Fluorobenzene
1,1,1-Trichloroethane	1,2-Dichloroethane-d4	Fluorobenzene
2-Butanone	1,2-Dichloroethane-d4	Fluorobenzene
1,1-Dichloropropene	1,2-Dichloroethane-d4	Fluorobenzene
Heptane	1,2-Dichloroethane-d4	Fluorobenzene
Benzene	1,2-Dichloroethane-d4	Fluorobenzene
Propionitrile	1,2-Dichloroethane-d4	Fluorobenzene
Methacrylonitrile	1,2-Dichloroethane-d4	Fluorobenzene
Isobutanol	1,2-Dichloroethane-d4	Fluorobenzene
1,2-Dichloroethane	1,2-Dichloroethane-d4	Fluorobenzene
Trichloroethene	1,2-Dichloroethane-d4	Fluorobenzene
Methyl cyclohexane	1,2-Dichloroethane-d4	Fluorobenzene
n-butanol	1,2-Dichloroethane-d4	Fluorobenzene
Dibromomethane	1,2-Dichloroethane-d4	Fluorobenzene
1,2-Dichloropropane	1,2-Dichloroethane-d4	Fluorobenzene
Bromodichloromethane	1,2-Dichloroethane-d4	Fluorobenzene
Methyl methacrylate	1,2-Dichloroethane-d4	Fluorobenzene
1,4-Dioxane	1,2-Dichloroethane-d4	Fluorobenzene
Cis-1,3-Dichloropropene	1,2-Dichloroethane-d4	Fluorobenzene
2-Chloroethylvinyl ether	1,2-Dichloroethane-d4	Fluorobenzene
TAME	1,2-Dichloroethane-d4	Fluorobenzene
2-Methylhexane	1,2-Dichloroethane-d4	Fluorobenzene
2,3-Dimethylpentane	1,2-Dichloroethane-d4	Fluorobenzene
3-Methylhexane	1,2-Dichloroethane-d4	Fluorobenzene
3-Ethypentane	1,2-Dichloroethane-d4	Fluorobenzene
Heptane	1,2-Dichloroethane-d4	Fluorobenzene
Toluene	Toluene-d8	Chlorobenzene-d5
Dimethyl Disulfide	Toluene-d8	Chlorobenzene-d5
2-Nitropropane	Toluene-d8	Chlorobenzene-d5
4-Methyl-2-pentanone (MEK)	Toluene-d8	Chlorobenzene-d5
trans-1,3-Dichloropropene	Toluene-d8	Chlorobenzene-d5
Tetrachloroethene	Toluene-d8	Chlorobenzene-d5
Ethyl methacrylate	Toluene-d8	Chlorobenzene-d5
1,1,2-Trichloroethane	Toluene-d8	Chlorobenzene-d5
Chlorodibromomethane	Toluene-d8	Chlorobenzene-d5
1,3-Dichloropropane	Toluene-d8	Chlorobenzene-d5
1,2-Dibromoethane	Toluene-d8	Chlorobenzene-d5
2-Hexanone	Toluene-d8	Chlorobenzene-d5
Ethylbenzene	Toluene-d8	Chlorobenzene-d5

Compound	Assigned Surrogate	Assigned Internal Standard
Chlorobenzene	Toluene-d8	Chlorobenzene-d5
1,1,1,2-Tetrachloroethane	Toluene-d8	Chlorobenzene-d5
m,p-Xylenes	Toluene-d8	Chlorobenzene-d5
o-Xylenes	Toluene-d8	Chlorobenzene-d5
Styrene	Toluene-d8	Chlorobenzene-d5
1-Chlorohexane	Toluene-d8	Chlorobenzene-d5
Bromoform	Toluene-d8	1,4-Dichlorobenzene-d4
Isopropylbenzene	Toluene-d8	1,4-Dichlorobenzene-d4
n-Propylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,1,2,2-Tetrachloroethane	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Bromobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,3,5-Trimethylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
2-Chlorotoluene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
trans-1,4-dichlorobenzene-2-butene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2,3-Trichloropropane	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
4-Chlorotoluene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Cyclohexanone	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
t-Butylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2,4-Trimethylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Pentachloroethane	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
sec-Butylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
4-Isopropyltoluene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,3-Dichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,4-Dichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
n-Butylbenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2-Dichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,3,5-trichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2-Dibromo-3-chloropropane	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Hexachlorobutadiene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2,4-Trichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
Naphthalene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
1,2,3-Trichlorobenzene	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4
4-Chlorophenyl methyl sulfide	4-Bromofluorobenzene	1,4-Dichlorobenzene-d4

Attachment 1
Medium Level Soil Extraction Log

Analyst: _____ Extraction Date: _____

Methanol Lot ID: _____ Batch # _____

Balance ID: _____

The final volume of all extracts is 5 mL of methanol.
All weights are expressed in grams.

Sample ID	Sample Weight	Methanol volume	Sample spiked	Spike verification

QC Standards: LCS/MS/MSD_____

Surrogate_____

Appendix 1

1,4-Dioxane 8260C SIM Method

Standards

Internal Standard Working Mix 1,4-Dioxane-d8 50 ppm

Calibration Standard Working Mix 1,4-Dioxane 50 ppm

8260 IS Working Mix 8260 IS 1 ppm

Calibration Table

Level	1,4-Diox. Mix in 5ml	1,4-Diox. Mix in 20ml	d8-1,4-Diox in 20ml	8260 IS Mix in 20ml
5 ppb	0.5 µL	2µL	40 µL	10 µL
10 ppb	1.0 µL	4µL	40 µL	10 µL
20 ppb	2.0 µL	8µL	40 µL	10 µL
50 ppb	5.0 µL	20µL	40 µL	10 µL
100 ppb	10 µL	40 µL	40 µL	10 µL
200 ppb	20 µL	80 µL	40 µL	10 µL

d8-1,4-Dioxane IS concentration in sample 100 ppb

1,4-Dioxane ICV/LCS/MS/MSD concentration 20 ppb

8260 IS concentration in samples 0.5 ppb

Need MDL verification after BFB of each clock 2 ppb (based on current MDL 0.74 ppb)

Spike d8-1,4-Dioxane **and** 8260 IS in all analyses

GC/MS Method – 8260SIM Concentrator Method – 8260SIM

Title: GC/MS SEMIVOLATILES ANALYSIS [SW-846 8270D; EPA 625]

Approvals (Signature/Date):

Ben Hicks 5/2/13	Michael Ridenhower 5/2/13
Ben Hicks Date	Michael Ridenhower Date
Organics Manager	Health & Safety Manager / Coordinator
Marti Ward 5/2/13	Elaine Wild 5/2/13
Marti Ward Date	Elaine Wild Date
Quality Assurance Manager	Laboratory Director

This SOP was previously identified as SOP No. ST-MS-0001 Rev. 14

Facility Distribution No.: 0 **Distributed To: See Electronic Distribution Sheet**

1.0 SCOPE AND APPLICATION

1.1 This SOP is applicable to the determination of the concentration of semivolatile organic compounds in extracts prepared from solid and aqueous matrices

1.2 This SOP is based on SW-846 Method 8000B, 8000C and 8270D and EPA method 625.

1.3 The following compounds are documented in the method as problematic:

1.3.1 Benzidine can be subject to oxidative losses during solvent concentration and exhibits poor chromatography. Neutral extraction should be performed if this compound is expected.

1.3.2 Hexachlorocyclopentadiene is subject to thermal decomposition in the inlet of the gas chromatograph, chemical reaction in acetone solution, and photochemical decomposition.

1.3.3 Pentachlorophenol, 2,4-dinitrophenol, 4-nitrophenol, 4,6-dinitro-2-methylphenol, 4-chloro-3-methylphenol, benzoic acid, 2-nitroaniline, 3-nitroaniline, 4-chloroaniline, and benzyl alcohol are subject to erratic chromatographic behavior, especially if the GC system is contaminated with high boiling material.

1.3.4 Hexachlorophene may not be amenable to analysis by this method.

1.4 N-Nitrosodiphenylamine decomposes in the gas chromatographic inlet and cannot be distinguished from Diphenylamine.

1.5 3-Methylphenol cannot be separated from 4-Methylphenol by the conditions specified in this method.

1.6 Phthalic acid decomposes in the gas chromatographic inlet and cannot be distinguished from Phthalic anhydride.

1.7 Azobenzene is formed by decomposition of 1,2-diphenlyhydrazine. If 1,2-diphenylhydrazine is requested, it will be reported as Azobenzene.

1.8 The laboratory target analytes supported by this method, the reporting limits, method detection limits and QC limits are maintained in the Laboratory Information Management System (LIMS).

1.8.1 Additional compounds may be amendable to this method. The minimum requirement for non-standard analytes is that the reporting limit be set at the lowest required concentration that can actually be detected by the instrument, and when an MDL study can not be conducted, the MDL be set equal to the reporting limit.

2.0 SUMMARY OF METHOD

2.1 Aqueous samples are extracted with methylene chloride using a separatory funnel. Solid samples are extracted with methylene chloride / acetone using sonication. Waste dilution is used for organic or unusual matrix samples. The sample extract is concentrated to a volume of 1 mL or 10 mL, and analyzed by GC/MS. Qualitative identification of the parameters in the extract is performed using the retention time and the relative abundance of characteristic ions. Quantitative analysis is performed using the internal standard technique with a single characteristic ion.

2.2 The use of selected ion monitoring (SIM) is acceptable for applications requiring quantitation limits below the normal range of electro impact mass spectrometry. However, SIM may provide a lesser degree of confidence in the compound identification, since less mass spectral information is available. Instead of scanning everything in a retention time range, SIM looks for specific ions (qualitative and quantitative) that are placed in retention time groups. The ions used for qualitative and quantitative purposes are the same for scan and SIM analysis.

3.0 DEFINITIONS

3.1 See the TestAmerica St. Louis Quality Assurance Manual (QAM) for a glossary of common laboratory terms and data reporting qualifiers.
3.2 SIM –Selected Ion Monitoring

4.0 INTERFERENCES

4.1 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other processing apparatus that lead to discrete artifacts. All of these materials must be routinely demonstrated to be free from interferences under conditions of the analysis by running laboratory method blanks as described in the Quality Control section. Raw GC/MS data from all blanks, samples, and spikes must be evaluated for interferences. If an interference is detected it is necessary to determine if the source of interference is in the preparation and/or cleanup of the samples; then take corrective action to eliminate the problem.

4.2 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending upon the nature of the sample.

4.3 Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe must be rinsed with solvent between samples. Whenever an unusually concentrated sample is encountered, it should be followed by the analysis of solvent to check for cross contamination.

4.4 Phthalate contamination is commonly observed in this analysis and its occurrence should be carefully evaluated as an indicator of a contamination problem in the sample preparation step of the analysis.

5.0 SAFETY

5.1 Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001), Radiation Safety Manual and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.2 **SPECIFIC SAFETY CONCERNS OR REQUIREMENTS**

5.2.1 Latex and vinyl gloves provide no protection against the organic solvents used in this method. Nitrile, Silver Shield, or similar gloves must be used.

5.2.2 The gas chromatograph and mass spectrometer contain zones that have elevated temperatures. The analyst needs to be aware of the locations of those zones, and must cool them to room temperature prior to working on them.

5.2.3 The mass spectrometer is under deep vacuum. The mass spectrometer must be brought to atmospheric pressure prior to working on the source.

5.2.4 There are areas of high voltage in both the gas chromatograph and the mass spectrometer. Depending on the type of work involved, either turn the power to the instrument off, or disconnect it from its source of power.

5.3 PRIMARY MATERIALS USED

5.3.1 The following is a list of the materials used in this method, which have a serious or significant hazard rating. NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Methylene Chloride	Carcinogen Irritant	25 ppm (TWA) 125 ppm (STEL)	Causes irritation to respiratory tract. Has a strong narcotic effect with symptoms of mental confusion, light-headedness, fatigue, nausea, vomiting and headache. Causes irritation, redness and pain to the skin and eyes. Prolonged contact can cause burns. Liquid degreases the skin. May be absorbed through skin.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			
TWA – Time Weighted Average			
STEL – Short Term Exposure Limit			

6.0 EQUIPMENT AND SUPPLIES

6.1 Gas Chromatograph/Mass Spectrometer System: HP 6890/5973 - An analytical system complete with a temperature-programmable gas chromatograph suitable for split/splitless injection and all required accessories, including syringes, analytical columns, and gases. The capillary column should be directly coupled to the source. Capable of scanning from 35 to 500 AMU every one second or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer must be capable of producing a mass spectrum for decafluorotriphenylphosphine (DFTPP) which meets all of the criteria in Table 1 when 50 ng of the GC/MS tuning standard is injected through the GC.

6.2 Data System:

6.2.1 ChemStation software system that allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the length of the chromatographic program.

6.2.2 Target software system allows the searching of any GC/MS data file for ions of a specified mass and plots such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP). The software allows integrating the abundances in any EICP for a specified time or scan-number limit. Also, for the non-target compounds with a mass spectrum that meets the required criteria, software must be available that allows for the comparison of sample spectra against the reference library spectra.

6.2.3 Data Library: NIST05

6.3 Carrier gas: Ultra high purity helium

6.4 Instrument columns and run conditions are posted in the instrument area.

6.5 Amber vials. Crimp top seals

6.6 Disposal pipettes

6.7 Micro syringes- 10µL, 250µL, 500µL, 1000µL. Hamilton 1700 series, Agilent Gold Standard

6.8 Volumetric flasks, Class A

6.9 Analytical Balance, capable of weighing ± 0.01 grams.

7.0 REAGENTS AND STANDARDS

7.1 All standards and reagent preparation, documentation and labeling must follow the requirements of SOP ST-QA-0002, current revision.

7.2 See recipes for standards and QC samples in the Reagent Log program.

7.3 At a minimum, a five point calibration curve is prepared. The low point should be at or below the reporting limit. Refer to Table 3 for typical calibration levels for all analytes. Other calibration levels may be used, depending on instrument capability, but the low standard must support the reporting limit and the high standard defines the range of the calibration.

7.4 An Internal Standard (IS) solution is prepared. Compounds in the I.S. Mix are: acenaphthene-d10, chrysene-d12, 1,4-dichlorobenzene-d4, naphthalene-d8, perylene-d12, and phenanthrene-d10.

7.5 Internal Standards are added to all standards and extracts to result in 40 ng injected onto the column. SIM Analysis Internal Standards are added to all standards and extracts to result in 4 ng injected onto the column.

7.6 GC/MS Tuning Standard: A methylene chloride solution containing 50 µg/mL of decafluorotriphenylphosphine (DFTPP) is prepared.

7.7 ICV standards, NIST traceable:

7.7.1 The Semivolatile ICV standard is a second source from the calibration standard, where second source is available.

7.7.2 ICV standard is prepared and stored in the same way as calibration standards.

7.8 Standards are to be refrigerated at $\leq 6^{o}C$ when not in use. Refrigeration at $-10^{o}C$ to $-20^{o}C$ may be used if it can be demonstrated that analytes do not fall out of solution at this temperature. The standards must be replaced at least 6 months after opening.

8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1 TestAmerica St. Louis supplies sample containers and chemical preservatives in accordance with the method. TestAmerica St. Louis does not perform sample collection. Samplers should reference the methods referenced and other applicable sample collection documents for detailed collection procedures. Sample volumes and preservative information is given in ST-PM-0002.

8.2 Water samples are collected in amber glass, unpreserved and stored at 4 ± 2°C.

8.3 Soil samples are refrigerated at 4 ± 2°C.

8.4 The extraction holding time for Semivolatiles analysis in waters is 7 days.

8.5 The extraction holding time for Semivolatiles in soil/solid matrix is 14 days.

8.6 Extracts must be refrigerated at $\leq 6^{o}C$ and analyzed within 40 days of the beginning of the extraction.

9.0 QUALITY CONTROL

9.1 Batch

9.1.1 A sample batch is a maximum of 20 environmental samples, which are prepared together using the same process and same lot(s) of reagents.

9.1.2 Instrument conditions must be the same for all standards, samples and QC samples.

9.1.3 For this analysis, batch QC consists of a method blank, a Laboratory Control Sample (LCS), and Matrix Spike (MS)/ Matrix Spike Duplicate (MSD). In the event that there is insufficient sample to analyze a MS/MSD, an LCS Duplicate (LCSD) is prepared and analyzed.

9.2 **Method Blank (MB)**

9.2.1 A method blank is a blank matrix processed simultaneously with, and under the same conditions as, samples through all steps of the procedure.
9.2.2 A method blank must be prepared with every sample batch.
9.2.3 DI water is used for the Method Blank.

9.3 **Laboratory Control Sample (LCS)**
9.3.1 An LCS is a blank matrix spiked with a known amount of analyte(s), processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.
9.3.2 An LCS must be prepared with every sample batch.
9.3.3 The LCS is comprised of sodium sulfate fortified with the target analyte(s).

9.4 **Matrix Spike (MS) /Matrix Spike Duplicate (MSD)**
9.4.1 A Matrix Spike is an aliquot of a field sample to which a known amount of target analyte(s) is added, and is processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.5 **Surrogate**
9.5.1 A surrogate is a non-target analyte similar in chemical composition and behavior, which mimics the target analytes during preparation, extraction and analysis.
9.5.2 Surrogate(s) is added to every field sample, method blank, LCS and MS/MSD for analysis at the beginning of the sample preparation process.

9.6 **Procedural Variations/ Nonconformance and Corrective Action**
9.6.1 Any variation shall be completely documented using a Nonconformance Memo and approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.
9.6.2 Any deviations from QC procedures must be documented as a nonconformance, with applicable cause and corrective action approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Internal standard calibration is used.
10.1.1 Internal Standard Calibration Procedure: Internal standards are listed in Table 5. Use the base peak m/z as the primary m/z for quantitation of the standards. If interferences are noted, use one of the next two most intense masses for quantitation.
10.1.1.1 Compounds are assigned to the IS, generally with the closest retention time. See Table 5.

10.2 **Instrument Tuning**
10.2.1 The GC/MS system must be checked to see if acceptable performance criteria are achieved for DFTPP (decafluorotriphenylphosphine). See Table 1 in this SOP.
10.2.1.1 The DFTPP and calibration verification standard may be combined into a single standard as long as both tuning and calibration verification acceptance criteria for the project can be met without interferences.
10.2.1.2 **8270** - At the beginning of every twelve hour shift
10.2.1.3 **625** - At the beginning of every 24 hour shift.
10.2.1.3.1 The time period begins at the moment of injection of DFTPP.
10.2.2 Inject 50 ng of the GC/MS tuning standard into the GC/MS system. Obtain a background-corrected mass spectrum of DFTPP and confirm that all the key m/z criteria in Table 1 are achieved The performance criteria must be achieved before any samples, blanks, or standards are analyzed.
10.2.3 Degradation of DDT to DDE and DDD should not exceed 20%.

$$\% \text{ breakdown of DDT} = \frac{\text{sum of degradation peak areas (DDD \% DDE)}}{\text{sum of all peak areas (DDT \% DDE \% DDD)}} \times 100$$

10.2.4 Benzidine and pentachlorophenol should be present at their normal responses, and should not exceed a tailing factor of 2 given by the following equation:

$$\text{Tailing Factor} = BC/AB$$

Where the peak is defined as follows:

AC is the width at 10% height; DE is the height of peak and B is the height at 10% of DE. This equation compares the width of the back half of the peak to the width of the front half of the peak at 10% of the height.

10.3 **Initial Calibration**

10.3.1 Prepare calibration standards at a minimum of five concentration levels, six points for a quadratic fit, (see Table 3 for suggested concentrations) for each parameter of interest. It may be useful to analyze six calibration levels and use the lower five for most analytes and the upper five for analytes that have poor response. The low level standard should be at or below the reporting limit. The other standards define the working range of the detector.

10.3.2 Add the internal standard mixture to result in 40 ng on column. The concentrations of all analytes are listed in Table 3. Add the internal standard mixture to result in 4ng on column for SIM analysis.

10.3.3 Analyze each calibration standard and tabulate the area of the primary characteristic m/z against concentration for each compound and internal standard. The low level standard must be at or below the reporting limit.

10.3.4 Except in specific instances, it is NOT acceptable to remove points from a calibration curve for the purpose of meeting criteria. Refer to the TestAmerica corporate policy, "Calibration Curves."

10.3.5 It may be necessary to analyze more than one set of calibration standards to encompass all of the analytes required for some tests.

10.3.6 A new calibration curve must be generated after major changes to the system and may be required when the continuing calibration criteria cannot be met. Major changes include new columns, any significant changes in instrument operating parameters, and major instrument maintenance (e.g., cleaning the ion source).

10.3.7 Sample peak areas are compared to peak areas of the standards. The ratio of the detector response to the amount concentration of analyte in the calibration standard is defined as the response factor (RF) or calibration factor (CF).

10.3.8 **Initial Calibration Criteria (8270D)**

10.3.8.1 Minimum Response Factors

10.3.8.2 See Table 4 in this SOP for the minimum response factors. These minimum response factors are prescribed by SW method 8270D. For analytes not given a minimum response factor by the method, St. Louis has established a default minimum response factor of 0.01 for compound, except for Famphur, Hexachlorophene, Kepone, Phthalic Anhydride which have a minimum response factor of 0.001.

10.3.8.2.1 SW-846 chromatographic methods allow the use of both linear and non-linear models for the calibration data.

10.3.8.3 The first way is to begin with the simplest approach, the linear model through the origin, and then progress through other options until the calibration acceptance criteria are met. The second way is to use technical knowledge of the detector response to the target compound to choose the calibration model.

10.3.8.4 The option for non-linear calibration may be necessary to address specific instrumental techniques. However, it is not EPA's intent to allow non-linear calibration to be used to compensate for detector saturation or to avoid proper instrument maintenance.

10.3.8.5 **Linear calibration using the average response factor**

10.3.8.5.1 The Relative Standard Deviation (RSD) of the calibration points from the curve used must be ≤ 20% for each target analyte.

10.3.8.5.2 If the %RSD in the initial calibration is > 20%, then calibration using a linear regression may be employed.

10.3.8.6 **Linear calibration using a least squares regression**

. The intercept of a linear calibration at zero response (i.e. the y-intercept) must have an absolute value less than the reporting limit for each analyte. Client requirements may be tighter, please check Client Requirement Memorandum (CRM) if identified in comments.

Note, for analyses utilizing an internal standard the Target variable "b" does NOT equal the y-intercept. For analyses utilizing an internal standard, the Target variable "b" must be multiplied by the associated internal standard concentration to derive the concentration at the y-intercept.

10.3.8.6.1 r (correlation coefficient) must be ≥ 0.995 OR r^2 (coefficient of difference) must be ≥ 0.990.

10.3.8.6.2 When calculating the calibration curves using the linear regression model, a minimum quantitation check on the viability of the lowest calibration point should be performed by re-fitting the response from the low concentration calibration standard back into the curve.

10.3.8.6.3 It is not necessary to re-analyze a low concentration standard; rather the data system can recalculate the concentrations.

10.3.8.6.4 The recalculated concentration of the low calibration point should be within ± 30% of the standard's true concentration.

10.3.8.6.4.1 Analytes which do not meet the minimum quantitation calibration re-fitting criteria should be considered "out of control" and corrective action should be taken.

10.3.8.7 **Linear calibration using a least squares regression, forcing thru zero**

10.3.8.7.1 Forcing the curve through zero is not the same as including the origin as a fictitious point in the calibration. In essence, if the curve is forced through zero, the intercept is set to 0 *before* the regression is calculated, thereby setting the bias to favor the low end of the calibration range by "pivoting" the function around the origin to find the best fit and resulting in one less degree of freedom. It may be appropriate to force the regression though zero for some calibrations.

10.3.8.7.2 Curve must still meet criteria in 10.3.8.6.1 and 10.3.8.6.2

10.3.8.7.3 For samples requiring adherence to method 8000B, forcing through zero is ***NOT*** allowed.

10.3.8.8 **Linear calibration using a least squares regression, weighting of data points**

10.3.8.8.1 In linear, the points at the lower end of the calibration curve have less absolute variance than points at the high concentration end of the curve. This can cause severe errors in quantitation at the low end of the calibration; for this reason it may be preferable to increase the weighting of the lower concentration points, $1/Concentration^2$ weighting (often called $1/X^2$ weighting), to improve accuracy at the low end of the curve.

10.3.8.8.2 Curve must still meet criteria in 10.3.8.6.1 and 10.3.8.6.2

10.3.8.9 **Non-linear calibration**

10.3.8.9.1 In situations where the analyst knows that the instrument response does not follow a linear model over a sufficiently wide working range, or when the other approaches have not met the acceptance criteria, a non-linear calibration model may be employed.

10.3.8.9.2 It is not EPA's intent to allow non-linear calibration to be used to compensate for detector saturation or to avoid proper instrument maintenance. Thus, non-

linear calibrations are not to be employed for analytes shown to consistently exhibit linear calibration for the analytes of interest.

10.3.8.9.2.1 These compounds are not to use non-linear calibrations:
1,4-Dioxane; Pyridine; n-Nitrosodimethylamine; 2-Fluorophenol; Aniline; Bis(2-chloroethyl)ether; Phenol-d5; Phenol; 2-Chlorophenol; 1,3-Dichlorobenzene; 1,4-Dichlorobenzene; 1,2-Dichlorobenzene; Benzyl Alcohol; 2-Methylphenol; N-nitrosodinpropylamine; Hexachloroethane; 3 and 4-Methylphenol; Nitrobenzene-d5; Nitrobenzene; Isophorone; 2-Nitrophenol; 2,4-Dimethylphenol; Bis(2-chloroethoxy) methane; 2,4- Dichlorophenol; 1,2,4-Trichlorobenzene; Naphthalene; Hexachlorobutadiene; 4-Chloro-3-Methylphenol; 2-Methylnaphthalene; 2,4,6-Trichlorophenol; 2-Fluorobiphenyl; 2,4,5-Trichlorophenol; 2-Chloronaphthalene; Dimethylphathalate; Acenaphthylene; Acenaphthene; Dibenzofuran; Diethylphthalate; Fluorene; 4-Chlorophenyl-phenylether; N-Nitrosodiphenylamine; Azobenzene; 4-Bromophenyl-phenylether; Hexachlorobenzene; Phenanthrene; Anthracene; Carbazole; Di-n-Butylphthalate; Fluoranthene; Pyrene; Terphenyl-d14; Butylbenzylphthalate; Benzo(a)Anthracene; Chrysene; bis(2-ethylhexyl)Phthalate; 2-Picoline; n-Nitrosomethylethylamine; Methyl methanesulfonate; n-Nitrosodiethylamine; Ethyl Methanesulfonate; Pentachloroethane; Acetophenone; n-Nitrosopyrrolidine; n-Nitrosomorpholine; O-Toluidine; n-Nitrosopiperidine; o,o,o-Triethyl-Phosphorothioate; 2,6-Dichlorophenol; Hexachloropropene; Benzothiazole; n-Nitrosodi-n-butylamine; Safrole; 1,2,4,5-Tetrachlorobenzene; cis-Isosafrole; trans-Isosafrole; 1,4-Dinitrobenzene; 1,3-Dinitrobenzene; Pentachlorobenzene; 1-Naphthylamine; 2-Naphthylamine; Thionazin; 5-Nitro-o-toluidine; Tri-n-butylphosphate; Sulfotepp; Diallate; Phorate; Phenacetin; Tris (2-chloroethyl) phosphate; 4-Aminobiphenyl; Pronamide; Pentachloronitrobenzene; Disulfoton; Parathion; Isodrin; Aramite; p- (Dimethylamino) azobenzene; Chlorobenzilate; 2-Acetylaminofluorene; 4,4'-Methylenebis (2)-Chloroaniline; 7,12-Dimethylbenz (a) anthracene; 3-Methylcholanthrene; Isosafrole; Octachlorostyrene; Methyl methacrylate; Ethyl methacrylate; Benzaldehyde; Caprolactam; 1-Methylnaphthalene; Biphenyl; Atrazine.

10.3.8.9.2.2 EPA Method 8000C suggests a 20% RSD limit be used when evaluating a calibration. The above compound list was constructed based on the 20% RSD criteria. TestAmerica St. Louis reserves the right to employ different calibration models when client mandated criteria are less than the 20% criteria found in method 8000C.

10.3.8.9.3 The intercept of the curve at zero response must be less than + or – the reporting limit for the analyte.

10.3.8.9.4 r (correlation coefficient) must be ≥ 0.995 OR r^2 (coefficient of difference) must be ≥ 0.990.

10.3.8.9.5 Due to the nature of SIM analysis, non-linear calibrations may be used.

10.3.9 **625 criteria**

10.3.9.1 Method 625 only requires a 3 point calibration. We routinely perform a 6 point calibration; however, 3 points may be removed from the curve if necessary to meet 625 calibration criteria.

10.3.9.1.1 Refer to the TestAmerica corporate policy, "Calibration Curves."

10.3.9.2 The Relative Standard Deviation (RSD) of the calibration points from the curve used must be < 35%.

10.3.9.3 If the %RSD in the initial calibration is > 35%, then calibration using a linear regression may be employed.

10.3.9.4 If a linear regression curve is used, the intercept of the curve at zero response must be less than ± the reporting limit for the analyte. It is recommended that for linear regression curves the line be set through the origin.

10.3.9.5 Use of $1/Concentration^2$ weighting is recommended to improve the accuracy of quantitation at the low end of the curve. The analyst should consider instrument maintenance to improve the linearity of response.

10.3.9.6 Weighting of data points

10.3.9.6.1 The points at the lower end of the calibration curve have less weight in determining the curve generated than points at the high concentration end of the curve. However, in environmental analysis, accuracy at the low end of the curve is very important. For this reason it is preferable to increase the weighting of the lower concentration points. $1/Concentration^2$ weighting (often called $1/X^2$ weighting) will improve accuracy at the low end of the curve and should be used if the data system has this capability.

10.4 **Initial Calibration Verification (ICV)**

10.4.1 An initial calibration verification standard is a different standard source than the one used for the initial calibration.

10.4.2 An ICV must be performed with every initial calibration.

10.4.3 The ICV performance must be within ± 30% D criteria.

10.4.3.1 Not meeting this requirement may be indicative of serious system malfunction or inaccuracies in the standards used for the initial calibration curve or ICV standard. Corrective action must be taken (including reanalysis of the ICV or analysis of a different ICV). Any decision to proceed with analysis of samples when the ICV is out-of-control must be taken with great care and in consultation with the QA department and the laboratory director. Any such action must be documented in an NCM.

10.5 **Continuing Calibration Verification (CCV)**

10.5.1 At the start of each 12 hour period (8270) or 24 hour period (EPA 625) the GC/MS tuning standard must be analyzed. A 50 ng injection of DFTPP must result in a mass spectrum for DFTPP which meets the criteria. See Table 1 in this SOP.

10.5.2 Following a successful DFTPP analysis the continuing calibration standard(s) are analyzed. The standards must contain all semivolatile analytes, including all required surrogates. A mid level calibration standard is used for the continuing calibration

10.5.3 A CCV standard is analyzed every analysis tune clock immediately following the DFTPP tune.

10.5.3.1 **EPA 8270** – for each 12 hour tune time period

10.5.3.2 **EPA 625** – for each 24 hour tune time period

10.5.4 The CCV can be the same source or a second source from the calibration.

10.5.5 The internal standard response must be within 50-200 area counts (-50% to 100%) of the response in the mid level of the initial calibration. The internal standard retention times must be within 30 seconds of the retention times in the mid-level of the initial calibration.

10.5.6 **EPA 8270 Criteria**

10.5.6.1 Minimum Response Factors

10.5.6.2 See Table 4 in this SOP for the minimum response factors. These minimum response factors are prescribed by SW-846 method 8270D. For analytes not given a minimum response factor by the method, St. Louis has established a default minimum response factor of 0.01 per compound, except for Famphur, Hexachlorophene, Kepone, and Phthalic Anhydride which have a minimum response factor of 0.001.

10.5.6.3 The CCV performance must be with ± 20% D criteria.

10.5.6.4 If a CCV has failed and the analyst can document the reason for failure (e.g. broken vial, carryover from the previous sample etc.) then a second CCV may be analyzed without any adjustments to the instrument. If this CCV meets criteria then sample analysis may continue; however the preceding samples must be reanalyzed. If this second CCV does not meet criteria, the analysis run is terminated. Instrument maintenance is performed and the instrument may require re-calibration (i.e. initial calibration).

10.5.7 **EPA 625 Criteria**

10.5.7.1 For each target analyte %D must be < 20%.

10.5.8 Calibration excursions are to be documented via a NCM.

10.6 Retention Time (RT) windows

10.6.1 Relative Retention Time (RRT)

10.6.1.1 In addition to normalizing the response (peak area) of the target compound to the response of the internal standard in that sample or extract for that injection, the retention times of the target compound and the internal standard may be used to calculate the relative retention time (RRT) of the target compound.

10.6.1.2 The RRT is expressed as a unit-less quantity:

$$RRT = \frac{\text{Retention time of the analyte}}{\text{Retention time of the internal standard}}$$

10.6.1.3 The RRT of each target analyte in each calibration standard should agree within ± 0.06 RRT units.

10.6.1.4 It is recognized here that with increasing retention times of the internal standard, target analytes will be able to more easily meet this criterion. Thus, care should be exercised when selecting the appropriate internal standards by retention times. The process of selecting internal standards to quantify target analytes should also include consideration of retention times as they should be similar.

10.6.1.5 If this criterion is not met and unless there are no other indicators of a component's identification such as a very unique but a high probability mass spectral match then that component may not be considered as identified by relative retention time.

10.6.1.6 The RRT evaluation allows the analyst to compensate for modest shifts in the chromatographic conditions that can occur due to interferences and simple day-to-day instrument variability. Many methods that employ internal standard calibration use more than one internal standard and the target compounds are related to the internal standards on the basis of the similarity of their respective chromatographic retention times (see Table 5).

10.6.2 Internal standard retention time

10.6.2.1 The retention times of the internal standards in the calibration verification standard must be evaluated immediately after or during data acquisition. If the retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard level of the most recent initial calibration sequence, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

10.6.3 Retention Time Criteria

10.6.3.1 The retention times of all compounds in each continuing calibration must be within the retention time windows established.

11.0 PROCEDURE

11.1 Samples are prepared following ST-OP-0002.

11.2 All standards and extracts are allowed to warm to room temperature before injecting.

11.3 All samples must be analyzed using the same instrument conditions as the initial calibration.

11.4 Add internal standard to the extract to result in 40ng injected on column. Mix thoroughly before injection into the instrument.

11.4.1 Add internal standard to the extract to result in 4ng injected on column for SIM analysis.

11.5 Inject the sample extract into the GC/MS system using the same injection technique as used for the standards.

11.6 The data system will determine the concentration of each analyte in the extract using calculations equivalent to those in section 12. Quantitation is based on the initial calibration, not the continuing calibration.

11.7 Perform all qualitative and quantitative measurements. When the extracts are not being used for analyses, refrigerate at -10°C to -20°C (if it can be demonstrated that analytes do not fall out of solution at this temperature), protected from light in screw cap vials equipped with un-pierced Teflon lined septa.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 External Standard Calculations

12.1.1 See Target software for calculations.

12.2 Manual Integrations

12.2.1 Identified compounds are reviewed for proper integration. Integrations are performed automatically by the data system. If necessary, manual integrations are performed and are documented by the analyst. Manual integrations are denoted with "M" flag on the Target quantitation report. See TestAmerica Policy CA-Q-S-002, Acceptable Manual Integration Practices

12.3 Qualitative identification

12.3.1 An analyte is identified by retention time and by comparison of the sample mass spectrum with the mass spectrum of a standard of the suspected compound (standard reference spectrum). Mass spectra for standard reference may be obtained on the user's GC/MS by analysis of the calibration standards or from the NIST Library. Two criteria must be satisfied to verify identification: (1) elution of sample component at the same GC retention time as the standard component; and (2) correspondence of the sample component and the standard component characteristic ions.

12.3.1.1 Note: Care must be taken to ensure that spectral distortion due to co-elution is evaluated. The following analytes should be carefully reviewed:

1,4-Dichlorobenzene-d4	Aniline	Bis (2-Chloroethyl) ether
1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,2-Dichlorobenzene
Benzyl alcohol	2-Methylphenol	3,4-Methylphenol
2,4-Dichlorophenol	2,4,6-Trichlorophenol	2,4,5-Trichlorophenol
Phenanthrene	Anthracene	Benz (a) anthracene
Bis (2-ethylhexyl) phthalate	Chrysene	Di-n-octyl phthalate
Benzo (b) fluoranthene	Benzo (k) fluoranthene	Indeno (1,2,3-cd) pyrene

Benzo (g,h,i) perylene	p-Phenylenediamine	Safrole
Cis-Isosafrole	Trans-Isosafrole	1,4-Dinitrobenzene
1,3-Dinitrobenzene	1-Naphthylamine	2-Naphthylamine
2,3,4,6-Tetrachlorophenol	Dinoseb	Sulfotepp
Diallate 1 & 2	Methapyrilene	Aramite 1 & 2

12.3.2 The sample component retention time must compare to within ± 0.2 min. of the retention time of the standard component. For reference, the standard must be run within the same twelve hours as the sample.

12.3.3 All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) should be present in the sample spectrum.

12.3.4 The relative intensities of ions should agree to within ±30% between the standard and sample spectra. (Example: For an ion with an abundance of 50% in the standard spectra, the corresponding sample abundance should be between 20 and 80 percent.)

12.3.4.1 See Table 2 for primary, secondary and tertiary ion assignments.

12.3.5 If a compound cannot be verified by all the above criteria, but in the technical judgment of the analyst, the identification is correct, then the analyst shall report that identification and proceed with quantitation.

12.3.6 Retention time criteria for samples

12.3.6.1 If the retention time for any internal standard changes by more than 0.5 minutes from the last continuing calibration standard, the chromatographic system must be inspected for malfunctions and corrected. Reanalysis of samples analyzed while the system was malfunctioning is required.

12.3.6.2 If the retention time of any internal standard in any sample varies by more than 0.1 minute from the preceding continuing calibration standard, the data must be carefully evaluated to ensure that no analytes have shifted outside their retention time windows.

12.4 Library searches of peaks present in the chromatogram that are not target compounds (Tentatively Identified Compounds, TIC) may be performed if required by the client.

12.4.1 TICs are done as follows:

12.4.1.1 The computer will give quality matches in order from most likely to least likely. In order for us to call a TIC a certain compound, the quality match must be at least 90%. However, if the next two quality matches are within (around) 10% quality match of the first choice, the compound will be identified as an unknown because it is too close to call. Unknowns are put into a group if possible (such as Unknown alkanes) but if a group is not available it will be called Unknown. A compound will be also called unknown if the top three matches are all different groups of compounds and the quality match is < 90% (ex. If the top choice is an alkane, the second choice is an alcohol, the third choice is an acid).

12.4.1.2 The first 30 TICs, based on abundance, will be identified in a sample, unless a different number is specified by the client. See client requirement sheet.

12.5 Dilutions

12.3.7 If the concentrations of any analytes exceed the working range as defined by the calibration standards, then the sample must be diluted and reanalyzed.

12.5.1 A dilution should target the most concentrated analyte in the upper half (over 50% of the high level standard) of the client specific project requirements.

12.5.2 Samples may be diluted initially if the project reporting limits are above the laboratory's routine calibration lower limit, if there is physical evidence of matrix, or historical knowledge of the site.

12.6 Carryover

12.6.1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.

12.6.1.1 If a sample analyzed after a sample with high concentrations has negative results or is non-detect, carryover did not occur.
12.6.1.2 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, carryover may have occurred.
12.6.1.2.1 This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

13.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA; CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

13.1 This SOP lists requirements for the standard Quality Assurance criteria followed at TestAmerica St. Louis. If a client or program requires stricter quality controls (i.e. DoD, DOE) the analyst is directed to the Client Requirement Memo for that client/project for limits.
13.2 The data assessment and corrective action process is detailed through the LIMS Nonconformance Memorandum (NCM) process. The NCM process is described in SOP: ST-QA-0036.
13.3 Method Blank
13.3.1 Acceptance Criteria:
13.3.1.1 No target analytes may be present in the method blank above the reporting limit.
13.3.1.2 The method blank must have acceptable surrogate recoveries.
13.3.1.3 Corrective Action for Method Blanks not meeting acceptance criteria:
13.3.1.3.1 Method Blank Contamination – Blank contamination above the RL (>1/2 RL for some programs – see specific Client Requirement Memos for details) requires re-prep of batch unless all associated samples are < RL or greater than 10 times the amount detected in the method blank.
13.3.1.3.2 Method Blank Surrogate excursion – If excursion is limited to the blank, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-anlaysis is required. In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM.
13.4 Laboratory Control Sample (LCS)
13.4.1 Acceptance Criteria: All control analytes must be within established control limits for accuracy (%Recovery) and precision (RPD).
13.4.1.1 For long analyte spike lists, marginal exceedances (ME) are allowed as follows:
13.4.1.2 less than 11 analytes in LCS, no analytes allowed in ME of the LCS control limit.
13.4.1.3 11-30 analytes in LCS, 1 analytes allowed in ME of the LCS control limit.
13.4.1.4 31-50 analytes in LCS, 2 analytes allowed in ME of the LCS control limit.
13.4.1.5 51-70 analytes in LCS, 3 analytes allowed in ME of the LCS control limit.
13.4.1.6 71-90 analytes in LCS, 4 analytes allowed in ME of the LCS control limit.
13.4.1.7 More than 90 analytes in LCS, 5 analytes allowed in ME of the LCS control limit.
13.4.1.8 No LCS recoveries may be outside the Marginal Exceedance limit.
13.4.1.9 Marginal exceedances must be random. If the same LCS analyte exceeds the control limit repeatedly, it is an indication of a systemic problem. The source of the error must be located and corrective action taken.
13.4.2 The LCS should have acceptable surrogate recoveries.
13.4.3 Corrective Action for LCS not meeting acceptance criteria:
13.4.3.1 LCS Spike Recovery excursion (high) – Samples that are non-detect may be reported with an NCM (unless prohibited by client requirements). Samples with detects for the analyte recovered high in the LCS are re-prepped and re-analyzed. . In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM
13.4.3.2 LCS Spike Recovery excursion (low) – batch is re-prepped and re-analyzed.
13.4.3.3 LCS Surrogate Recovery excursion – If excursion is limited to the LCS, data may be reported with an NCM. If target analytes are in control in the LCS, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-analysis is required.

13.4.3.4 RPD excursion for LCS/LCSD – If target analytes recoveries are in control, data may be reported with an NCM

13.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

13.5.1 All analytes should be within established control limits for accuracy (%Recovery) and precision (RPD).

13.5.2 Corrective Action for MS/MSD not meeting acceptance criteria:

13.5.2.1 MS/MSD Spike Rec. excursion may not necessarily warrant corrective action other than narration. If affected analyte concentration in the original sample is greater than four times the amount spiked, percent recovery information is ineffective. Data is reported with an NCM. If the excursion is due to a physically evident matrix interference, the data is reported with an NCM (the physical interference must be described in the NCM). If there is no evidence of interference and the RPD as well as spike recoveries out outside limits out, sample re-prep and re-analysis are required.

13.6 Sample result evaluation

13.6.1 Dilutions

13.6.1.1 If the response for any compound exceeds the working range of the analytical system, a dilution of the extract is prepared and analyzed. An appropriate dilution should be in the upper half of the calibration range.

13.6.1.2 Dilution: Sample– An NCM is created when dilutions are required.

13.6.1.3 Dilution: Surrogate(s)/spikes diluted out– An NCM is generated to document the surrogates/spikes being diluted out.

13.6.2 Carryover

13.6.2.1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.

13.6.2.2 If a sample analyzed after a sample with high concentrations is non-detect for the high concentration analyte, carryover did not occur.

13.6.2.3 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, the results are questionable. This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

13.6.3 Internal Standards

13.6.3.1 Acceptance Criteria:

13.6.3.1.1 If the EICP area for any of the internal standards in the calibration verification standard changes by a factor of two (-50% to +100%) from that in the mid-point standard level of the most recent initial calibration sequence, corrective action must be taken.

13.6.3.1.2 If the EICP area for any of the internal standards in samples, spikes and blanks changes by a factor of two (-50% to +100%) from the areas determined in the continuing calibration analyzed that day, corrective action must be taken. The samples, spikes or blanks should be reanalyzed or the data should be qualified. (Some programs may require that the midpoint of the initial calibration be used for ISTD monitoring. See the project CRM for specifics.)

13.6.3.2 Corrective Action for Internal Standards not meeting acceptance criteria:

13.6.3.2.1 Internal Standard excursion – high – High ISTD recovery indicates a potential low bias to analytical results. Instrument maintenance, if required, is done and affected samples are reanalyzed. If ISTDs are outside criteria on the re-analysis, a matrix interference is suspected and data reported with an NCM.

13.6.3.2.2 Internal Standard excursion – low – Low ISTD recovery indicates the potential for a high bias to analytical results. Samples that are non-detect for affected analytes may be reported with an NCM. Samples with positive hits above the RL for analytes associated with the poor ISTD recovery require re-analysis. Instrument maintenance, if required, is done. If ISTDs are outside

criteria on the re-analysis, a matrix interference is suspected and data reported with an NCM.

13.7 Insufficient Sample

13.7.1 For each prescribed re-preparation corrective action, if there is insufficient sample to repeat the analysis, an NCM is created and a narrative comment stating such is included in the report's Case Narrative.

14.0 METHOD PERFORMANCE AND DEMONSTRATION OF CAPABILITY

14.1 Method performance data, Reporting Limits, and QC acceptance limits, are given in the LIMS.

14.2 Demonstration of Capability

14.2.1 Initial and continuing demonstrations of capability requirements are established in the QAM.

14.3 Training Qualification

14.3.1 The manager/supervisor has the responsibility to ensure that this procedure is performed by an analyst who has been properly trained in its use and has the required experience.

14.3.2 The analyst must have successfully completed the initial demonstration capability requirements prior to working independently. See requirements in the QAM.

14.4 Annually, the analyst must successfully demonstrate proficiency to continue to perform this analysis. See requirements in the QAM.

15.0 VALIDATION

15.1 Laboratory SOPs are based on standard reference EPA Methods that have been validated by the EPA and the lab is not required to perform validation for these methods. The requirements for lab demonstration of capability are included in LQM. Lab validation data would be appropriate for performance based measurement systems or non-standard methods. TestAmerica St. Louis will include this information in the SOP when accreditation is sought for a performance based measurement system or non-standard method.

16.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

16.1 All waste will be disposed of in accordance with Federal, State and Local regulations. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in section 13 of the Corporate Safety Manual for "Waste Management and Pollution Prevention."

16.2 Waste Streams Produced by the Method

16.2.1 The following waste streams are produced when this method is carried out.

16.2.1.1 Auto-sample vials containing Methylene Chloride are to be disposed of in the appropriate solvent vial waste accumulation container located within the GC/MS lab, for temporary storage. Once this temporary container is full or once it reaches a one-year collection time, this container must be dumped into the permanent solvent vial waste container located in the 90-day storage area, which is marked as a Type "C" waste accumulation container.

16.2.1.2 Waste Methylene Chloride rinses are to be collected and disposed of within the solvent waste accumulation container located in the Organic Prep. Lab. This temporary storage container shall be dumped on a daily basis into the permanent waste accumulation container located in the 90-day storage area which is marked as a Type "D" waste drum.

17.0 REFERENCES

17.1 SW846, Test Methods for Evaluating Solid Waste, Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Method 8000B, 8000C and 8270D.

17.2 40CFR Part 136: "Guidelines Establishing Test Procedures for the Analysis of Pollutants, Appendix A, "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", Code of Federal Regulations, Revised July1, 1995, Method 625.

17.3 TestAmerica St. Louis Quality Assurance Manual (QAM), current revision.

17.4 TestAmerica Corporate Environmental Health and Safety Manual (CW-E-M-002) and St. Louis Facility Addendum (ST-HS-0002), current revision.

17.5 TestAmerica Policy CA-Q-S-001, Acceptable Manual Integration Practices

17.6 TestAmerica Policy CA-T-P-002, Selection of Calibration Points

17.7 Associated SOPs, current revisions
- 17.7.1 ST-OP-0002, Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, and 600 Series Methods
- 17.7.2 ST-PM-0002, Sample Receipt and Chain of Custody
- 17.7.3 ST-QA-0002, Standard and Reagent Preparation
- 17.7.4 ST-QA-0005, Calibration and Verification Procedure for Thermometers, Balances, Weights and Pipettes.
- 17.7.5 ST-QA-0014, Evaluation of Analytical Accuracy and Precision Through the Use of Control Charts
- 17.7.6 ST-QA-0016, IDL/MDL, LOD/LOQ Determination
- 17.7.7 ST-QA-0036, Non-conformance Memorandum (NCM) Process

18.0 CLARIFICATIONS, MODIFICATIONS TO THE REFERENCE METHOD

18.1 The quantitation and qualifier ions for some compounds have been changed from those recommended in SW-846 in order to improve the reliability of qualitative identification.

19.0 CHANGES TO PREVISION SOP REVISION

19.1 Table reference in Section 6.1 was corrected.
19.2 Y-intercept requirements added to Section 10.
19.3 Added requirement for 6 levels for a quadratic curve to Section 10
19.4 Added CLP allowance for reporting data within 10% of upper standard without dilution to Section 12
19.5 Clarification of criteria for TIC reporting added to Section 12.4.
19.6 Table 1: clarified Tune criteria and added allowance of other published DFTPP Tune criteria (i.e. EPA CLP)
19.7 Added Table 5, a listing of internal standards and associated analytes
19.8 Revision 13:
- 19.8.1 Grammatical /spelling corrections
- 19.8.2 Added SIM analysis to section 11

19.9 Revision 14:
- 19.9.1 Removed QuantIMS and Clouseau references – replaced with LIMs
- 19.9.2 Created hyperlinks to tables
- 19.9.3 Appended LVI Calibration Levels to Table 3
- 19.9.4 Combined fragmented Table 5 into one table
- 19.9.5 Added table of potentially mis-identifiable analytes to Section 12.3.
- 19.9.6 Removed CLP allowance for reporting data within 10% of upper standard without dilution from Section 12.

19.9.7 Revised Section 13 to remove Clouseau corrective action references and to provide specific corrective actions for non-conformances.

19.10 Revision 15:

19.10.1 Section 3, updated SIM definition

19.10.2 Section 7.5 Added SIM requirement

19.10.3 Section 7.7 ICV standard 2nd source where available to acquire

19.10.4 Section 10.1 corrected table references

19.10.5 Section 10.2 Added % breakdown calculation and added Benzidine and pentachlorophenol requirements

19.10.6 Section 10.3.8.9.2.1 removed compounds that are not to use non-linear calibration model

19.10.7 Removed 12.6.1.3

19.10.8 Section 13.6.2.3 removed chromatographic profile reference

Table 1
DFTPP Key Ions and Ion Abundance Criteria*

Mass	Ion Abundance Criteria
51	30 - 60% of mass 198
68	<2% of mass 69
70	<2% of mass 69
127	40 - 60% of mass 198
197	<1% of mass 198
198	Base peak, 100% relative abundance
199	5 - 9% of mass 198
275	10 - 30% of mass 198
365	>1% of mass 198
441	Present, but less than mass 443
442	>40% of mass 198
443	17 - 23% of mass 442

* Tune criteria in use is a combination of 8270C and 8270D which is more stringent than either method. Alternatively, other documented tuning criteria (e.g. EPA CLP) may be used provided method performance is not aversely affected.

Table 2
Analytes in Approximate Retention Time Order and Characteristic Ions

Primary Standard			
Analyte	**Primary**	**Secondary**	**Tertiary**
1,4 Dioxane	88	58	43
n-Nitrosodimethylamine	74*	42	44
Pyridine	79	52	—
Dimethylformamide	44	73	42
Cyclohexanol	57	82	67
2-Fluorophenol (Surrogate Standard)	112	64	63**
Phenol-d5 (Surrogate Standard)	99	42	71
Aniline	93	66	65
Phenol	94	65	66
Bis(2-chloroethyl)ether	93	63	95
2-Chlorophenol	128	64	130
1,3-Dichlorobenzene	146	148	111
1,4-Dichlorobenzene-d4 (Internal Standard)	152	150	115
1,4-Dichlorobenzene	146	148	111
Benzyl Alcohol	108	79	77
1,2-Dichlorobenzene	146	148	111
2-Methylphenol	108*	107	79
2,2'-oxybis(1-chloropropane)[1]	45	77	121
3&4-Methylphenol	107	108	79
n-Nitroso-di-n-propylamine	70	42	101
Hexachloroethane	117	201	199
Nitrobenzene-d5 (Surrogate Standard)	82	128	54
Nitrobenzene	77	123	65
Isophorone	82	95	138
2-Nitrophenol	139	65	109
2,4-Dimethylphenol	107*	121	122
Benzoic Acid	122	105	77
Bis(2-chloroethoxy)methane	93	95	123

Table 2
Analytes in Approximate Retention Time Order and Characteristic Ions

Primary Standard			
Analyte	**Primary**	**Secondary**	**Tertiary**
2,4-Dichlorophenol	162	164	98
1,2,4-Trichlorobenzene	180	182	145
Naphthalene-d8 (Internal Standard)	136	68	54**
Naphthalene	128	129	127
4-Chloroaniline	127	129	65
Hexachlorobutadiene	225	223	227
4-Chloro-3-methylphenol	107	144	142
2-Methylnaphthalene	142	141	—
Hexachlorocyclopentadiene	237	235	272
2,4,6-Trichlorophenol	196	198	200
2,4,5-Trichlorophenol	196	198	200
2-Fluorobiphenyl (Surrogate Standard)	172	171	—
2-Chloronaphthalene	162	164	127
2-Nitroaniline	65	92	138
Dimethylphthalate	163	194	164
Acenaphthylene	152	151	153
2,6-Dinitrotoluene	165	63	89
Acenaphthene-d10 (Internal Standard)	164	162	160
3-Nitroaniline	138	108	92
Acenaphthene	153*	152	154
2,4-Dinitrophenol	184	63	154
Dibenzofuran	168	139	—
4-Nitrophenol	109*	139	65
2,4-Dinitrotoluene	165	63	89
Diethylphthalate	149	177	150
Fluorene	166	165	167
4-Chlorophenylphenylether	204	206	141
4-Nitroaniline	138	92	108
4,6-Dinitro-2-methylphenol	198	105	51

Table 2
Analytes in Approximate Retention Time Order and Characteristic Ions

Primary Standard			
Analyte	**Primary**	**Secondary**	**Tertiary**
n-Nitrosodiphenylamine	169	168	167
2,4,6-Tribromophenol (Surrogate Standard)	330	332**	141
Azobenzene	77	51**	105
4-Bromophenylphenylether	248	250	141
Hexachlorobenzene	284	142	249
Pentachlorophenol	266	264	268
Phenanthrene-d10 (Internal Standard)	188	94	80
Phenanthrene	178	179	176
Anthracene	178	179	176
Carbazole	167	166	139
Di-n-butylphthalate	149	150	104
Fluoranthene	202	101	203
Benzidine	184	92	185
Pyrene	202	200	203
Terphenyl-d14 (Surrogate Standard)	244	122	212
Butylbenzylphthalate	149	91	206
Benzo(a)Anthracene	228	229	226
Chrysene-d12 (Internal Standard)	240	120	236
3,3'-Dichlorobenzidine	252	254	126
Chrysene	228	226	229
Bis(2-ethylhexyl)phthalate	149	167	279
Di-n-octylphthalate	149	167	43
Benzo(b)fluoranthene	252	253	125
Benzo(k)fluoranthene	252	253	125
Benzo(a)pyrene	252	253	125
Perylene-d12 (Internal Standard)	264	260	265
Indeno(1,2,3-cd)pyrene	276	138	277
Dibenz(a,h)anthracene	278	139	279
Benzo(g,h,i)perylene	276	138	277

Table 2
Analytes in Approximate Retention Time Order and Characteristic Ions

Primary Standard			
Analyte	**Primary**	**Secondary**	**Tertiary**

***** primary/secondary and/or tertiary ions are switched from order in Method
** not listed in the method

Appendix IX Standard

Analyte	Primary	Secondary	Tertiary
Methyl methacrylate	69	41	39
Ethyl methacrylate	69	41	39
2-Picoline	93	66	92
n-Nitrosomethylethylamine	88	42	43
Methyl methanesulfonate	80	79	65
2-Fluorophenol (Surrogate Standard)	112	64	63**
n-Nitrosodiethylamine	102	44	57
Ethyl methanesulfonate	79	109	97
Benzaldehyde	77	106	51
Phenol-d5 (Surrogate Standard)	99	42	71
Pentachloroethane	117	119	167
1,4-Dichlorobenzene-d4 (Internal Standard)	152	150	115
Acetophenone	105	77	120
n-Nitrosopyrrolidine	100	41	42
n-Nitrosomorpholine	116	56	86
o-Toluidine	106	107	—
Nitrobenzene-d5 (Surrogate Standard)	82	128	54
n-Nitrosopiperidine	114	42	55
O,o,o-Triethyl-Phosphorothioate	198	121	93
a,a-Dimethyl-phenethylamine	58	91	—
Naphthalene-d8 (Internal Standard)	136	68	54**
2,6-Dichlorophenol	162	164	63
Hexachloropropene	213	215	211
Benzothiazole	135	108	69
Caprolactam	55	113	42

Appendix IX Standard

Analyte	Primary	Secondary	Tertiary
p-Phenylenediamine	108	80	—
n-Nitrosodi-n-butylamine	84	57	41
Safrole	162	104	77
Phthalic anhydride	104	76	50
1-methylnaphthalene	142	141	115
1,2,4,5-Tetrachlorobenzene	216	214	218
Isosafrole, cis	162	104	131
2-Fluorobiphenyl (Surrogate Standard)	172	171	—
Isosafrole, trans	162	104	131
Biphenyl	154	153	152
1,4-Dinitrobenzene	168	75	50
1,4-Naphthoquinone	158	104	102
1,3-Dinitrobenzene	168	75	76
Acenaphthene-d10 (Internal Standard)	164	162	160
Pentachlorobenzene	250	248	252
1-Naphthylamine	143	115	—
2-Naphthylamine	143	115	—
2,3,4,6-Tetrachlorophenol	232	230	131
5-Nitro-o-toluidine	152	77	106
Thionazin	107	96	143
1,3,5-Trinitrobenzene	213*	75	120
2,4,6-Tribromophenol (Surrogate Standard)	330	332**	141**
Sulfotepp	97	322	202
Phorate	75	97	121
Phenacetin	108	179	109
Diallate 1	86	234	43
Diallate 2	86	234	43
Dimethoate	87	93	125
4-Aminobiphenyl	169	168	170
Pentachloronitrobenzene	237	142	214
Phenanthrene-d10 (Internal Standard)	188	94	80
Pronamide	173	175	145
Disulfoton	88	97	89

Appendix IX Standard

Analyte	Primary	Secondary	Tertiary
2-secbutyl-4,6-dinitrophenol (Dinoseb)	211	163	147
Methyl parathion	109	125	263
4-Nitroquinoline-1-oxide	190	128	75
Parathion	109	97	291
Isodrin	193	66	195
Kepone	272	274	237
Methapyrilene	97	58**	—
Octachlorostyrene	308	343	154
Terphenyl-d14 (Surrogate Standard)	244	122	212
Aramite 1	185	319	—
Aramite 2	185	319	—
p-(Dimethylamino)azobenzene	120*	225	77
p-Chlorobenzilate	251	139	253
3,3'-Dimethylbenzidine	212	106	—
2-Acetylaminofluorene	181	180	223
Famphur	218	125	93
Chrysene-d12 (Internal Standard)	240	120	236
Hexachlorophene	196	198	209
7,12-Dimethylbenz(a)anthracene	256	241	120
Perylene-d12 (Internal Standard)	264	260	265
3-Methylcholanthrene	268	252	126

***** primary/secondary and/or tertiary ions are switched from order in Method
** not listed in the method

Table 3
Calibration Levels, Primary Standard, µg/mL[3]

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
1,4 Dioxane	10	20	50	80	120	160
Pyridine	10	20	50	80	120	160
n-Nitrosodimethylamine	10	20	50	80	120	160
Dimethylformamide	10	20	50	80	120	160
Cyclohexanol	10	20	50	80	120	160
Aniline	10	20	50	80	120	160
Phenol	10	20	50	80	120	160
Bis(2-chloroethyl)ether	10	20	50	80	120	160
2-Chlorophenol	10	20	50	80	120	160
1,3-Dichlorobenzene	10	20	50	80	120	160
1,4-Dichlorobenzene	10	20	50	80	120	160
Benzyl alcohol	10	20	50	80	120	160
1,2-Dichlorobenzene	10	20	50	80	120	160
2-Methylphenol	10	20	50	80	120	160
2,2'-oxybis(1-chloropropane)[1]	10	20	50	80	120	160
3&4-Methylphenol	20	40	100	160	240	320
n-Nitroso-di-n-propylamine	10	20	50	80	120	160
Hexachloroethane	10	20	50	80	120	160
Nitrobenzene	10	20	50	80	120	160
Isophorone	10	20	50	80	120	160
2-Nitrophenol	10	20	50	80	120	160
2,4-Dimethylphenol	10	20	50	80	120	160
Benzoic acid	10	20	50	80	120	160
bis(2-Chloroethoxy)methane	10	20	50	80	120	160
2,4-Dichlorophenol	10	20	50	80	120	160
1,2,4-Trichlorobenzene	10	20	50	80	120	160
Naphthalene	10	20	50	80	120	160
4-Chloroaniline	10	20	50	80	120	160
Hexachlorobutadiene	10	20	50	80	120	160

Table 3
Calibration Levels, Primary Standard, µg/mL[3]

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
4-Chloro-3-methylphenol	10	20	50	80	120	160
2-Methylnaphthalene	10	20	50	80	120	160
Hexachlorocyclopentadiene	10	20	50	80	120	160
2,4,6-Trichlorophenol	10	20	50	80	120	160
2,4,5-Trichlorophenol	10	20	50	80	120	160
2-Chloronaphthalene	10	20	50	80	120	160
2-Nitroaniline	10	20	50	80	120	160
Dimethyl phthalate	10	20	50	80	120	160
Acenaphthylene	10	20	50	80	120	160
3-Nitroaniline	10	20	50	80	120	160
Acenaphthene	10	20	50	80	120	160
2,4-Dinitrophenol	10	20	50	80	120	160
4-Nitrophenol	10	20	50	80	120	160
Dibenzofuran	10	20	50	80	120	160
2,4-Dinitrotoluene	10	20	50	80	120	160
2,6-Dinitrotoluene	10	20	50	80	120	160
Diethylphthalate	10	20	50	80	120	160
4-Chlorophenyl phenyl ether	10	20	50	80	120	160
Fluorene	10	20	50	80	120	160
4-Nitroaniline	10	20	50	80	120	160
4,6-Dinitro-2-methylphenol	10	20	50	80	120	160
N-Nitrosodiphenylamine	10	20	50	80	120	160
Azobenzene[2]	10	20	50	80	120	160
4-Bromophenyl phenyl ether	10	20	50	80	120	160
Hexachlorobenzene	10	20	50	80	120	160
Pentachlorophenol	10	20	50	80	120	160
Phenanthrene	10	20	50	80	120	160
Anthracene	10	20	50	80	120	160
Carbazole	10	20	50	80	120	160
Di-n-butyl phthalate	10	20	50	80	120	160
Fluoranthene	10	20	50	80	120	160

Table 3
Calibration Levels, Primary Standard, µg/mL[3]

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Benzidine	10	20	50	80	120	160
Pyrene	10	20	50	80	120	160
Butyl benzyl phthalate	10	20	50	80	120	160
3,3'-Dichlorobenzidine	10	20	50	80	120	160
Benzo(a)anthracene	10	20	50	80	120	160
Bis(2-ethylhexyl)phthalate	10	20	50	80	120	160
Chrysene	10	20	50	80	120	160
Di-n-octylphthalate	10	20	50	80	120	160
Benzo(b)fluoranthene	10	20	50	80	120	160
Benzo(k)fluoranthene	10	20	50	80	120	160
Benzo(a)pyrene	10	20	50	80	120	160
Indeno(1,2,3-cd)pyrene	10	20	50	80	120	160
Dibenz(a,h)anthracene	10	20	50	80	120	160
Benzo(g,h,i)perylene	10	20	50	80	120	160

[1] 2,2'oxybis(1-chloropropane) was formally known as bis(2-chloroisopropyl)ether
[2] Azobenzene is formed by decomposition of 1,2-diphenlyhydrazine. If 1,2-diphenylhydrazine is requested, it will be analyzed as azobenzene.
[3] Lower concentration standards may be analyzed on a project specific basis.

Calibration Levels, Appendix IX Standard, µg/mL

Semivolatiles	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Methyl methacrylate	10	20	50	80	120	160
Ethyl methacrylate	10	20	50	80	120	160
2-Picoline	10	20	50	80	120	160
n-Nitrosomethylethylamine	10	20	50	80	120	160
Methyl methanesulfonate	10	20	50	80	120	160
n-Nitrosodiethylamine	10	20	50	80	120	160
Ethyl methanesulfonate	10	20	50	80	120	160
Benzaldehyde	10	20	50	80	120	160

Calibration Levels, Appendix IX Standard, µg/mL

Semivolatiles	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Pentachloroethane	10	20	50	80	120	160
Acetophenone	10	20	50	80	120	160
n-Nitrosopyrrolidine	10	20	50	80	120	160
n-Nitrosomorpholine	10	20	50	80	120	160
o-Toluidine	10	20	50	80	120	160
n-Nitrosopiperidine	10	20	50	80	120	160
O,o,o-Triethyl-Phosphorothioate	10	20	50	80	120	160
A,a-Dimethyl-phenethylamine	10	20	50	80	120	160
2,6-Dichlorophenol	10	20	50	80	120	160
Hexachloropropene	10	20	50	80	120	160
Benzothiazole	10	20	50	80	120	160
Caprolactam	10	20	50	80	120	160
p-Phenylenediamine	10	20	50	80	120	160
n-Nitrosodi-n-butylamine	10	20	50	80	120	160
Safrole	10	20	50	80	120	160
Phthalic anhydride	10	20	50	80	120	160
1-Methylnaphthalene	10	20	50	80	120	160
1,2,4,5-Tetrachlorobenzene	10	20	50	80	120	160
Isosafrole, cis	10	20	50	80	120	160
Isosafrole, trans	10	20	50	80	120	160
Biphenyl	10	20	50	80	120	160
1,4-Dinitrobenzene	10	20	50	80	120	160
1,4-Naphthoquinone	10	20	50	80	120	160
1,3-Dinitrobenzene	10	20	50	80	120	160
Pentachlorobenzene	10	20	50	80	120	160
1-Naphthylamine	10	20	50	80	120	160
2-Naphthylamine	10	20	50	80	120	160
2,3,4,6-Tetrachlorophenol	10	20	50	80	120	160
5-Nitro-o-toluidine	10	20	50	80	120	160
Thionazin	10	20	50	80	120	160
1,3,5-Trinitrobenzene	10	20	50	80	120	160
Sulfotepp	10	20	50	80	120	160
Phorate	10	20	50	80	120	160

Calibration Levels, Appendix IX Standard, µg/mL

Semivolatiles	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Phenacetin	10	20	50	80	120	160
Diallate 1	10	20	50	80	120	160
Diallate 2	10	20	50	80	120	160
Dimethoate	10	20	50	80	120	160
4-Aminobiphenyl	10	20	50	80	120	160
Pentachloronitrobenzene	10	20	50	80	120	160
Pronamide	10	20	50	80	120	160
Disulfoton	10	20	50	80	120	160
2-sec butyl-4,6-dinitrophenol (Dinoseb)	10	20	50	80	120	160
Methyl parathion	10	20	50	80	120	160
4-Nitroquinoline-1-oxide	10	20	50	80	120	160
Parathion	10	20	50	80	120	160
Isodrin	10	20	50	80	120	160
Kepone	10	20	50	80	120	160
Famphur	10	20	50	80	120	160
Methapyrilene	10	20	50	80	120	160
Octachlorostyrene	10	20	50	80	120	160
Aramite 1	10	20	50	80	120	160
Aramite 2	10	20	50	80	120	160
p-(Dimethylamino)azobenzene	10	20	50	80	120	160
p-Chlorobenzilate	10	20	50	80	120	160
3,3'-Dimethylbenzidine	10	20	50	80	120	160
Hexachlorophene	100	200	500	800	1200	1600
2-Acetylaminofluorene	10	20	50	80	120	160
Dibenz (a,j)acridine	10	20	50	80	120	160
7,12-Dimethylbenz(a)anthracene	10	20	50	80	120	160
3-Methylcholanthrene	10	20	50	80	120	160
2-Fluorophenol (Surrogate Standard	10	20	50	80	120	160
Phenol-d5 (Surrogate Standard)	10	20	50	80	120	160
Nitrobenzene-d5 (Surrogate Standard)	10	20	50	80	120	160
2-Fluorobiphenyl (Surrogate Standard)	10	20	50	80	120	160
2,4,6-Tribromophenol (Surrogate Standard)	10	20	50	80	120	160
Terphenyl-d14 (Surrogate Standard)	10	20	50	80	120	160

Calibration Levels SIM Standard, ug/mL

Naphthalene	0.2	0.5	1.0	2.0	5.0	10.0
Acenaphthylene	0.2	0.5	1.0	2.0	5.0	10.0
Acenaphthene	0.2	0.5	1.0	2.0	5.0	10.0
Fluorene	0.2	0.5	1.0	2.0	5.0	10.0
Phenanthrene	0.2	0.5	1.0	2.0	5.0	10.0
Pyrene	0.2	0.5	1.0	2.0	5.0	10.0
Benzo(a)anthracene	0.2	0.5	1.0	2.0	5.0	10.0
Chrysene	0.2	0.5	1.0	2.0	5.0	10.0
Benzo(b)fluoranthene	0.2	0.5	1.0	2.0	5.0	10.0
Benzo(k)fluoranthene	0.2	0.5	1.0	2.0	5.0	10.0
Benzo(a)pyrene	0.2	0.5	1.0	2.0	5.0	10.0
Indeno(1,2,3-cd)pyrene	0.2	0.5	1.0	2.0	5.0	10.0
Dibenz(a,h)anthracene	0.2	0.5	1.0	2.0	5.0	10.0
Anthracene	0.2	0.5	1.0	2.0	5.0	10.0
Fluoranthene	0.2	0.5	1.0	2.0	5.0	10.0
Benzo(g,h,i)perylene	0.2	0.5	1.0	2.0	5.0	10.0

Table 3

LVI Calibration Levels, Primary Standard, µg/mL[3]

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
1,4 Dioxane	1	2	5	10	20	30	40	50	60
Pyridine	1	2	5	10	20	30	40	50	60

Table 3

LVI Calibration Levels, Primary Standard, µg/mL[3]

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
n-Nitrosodimethylamine	1	2	5	10	20	30	40	50	60
Dimethylformamide	1	2	5	10	20	30	40	50	60
Cyclohexanol	1	2	5	10	20	30	40	50	60
Aniline	1	2	5	10	20	30	40	50	60
Phenol	1	2	5	10	20	30	40	50	60
Bis(2-chloroethyl)ether	1	2	5	10	20	30	40	50	60
2-Chlorophenol	1	2	5	10	20	30	40	50	60
1,3-Dichlorobenzene	1	2	5	10	20	30	40	50	60
1,4-Dichlorobenzene	1	2	5	10	20	30	40	50	60
Benzyl alcohol	1	2	5	10	20	30	40	50	60
1,2-Dichlorobenzene	1	2	5	10	20	30	40	50	60
2-Methylphenol	1	2	5	10	20	30	40	50	60
2,2'-oxybis(1-chloropropane)[1]	1	2	5	10	20	30	40	50	60
3&4-Methylphenol	2	4	10	20	40	60	80	100	120
n-Nitroso-di-n-propylamine	1	2	5	10	20	30	40	50	60
Hexachloroethane	1	2	5	10	20	30	40	50	60
Nitrobenzene	1	2	5	10	20	30	40	50	60
Isophorone	1	2	5	10	20	30	40	50	60
2-Nitrophenol	1	2	5	10	20	30	40	50	60
2,4-Dimethylphenol	1	2	5	10	20	30	40	50	60
Benzoic acid	1	2	5	10	20	30	40	50	60
bis(2-Chloroethoxy)methane	1	2	5	10	20	30	40	50	60
2,4-Dichlorophenol	1	2	5	10	20	30	40	50	60
1,2,4-Trichlorobenzene	1	2	5	10	20	30	40	50	60
Naphthalene	1	2	5	10	20	30	40	50	60
4-Chloroaniline	1	2	5	10	20	30	40	50	60
Hexachlorobutadiene	1	2	5	10	20	30	40	50	60
4-Chloro-3-methylphenol	1	2	5	10	20	30	40	50	60
2-Methylnaphthalene	1	2	5	10	20	30	40	50	60
Hexachlorocyclopentadiene	1	2	5	10	20	30	40	50	60
2,4,6-Trichlorophenol	1	2	5	10	20	30	40	50	60
2,4,5-Trichlorophenol	1	2	5	10	20	30	40	50	60

Table 3

LVI Calibration Levels, Primary Standard, µg/mL[3]

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
2-Chloronaphthalene	1	2	5	10	20	30	40	50	60
2-Nitroaniline	1	2	5	10	20	30	40	50	60
Dimethyl phthalate	1	2	5	10	20	30	40	50	60
Acenaphthylene	1	2	5	10	20	30	40	50	60
3-Nitroaniline	1	2	5	10	20	30	40	50	60
Acenaphthene	1	2	5	10	20	30	40	50	60
2,4-Dinitrophenol	1	2	5	10	20	30	40	50	60
4-Nitrophenol	1	2	5	10	20	30	40	50	60
Dibenzofuran	1	2	5	10	20	30	40	50	60
2,4-Dinitrotoluene	1	2	5	10	20	30	40	50	60
2,6-Dinitrotoluene	1	2	5	10	20	30	40	50	60
Diethylphthalate	1	2	5	10	20	30	40	50	60
4-Chlorophenyl phenyl ether	1	2	5	10	20	30	40	50	60
Fluorene	1	2	5	10	20	30	40	50	60
4-Nitroaniline	1	2	5	10	20	30	40	50	60
4,6-Dinitro-2-methylphenol	1	2	5	10	20	30	40	50	60
N-Nitrosodiphenylamine	1	2	5	10	20	30	40	50	60
Azobenzene[2]	1	2	5	10	20	30	40	50	60
4-Bromophenyl phenyl ether	1	2	5	10	20	30	40	50	60
Hexachlorobenzene	1	2	5	10	20	30	40	50	60
Pentachlorophenol	1	2	5	10	20	30	40	50	60
Phenanthrene	1	2	5	10	20	30	40	50	60
Anthracene	1	2	5	10	20	30	40	50	60
Carbazole	1	2	5	10	20	30	40	50	60
Di-n-butyl phthalate	1	2	5	10	20	30	40	50	60
Fluoranthene	1	2	5	10	20	30	40	50	60
Benzidine	1	2	5	10	20	30	40	50	60
Pyrene	1	2	5	10	20	30	40	50	60
Butyl benzyl phthalate	1	2	5	10	20	30	40	50	60
3,3'-Dichlorobenzidine	1	2	5	10	20	30	40	50	60
Benzo(a)anthracene	1	2	5	10	20	30	40	50	60
Bis(2-ethylhexyl)phthalate	1	2	5	10	20	30	40	50	60

Table 3

LVI Calibration Levels, Primary Standard, µg/mL[3]

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
Chrysene	1	2	5	10	20	30	40	50	60
Di-n-octylphthalate	1	2	5	10	20	30	40	50	60
Benzo(b)fluoranthene	1	2	5	10	20	30	40	50	60
Benzo(k)fluoranthene	1	2	5	10	20	30	40	50	60
Benzo(a)pyrene	1	2	5	10	20	30	40	50	60
Indeno(1,2,3-cd)pyrene	1	2	5	10	20	30	40	50	60
Dibenz(a,h)anthracene	1	2	5	10	20	30	40	50	60
Benzo(g,h,i)perylene	1	2	5	10	20	30	40	50	60

[1]2,2'oxybis(1-chloropropane) was formally known as bis(2-chloroisopropyl)ether
[2]Azobenzene is formed by decomposition of 1,2-diphenlyhydrazine. If 1,2-diphenylhydrazine is requested, it will be analyzed as azobenzene.
[3]Lower concentration standards may be analyzed on a project specific basis.

LVI Calibration Levels, Appendix IX Standard, µg/mL

Semivolatiles	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
Methyl methacrylate	1	2	5	10	20	30	40	50	60
Ethyl methacrylate	1	2	5	10	20	30	40	50	60
2-Picoline	1	2	5	10	20	30	40	50	60
n-Nitrosomethylethylamine	1	2	5	10	20	30	40	50	60
Methyl methanesulfonate	1	2	5	10	20	30	40	50	60
n-Nitrosodiethylamine	1	2	5	10	20	30	40	50	60
Ethyl methanesulfonate	1	2	5	10	20	30	40	50	60
Benzaldehyde	1	2	5	10	20	30	40	50	60
Pentachloroethane	1	2	5	10	20	30	40	50	60
Acetophenone	1	2	5	10	20	30	40	50	60
n-Nitrosopyrrolidine	1	2	5	10	20	30	40	50	60
n-Nitrosomorpholine	1	2	5	10	20	30	40	50	60
o-Toluidine	1	2	5	10	20	30	40	50	60
n-Nitrosopiperidine	1	2	5	10	20	30	40	50	60
O,o,o-Triethyl-Phosphorothioate	1	2	5	10	20	30	40	50	60
A,a-Dimethyl-phenethylamine	1	2	5	10	20	30	40	50	60

LVI Calibration Levels, Appendix IX Standard, µg/mL

Semivolatiles	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
2,6-Dichlorophenol	1	2	5	10	20	30	40	50	60
Hexachloropropene	1	2	5	10	20	30	40	50	60
Benzothiazole	1	2	5	10	20	30	40	50	60
Caprolactam	1	2	5	10	20	30	40	50	60
p-Phenylenediamine	1	2	5	10	20	30	40	50	60
n-Nitrosodi-n-butylamine	1	2	5	10	20	30	40	50	60
Safrole	1	2	5	10	20	30	40	50	60
Phthalic anhydride	1	2	5	10	20	30	40	50	60
1-Methylnaphthalene	1	2	5	10	20	30	40	50	60
1,2,4,5-Tetrachlorobenzene	1	2	5	10	20	30	40	50	60
Isosafrole, cis	1	2	5	10	20	30	40	50	60
Isosafrole, trans	1	2	5	10	20	30	40	50	60
Biphenyl	1	2	5	10	20	30	40	50	60
1,4-Dinitrobenzene	1	2	5	10	20	30	40	50	60
1,4-Naphthoquinone	1	2	5	10	20	30	40	50	60
1,3-Dinitrobenzene	1	2	5	10	20	30	40	50	60
Pentachlorobenzene	1	2	5	10	20	30	40	50	60
1-Naphthylamine	1	2	5	10	20	30	40	50	60
2-Naphthylamine	1	2	5	10	20	30	40	50	60
2,3,4,6-Tetrachlorophenol	1	2	5	10	20	30	40	50	60
5-Nitro-o-toluidine	1	2	5	10	20	30	40	50	60
Thionazin	1	2	5	10	20	30	40	50	60
1,3,5-Trinitrobenzene	1	2	5	10	20	30	40	50	60
Sulfotepp	1	2	5	10	20	30	40	50	60
Phorate	1	2	5	10	20	30	40	50	60
Phenacetin	1	2	5	10	20	30	40	50	60
Diallate 1	1	2	5	10	20	30	40	50	60
Diallate 2	1	2	5	10	20	30	40	50	60
Dimethoate	1	2	5	10	20	30	40	50	60
4-Aminobiphenyl	1	2	5	10	20	30	40	50	60
Pentachloronitrobenzene	1	2	5	10	20	30	40	50	60
Pronamide	1	2	5	10	20	30	40	50	60
Disulfoton	1	2	5	10	20	30	40	50	60

LVI Calibration Levels, Appendix IX Standard, µg/mL

Semivolatiles	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9
2-sec butyl-4,6-dinitrophenol (Dinoseb)	1	2	5	10	20	30	40	50	60
Methyl parathion	1	2	5	10	20	30	40	50	60
4-Nitroquinoline-1-oxide	1	2	5	10	20	30	40	50	60
Parathion	1	2	5	10	20	30	40	50	60
Isodrin	1	2	5	10	20	30	40	50	60
Kepone	1	2	5	10	20	30	40	50	60
Famphur	1	2	5	10	20	30	40	50	60
Methapyrilene	1	2	5	10	20	30	40	50	60
Octachlorostyrene	1	2	5	10	20	30	40	50	60
Aramite 1	1	2	5	10	20	30	40	50	60
Aramite 2	1	2	5	10	20	30	40	50	60
p-(Dimethylamino)azobenzene	1	2	5	10	20	30	40	50	60
p-Chlorobenzilate	1	2	5	10	20	30	40	50	60
3,3'-Dimethylbenzidine	1	2	5	10	20	30	40	50	60
2-Acetylaminofluorene	1	2	5	10	20	30	40	50	60
Dibenz (a,j)acridine	1	2	5	10	20	30	40	50	60
7,12-Dimethylbenz(a)anthracene	1	2	5	10	20	30	40	50	60
3-Methylcholanthrene	1	2	5	10	20	30	40	50	60
2-Fluorophenol (Surrogate Standard	1	2	5	10	20	30	40	50	60
Phenol-d5 (Surrogate Standard)	1	2	5	10	20	30	40	50	60
Nitrobenzene-d5 (Surrogate Standard)	1	2	5	10	20	30	40	50	60
2-Fluorobiphenyl (Surrogate Standard)	1	2	5	10	20	30	40	50	60
2,4,6-Tribromophenol (Surrogate Standard)	1	2	5	10	20	30	40	50	60
Terphenyl-d14 (Surrogate Standard)	1	2	5	10	20	30	40	50	60

Table 4
Minimum Response Factor Criteria

Semivolatile Compounds	Minimum Response Factor (RF)
Benzaldehyde	0.010
Phenol	0.800

Table 4
Minimum Response Factor Criteria

Semivolatile Compounds	Minimum Response Factor (RF)
Bis(2-chloroethyl)ether	0.700
2-Chlorophenol	0.800
2-Methylphenol	0.600
2,2'-Oxybis-(1-chloropropane)	0.010
Acetophenone	0.010
4-Methylphenol	0.600
N-Nitroso-di-n-propylamine	0.500
Hexachlorethane	0.300
Nitrobenzene	0.200
Isophorone	0.400
2-Nitrophenol	0.100
2,4-Dimethylphenol	0.200
Naphthalene	0.700
4-Chloroanline	0.010
Hexachlorobutadiene	0.010
Caprolactam	0.010
4-Chloro-3-methylphenol	0.200
2-Methylnaphthalene	0.400
Hexachlorocyclopentadiene	0.050
2,4,6-Trichlorophenol	0.200
2,4,5-Trichlorophenol	0.200
1,1'-Biphenyl	0.010
2-Chloronaphthanlene	0.800
2-Nitroaniline	0.010
Dimethyl phthalate	0.010
2,6-Dinitrotulene	0.200

Table 4
Minimum Response Factor Criteria

Semivolatile Compounds	Minimum Response Factor (RF)
Acenaphthylene	0.900
3-Nitroaniline	0.010
Acenaphthene	0.900
2,4-Dinitrophenol	0.010
4-Nitrophenol	0.010
Dibenzofuran	0.800
2,4-Dinitrotoluene	0.200
Diethyl phthalate	0.010
1,2,4,5-Tetrachlorobenzene	0.010
4-Chlorophenyl-phenyl ether	0.400
Fluorene	0.900
4-Nitroaniline	0.010
4,6-Dinitro-2-methylphenol	0.010
N-Nitrosodiphenylamine	0.010
Hexachlorobenzene	0.100
Atrazine	0.010
Pentachlorophenol	0.050
Phenanthrene	0.700
Anthracene	0.700
Carbazole	0.010
Di-n-butyl phthalate	0.010
Fluoranthene	0.600
Pyrene	0.600
Butyl benzyl phthalate	0.010
3,3'-Dichlorobenzidine	0.010
Benzo(a)anthracene	0.800

Table 4
Minimum Response Factor Criteria

Semivolatile Compounds	Minimum Response Factor (RF)
Chrysene	0.700
Bis-(2-ethylhexyl)phthalate	0.010
Di-n-octyl phthalate	0.010
Benzo(b)fluoranthene	0.700
Benzo(k)fluoranthene	0.700
Benzo(a)pyrene	0.700
Indeno(1,2,3-cd)pyrene	0.500
Dibenz(a,h)anthracene	0.400
Benzo(g,h,i)perylene	0.500
2,3,4,6-Tetrachlorophenol	0.010

TestAmerica St. Louis has established a default minimum response factor of 0.01 for compound not identified in this table, except for Famphur, Hexachlorophene, Kepone, Phthalic Anhydride which have a minimum response factor of 0.001.

Table 5

Semi-Volatile Internal Standards with Corresponding Analytes*

1,4-Dichlorobenzene-d4	Naphthalene-d8	Acenaphthene-d10	Phenanthrene-d10	Chrysene-d12	Perylene-d12
1,4-Dioxane	Acetophenone	cis-Isosafrole	5-Nitro-o-toluidine	Benzidine	Benzo(b)fluoranthene
Methyl methacrylate	N-Nitrosopyrrolidine	1,2,4,5-Tetrachlorobenzene	4,6-Dinitro-2-methylphenol	Pyrene	Benzo(k)fluoranthene
Pyridine	N-Nitrosomorpholine	Hexachlorocyclopentadiene	N-Nitrosodiphenylamine	Terphenyl-d14	7,12-Dimethyl benz(a)anthracene
N-Nitrosodimethylamine	O-Toluidine	2,4,6-Trichlorophenol	Tri-n-butyl phosphate	Aramite 1	Hexachlorophene
N,N-Dimethylformamide	Nitrobenzene-d5	2,4,5-Trichlorophenol	Azobenzene	Kepone	Benzo(a)pyrene
Ethyl methacrylate	Nitrobenzene	2-Fluorobiphenyl	Sulfotep	Aramite 2	3-methylcholanthrene
2-Picoline	N-Nitrosopiperidine	trans-Isosafrole	Diallate 1	p-(dimethylamino) azobenzene	Indeno (1,2,3-cd) pyrene
N-Nitrosomethylethylamine	Isophorone	Biphenyl	1,3,5-Trinitrobenzene	Chlorobenzilate	Dibenz(a,h)anthracene
Methyl methanesulfonate	2-Nitrophenol	2-Chloronaphthalene	Phorate	3,3'-Dimethylbenzidine	Benzo(g,h,i)perylene
2-Fluorophenol	2,4-Dimethylphenol	2-Nitroaniline	4-Bromophenyl phenyl ether	Butyl benzyl phthalate	
Cyclohexanol	Bis (2-chloroethoxy) methane	1,4-Naphthoquinone	Phenacetin	2-Acetylaminofluorene	
N-Nitrosodiethylamine	o,o,o-Triethylphosphorothioate	1,4-Dinitrobenzene	Diallate 2	Famphur	
Ethyl methanesulfonate	Benzoic acid	Dimethylphthalate	Hexachlorobenzene	Benzo (a) anthracene	
Benzaldehyde	2,4-Dichlorophenol	1,3-Dinitrobenzene	Dimethoate	4,4'-methylenebis (2-Chloroaniline)	
Phenol-d5	a,a-Dimethylphenethylamine	Acenaphthylene	Atrazine	3,3'-Dichlorobenzidine	
Phenol	1,2,4-Trichlorobenzene	2,6-Dinitrotoluene	Tris(2-chloroethyl) phosphate	Chrysene	
Aniline	Naphthalene	3-Nitroaniline	4-Aminobiphenyl	Bis (2-ethylhexyl) phthalate	
Pentachloroethane	4-Chloroaniline	Acenaphthene	Pentachlorophenol	Di-n-octyl phthalate	
Bis (2-chloroethyl) ether	2,6-Dichlorophenol	2,4-Dinitrophenol	Pronamide		
2-Chlorophenol	Hexachloropropene	4-Nitrophenol	Pentachloronitrobenzene		
1,3-Dichlorobenzene	Hexachlorobutadiene	Dibenzofuran	Phenanthrene		

Table 5

Semi-Volatile Internal Standards with Corresponding Analytes*

1,4-Dichlorobenzene-d4	Naphthalene-d8	Acenaphthene-d10	Phenanthrene-d10	Chrysene-d12	Perylene-d12
1,4-Dichlorobenzene	Benzothiazole	Pentachlorobenzene	Disulfoton		
1,2-Dichlorobenzene	Caprolactam	2,4-Dinitrotoluene	Anthracene		
Benzyl alcohol	N-Nitroso-di-n-butylamine	1-Naphthylamine	Dinoseb		
2-Methylphenol	p-Phenylenediamine	2-Naphthylamine	Carbazole		
Bis (2-chloroisopropyl) ether	4-Chloro-3-methylphenol	2,3,4,6-Tetrachlorophenol	Methyl parathion		
3,4-Methylphenol	Safrole	Diethylphthalate	Di-n-butyl phthalate		
N-Nitroso-di-n-propylamine	2-Methylnaphthalene	Fluorene	Parathion		
Hexachloroethane		4-Chlorophenyl phenyl ether	4-Nitroquinoline-1-oxide		
		Thionazin	Methapyrilene		
		4-Nitroaniline	Isodrin		
		2,4,6-Tribromophenol	Fluoranthene		

* ISTD assignment is based on instrument operating conditions and column type and may vary slightly from this listing.

Title: PESTICIDE GAS CHROMATOGRAPHIC ANALYSIS [SW-846 8081B; EPA 608]

Approvals (Signature/Date):

Ben Hicks — Date: 2/14/13
Organics Manager

Michael Ridenhower — Date: 2/14/13
Health & Safety Manager / Coordinator

Marti Ward — Date: 2.14.13
Quality Assurance Manager

Elaine Wild — Date: 2/14/13
Laboratory Director

This SOP was previously identified as SOP No. ST-GC-0016 Rev. 13

Facility Distribution No.: 0 **Distributed To:** See Electronic Distribution Sheet

1.0 SCOPE AND APPLICATION

1.1 This SOP describes procedures to be used for the analysis of Pesticides by GC/ECD.

1.2 Sample preparation techniques are described in SOP ST-OP-0002.

1.3 This SOP is based on SW-846 Methods 8000B, 8000C and 8081B and EPA Method 608.

1.4 The laboratory target analytes supported by this method, the reporting limits, method detection limits and QC limits are maintained in the Laboratory Information Management System (LIMS).

1.4.1 Additional compounds may be amendable to this method. The minimum requirement for non-standard analytes is that the reporting limit be set at the lowest required concentration that can actually be detected by the instrument, and when an MDL study can not be conducted, the MDL be set equal to the reporting limit.

2.0 SUMMARY OF METHOD

2.1 Aqueous samples are prepared for analysis using continuous or separatory funnel liquid / liquid extraction. Solid samples are prepared using sonication. Waste dilution and wipes are extracted by autoshaker.

2.2 After the initial preparation step, the sample is introduced to the GC, equipped with capillary columns and dual Electron Capture Detectors (ECD). Concentrations of target analytes are measured by the detector response within a defined retention time window, relative to the response to standard concentrations. The external standardization procedure is used.

3.0 DEFINITIONS

3.1 See the TestAmerica St. Louis Quality Assurance Manual (ST-QAM) for a glossary of common laboratory terms and data reporting qualifiers.

4.0 INTERFERENCES

4.1 Interferences in the GC analysis arise from many compounds amenable to gas chromatography that give a measurable response on the electron capture detector. Phthalate esters, which are common plasticizers, can pose a major problem in the determinations. Interferences from phthalates are minimized by avoiding contact with any plastic materials.

4.2 Interferences co-extracted from samples will vary considerably from source to source. The presence of interferences may raise quantitation limits for individual samples. Specific cleanups may be performed on the sample extracts, including florisil cleanup (Method 3620).

4.3 Contamination by carryover can occur when a low concentration sample is analyzed after a high concentration sample. Co-elution of target analytes with non-targets can occur, resulting in false positives or biased high results.

4.4 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and interferences to sample extracts. Strict attention to glassware cleaning and handling and demonstration of solvent purity will lead minimization of these interferences.

5.0 SAFETY

5.1 Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual, Radiation Safety Manual and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the

safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.2 SPECIFIC SAFETY CONCERNS OR REQUIREMENTS

5.2.1 The gas chromatograph contains zones that have elevated temperatures. The analyst needs to be aware of the locations of those zones, and must cool them to room temperature prior to working on them.

5.2.2 There are areas of high voltage in the gas chromatograph. Depending on the type of work involved, either turn the power to the instrument off, or disconnect it from its source of power.

5.2.3 The ECD contains a source of radiation.

5.3 PRIMARY MATERIALS USED

5.3.1 The following is a list of the materials used in this method, which have a serious or significant hazard rating. **NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table.** A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Hexane	Flammable Irritant	500 ppm (TWA)	Inhalation of vapors irritates the respiratory tract. Overexposure may cause lightheadedness, nausea, headache, and blurred vision. Vapors may cause irritation to the skin and eyes.
Methanol	Flammable Poison Irritant	200 ppm (TWA)	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			
TWA – Time Weighted Average			

6.0 EQUIPMENT AND SUPPLIES

6.1 GC/ECD system: The lab utilizes an Agilent GC 6890 dual micro ECD system with auto-sampler.

6.1.1 The GC column type, and instrument run conditions are posted in the maintenance log and reside in the Chemstation method.

6.2 Data System – Chemstation for acquisition and Target™ for data processing

6.3 Disposable pipettes

6.4 Amber vials: Crimp top seals

6.5 Clear vials and silicon crimp seals

6.6 Micro syringes- 10-µL, 250-µL, 500-µL, 1000-µL. Hamilton 1700 series

6.7 Volumetric flasks, Class A

6.8 Analytical Balance, capable of weighing ± 0.01 g

7.0 REAGENTS AND STANDARDS

7.1 All standards and reagent preparation, documentation and labeling must follow the requirements of SOP ST-QA-0002, current revision.

7.2 Pesticide stock standard solutions must be replaced after 6 months, once opened, or manufacturer's expiration date whichever is shorter. Pesticide calibration solutions must be refrigerated at ≤ 6 °C and protected from light. Intermediate and working standards must be replaced at least every six months, or the stock solutions expiration date, whichever is sooner. Additionally standards are discarded if comparison with check standards indicates a problem.

7.3 See reagent log for specific information regarding standards and reagents.

7.4 ICV standards, NIST traceable:
- 7.4.1 The Pesticide ICV standard is a second source from the calibration standard.
- 7.4.2 ICV standard is prepared and stored in the same way as calibration standards.

7.5 Surrogate Standards
- 7.5.1 Tetrachloro-m-xylene and decachlorobiphenyl are the surrogate standards.

7.6 Column Degradation Evaluation Mix (PEM Standard)
- 7.6.1 A standard containing 4,4'-DDT and Endrin and not containing any of their breakdown products must be prepared for evaluation of degradation of these compounds by the GC column and injection port. This mix must be replaced after 6 months, or whenever corrective action to columns fails to eliminate the breakdown of the compounds, whichever is shorter. This solution also contains the surrogates. Refer to Table 1 for details of the column degradation evaluation mix.

7.7 Gases for carrier and make-up: Hydrogen carrier, Nitrogen make-up

8.0 SAMPLE PRESERVATION AND STORAGE

8.1 TestAmerica St. Louis supplies sample containers and chemical preservatives in accordance with the method. TestAmerica St. Louis does not perform sample collection. Samplers should reference the methods referenced and other applicable sample collection documents for detailed collection procedures. Sample volumes and preservative information is given in ST-PM-0002.

8.2 Water samples are unpreserved and stored at 4 ± 2 °C.

8.3 Soil samples are refrigerated at 4 ± 2 °C.

8.4 The extraction holding time for Pesticides analysis in waters is 7 days.

8.5 The extraction holding time for Pesticides analysis in soil/solid matrix is 14 days.

8.6 Extracts must be refrigerated at ≤ 6 °C and analyzed within 40 days of the end of the extraction.

9.0 QUALITY CONTROL

9.1 **Batch**

9.1.1 A sample batch is a maximum of 20 environmental samples, which are prepared together using the same process and same lot(s) of reagents.

9.1.2 Instrument conditions must be the same for all standards, samples and QC samples.

9.1.3 For this analysis, batch QC consists of a method blank, a Laboratory Control Sample (LCS), and Matrix Spike (MS)/ Matrix Spike Duplicate (MSD). In the event that there is insufficient sample to analyze a MS/MSD an LCS Duplicate (LCSD) is prepared and analyzed.

9.2 **Method Blank (MB)**

9.2.1 A method blank is a blank matrix processed simultaneously with, and under the same conditions as, samples through all steps of the procedure.

9.2.2 A method blank must be prepared with every sample batch.

9.2.3 DI water is used as the blank matrix for water batches.

9.2.4 Sodium sulfate is used as the blank matrix for solid batches.

9.3 **Laboratory Control Sample (LCS)**

9.3.1 An LCS is a blank matrix spiked with a known amount of analyte(s), processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.3.2 An LCS must be prepared with every sample batch.

9.3.3 DI water, spiked with the analytes of interest is used as the LCS for water batches.

9.3.4 Sodium sulfate, spiked with the analytes of interest is used as the LCS for solid batches.

9.4 **Matrix Spike (MS) /Matrix Spike Duplicate (MSD)**

9.4.1 A Matrix Spike is an aliquot of a field sample to which a known amount of target analyte(s) is added, and is processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.4.2 For Method 608 a matrix spike must be performed at a frequency of one per ten samples.

9.5 **Surrogate**

9.5.1 A surrogate is a non-target analyte similar in chemical composition and behavior, which mimics the target analytes during preparation, extraction and analysis.

9.5.2 Surrogate(s) is added to every field sample, method blank, LCS and MS/MSD for analysis at the beginning of the sample preparation process.

9.6 **Procedural Variations/ Nonconformance and Corrective Action**

9.6.1 Any variation shall be completely documented using a Nonconformance Memo and approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

9.6.2 Any deviations from QC procedures must be documented as a nonconformance, with applicable cause and corrective action approved by the Supervisor and QA Manager. See SOP STL-QA-0036 for details regarding the NCM process.

10.0 CALIBRATION AND STANDARDIZATION

10.1 External standard calibration is used.

10.2 Column Degradation Evaluation (PEM)

10.2.1 The column evaluation mix must be injected before each initial calibration, the beginning of an analytical sequence and every subsequent 12 hours of continuous analysis.

10.2.2 The degradation of DDT and Endrin must be calculated (see equations Section 12) and each shown to be less than 15% before calibration can proceed.

10.2.3 If the breakdown of DDT and/or Endrin exceeds the limits given above, corrective action must be taken. This action may include:

10.2.3.1 Replacement of the injection port liner or the glass wool.
10.2.3.2 Cutting off a portion of the injection end of a capillary column.
10.2.3.3 Replacing the GC column.

10.3 Initial Calibration

10.3.1 Prepare a Pesticide standard at a minimum of five concentration levels. (Six points are required if a quadratic (second order) curve is used.) The low level standard should be at or below the reporting limit. The other standards define the working range of the detector. Six points are required for quadratic (2^{nd} order) curves.

10.3.2 A single point calibration for Technical Chlordane and Toxaphene is performed with every initial calibration for pattern recognition.

10.3.2.1 Select 3-5 major peaks in the multi-component analyte pattern. The area of each peak is used to calculate the concentration for each peak. An average of the concentrations is used.

10.3.2.2 If Toxaphene or Technical Chlordane is detected, sample will require re-analysis under a five point calibration for the analyte found. See Client Requirements Sheet to determine if this is needed.

10.3.3 The analyst may include a full 5 point calibration for any of the multi-component analytes with the initial calibration.

10.3.4 A new calibration curve must be generated after major changes to the system or when the continuing calibration criteria cannot be met. Major changes include new columns, any significant changes in instrument operating parameters, and major instrument maintenance (e.g., ECD replacement).

10.3.5 Except in specific instances, it is NOT acceptable to remove points from a calibration curve for the purpose of meeting criteria. Refer to the STL corporate policy, "Selection of Calibration Points", P-T-001.

10.3.6 Sample peak areas are compared to peak areas of the standards. The ratio of the detector response to the amount concentration of analyte in the calibration standard is defined as the response factor (RF) or calibration factor (CF).

10.4 SW 8081 criteria

10.4.1 SW-846 chromatographic methods allow the use of both linear and non-linear models for the calibration data.

10.4.1.1 The first way is to begin with the simplest approach, the linear model through the origin, and then progress through other options until the calibration acceptance criteria are met. The second way is to use technical knowledge of the detector response to the target compound to choose the calibration model.

10.4.1.2 The option for non-linear calibration may be necessary to address specific instrumental techniques. However, it is not EPA's intent to allow non-linear calibration to be used to compensate for detector saturation or to avoid proper instrument maintenance.

10.4.2 Linear calibration using the average response factor

10.4.2.1 The Relative Standard Deviation (RSD) of the calibration points from the curve used must be $\leq$ 20% for each target analyte.

10.4.2.2 If the %RSDs in the initial calibration is > 20%, then calibration using a linear regression may be employed.

10.4.3 Linear calibration using a least squares regression

10.4.3.1 The intercept of the curve at zero response must be less than ± the reporting limit for the analyte.

10.4.3.2 r (correlation coefficient) must be $\geq$ 0.995 OR r^2 (coefficient of difference) must be $\geq$ 0.990.

10.4.3.3 Linear calibration using a least squares regression, forcing thru zero

10.4.3.3.1 Forcing the curve through zero is not the same as including the origin as a fictitious point in the calibration. In essence, if the curve is forced through zero, the intercept is set to 0 *before* the regression is calculated, thereby setting the bias to favor the low end of the

calibration range by "pivoting" the function around the origin to find the best fit and resulting in one less degree of freedom. It may be appropriate to force the regression though zero for some calibrations.

10.4.3.3.2 Curve must still meet criteria in 10.4.3.1 and 10.4.3.2.

10.4.3.3.3 For samples requiring adherence to SW846 Method 8000B, forcing through zero is NOT allowed.

10.4.3.4 Linear calibration using a least squares regression, weighting of data points

10.4.3.4.1 In linear, the points at the lower end of the calibration curve have less absolute variance than points at the high concentration end of the curve. This can cause severe errors in quantitation at the low end of the calibration. For this reason it may preferable to increase the weighting of the lower concentration points. $^{1}/\text{Concentration}^{2}$ weighting (often called $^{1}/_{X}{}^{2}$ weighting) to improve accuracy at the low end of the curve.

10.4.3.4.2 Curve must still meet criteria in 10.4.3.1 and 10.4.3.2.

10.4.4 Non-linear calibration

10.4.4.1 In situations where the analyst knows that the instrument response does not follow a linear model over a sufficiently wide working range, or when the other approaches have not met the acceptance criteria, a non-linear calibration model may be employed. Non linear calibration requires 6 points.

10.4.4.1.1 It is not EPA's intent to allow non-linear calibration to be used to compensate for detector saturation or to avoid proper instrument maintenance. Thus, non-linear calibrations are not be employed for analytes shown to consistently exhibit linear calibration for the analytes of interest.

10.4.4.2 The intercept of the curve at zero response must be less than + or – the reporting limit for the analyte.

10.4.4.3 r (correlation coefficient) must be ≥ 0.995 OR r^2 (coefficient of difference) must be ≥ 0.990.

10.4.4.4 A quadratic calibration curve requires six standards.

10.5 608 Criteria

10.5.1 Method 608 only requires a 3-point calibration.

10.5.1.1 We routinely perform a 5-point calibration; however, 2 points may be removed from the curve if necessary to meet 608 calibration criteria.

10.5.1.2 Refer to the STL corporate policy, "Selection of Calibration Points", P-T-0001.

10.5.2 The Relative Standard Deviation (RSD) of the calibration points from the curve used must be $\leq 10\%$.

10.5.3 If the %RSDs in the initial calibration is > 10%, then calibration using a linear regression may be employed. See section 10.4.3 for criteria.

10.6 Initial Calibration Verification (ICV)

10.6.1 An initial calibration verification standard must be a different standard source than the one used for the initial calibration.

10.6.2 An ICV must be performed with every initial calibration.

10.6.3 The ICV performance must be within ± 20% D criteria.

10.6.3.1 Not meeting this requirement may be indicative of serious system malfunction or inaccuracies in the standards used for the initial calibration curve or ICV standard. Corrective action must be taken (including reanalysis of the ICV, or analysis of a different ICV). Any decision to proceed with analysis of samples when the ICV is out-of-control must be taken with great care and in consultation with the QA department and the laboratory director. Any such action must be documented in an NCM.

10.7 Continuing Calibration Verification (CCV)

10.7.1 A CCV may be the same source or second source as the calibration.

10.7.2 Analyte response factors must be verified at the beginning of each analytical run (by either an ICV or a CCV), after every 10 samples and at the end of the analysis run through the analysis of a mid-level calibration standard.

10.7.3 SW 8081 criteria

10.7.3.1 The calibration verification is acceptable if the %D for each single component pesticide is ≤ 20%.

10.7.3.2 The same criteria will be used if Technical Chlordane or Toxaphene verifications are performed.

10.7.3.3 If a CCV has failed and the analyst can document the reason for failure (e.g. broken vial, carryover from the previous sample etc.) then a second CCV may be analyzed without any adjustments to the instrument. If this CCV meets criteria then sample analysis may continue; however the preceding samples must be reanalyzed. If this second CCV does not meet criteria, the analysis run is terminated. Instrument maintenance is performed and the instrument may require re-calibration (i.e. initial calibration).

10.7.4 608 criteria

10.7.4.1 At the beginning of each 24-hour long (or less) analytical sequence, demonstrate that the instrument calibration is still within the linear range established by the initial calibration through the analysis of mid-level standards of each compound of interest.

10.7.4.2 If the analyzed concentration of each analyte is within ± 15% of the true value, the daily calibration check is successful, and samples may be analyzed until 24-hours have elapsed from the injection of the first daily calibration standard.

10.8 Retention Time (RT) Windows

10.8.1 Retention Time (RT) windows must be determined for all analytes.

10.8.1.1 Establishing RT windows:

10.8.1.1.1 Make an injection of all analytes of interest each day over a three day period. Calculate the mean and the standard deviation of the three retention times for each analyte.

10.8.1.1.2 The width of the retention time window for each analyte, surrogate, and major constituent in multi-component analytes is defined as ± 3 times the standard deviation of the mean absolute retention time established during the 72-hour period or 0.03 minutes, whichever is greater. Historically, calibrations RT windows have not been greater than 0.03 minutes. Windows larger than 0.03 minutes are indicative of equipment issues.

10.8.1.1.3 The center of the retention time window is the retention time from the CCV performed at the beginning of the analytical run. For samples run during the same shift as the initial calibration, use the retention time of the mid-point standard from the initial calibration. Some clients may have specific requirements regarding the updating of RT windows. Review the Client Requirement Memo for instructions.

10.8.1.1.4 A new retention time window study is performed annually or when the analytical column from a new vendor or different stationary phase is used.

10.8.1.1.4.1 Until these standards have been run on the new column, the retention time windows from the old column may be used, updated with the retention times from the new initial calibration.

10.8.2 Retention Time Criteria

10.8.2.1 The retention times of all compounds in each continuing calibration must be within the retention time windows established.

11.0 PROCEDURE

11.1 Allow standards, samples and sample extracts to reach ambient temperature before analysis.

11.2 All analysis conditions and injection volumes for samples must be the same as for the calibration standards.

11.3 Sample Introduction

11.3.1 Semivolatile analytes are introduced by direct injection of the extract. Samples, standards, and QC must be introduced using the same procedure.

11.4 Perform all qualitative and quantitative measurements. When the standards and extracts are not being used, refrigerate them at 4 $\pm$ 2 °C, protected from light in screw cap vials equipped with unpierced Teflon lined septa.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 Commonly used calculations (e.g. % recovery and RPD) and standard instrument software calculations are given in the TestAmerica St. Louis ST-QAM.

12.2 External Standard Calculations

12.2.1 *Analyte Concentration (µg/L) in sample*

Concentration (µg/L):

$$[C] = \frac{A_x * V_t * D}{\overline{CF} * V_i * V_s}$$

Where:

$[C]$	=	*Analyte Concentration in sample (µg/L)*
A_x	=	*Area of peak (response)*
V_t	=	*Total volume of extract (µL)*
D	=	*Dilution factor*
$\overline{CF}$	=	*Calibration factor ($\overline{RF}$ in target) – Response factor*
V_i	=	*Volume of extract injected (µL)*
V_s	=	*Volume of sample extracted*

12.2.2 *On column concentration*

On Column Concentration (µg/mL):

$$[OC] = \frac{A_x}{\overline{CF}}$$

Where:

$[OC]$ = *On Column Concentration [typically expressed in µg/mL (ppm)]*

Then substitute/derive

$$[C] = [OC]\left(\frac{V_t * D}{V_i * V_s}\right)$$

When *on column concentration* $[OC]$ is equal to the *CAL-AMT (calibration amount)* of the low level standard needed to support the *reporting limit (µg/L)* and we solve the equation for *concentration (µg/L)*

Then

$$[C] \equiv RL \equiv [OC]\left(\frac{V_t * D}{V_i * V_s}\right)$$

Where:

RL = Reporting Limit

12.3 See Target software for additional calculations.

12.4 Manual Integrations

12.4.1 Identified compounds are reviewed for proper integration. Manual integrations are performed if necessary and are documented by the analyst or automatically by the data system. See TestAmerica Policy CA-Q-S-002, Acceptable Manual Integration Practices. Manual integrations are denoted with a "M" flag on the Target quantitation report.

12.5 Dilutions

12.5.1 If the concentrations of any analytes exceed the working range as defined by the calibration standards, then the sample must be diluted and reanalyzed.

12.5.2 A dilution should target the most concentrated analyte in the upper half (over 50% of the high level standard) of the client specific project requirements.

12.6 Carryover

12.6..1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.

12.6.1.1 If a sample analyzed after a sample with high concentrations has negative results, carryover did not occur.

12.6.1.2 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, carryover may have occurred.

12.6.1.2.1 This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

12.6.1.3 If the chromatographic profile resembles the previous sample, the results are questionable.

12.1.1.1.1 This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

12.7 Dual column quantitation

12.7.1 As per 8000C, report the lower result of the two columns, unless the Client SOW requires that the higher result be reported. See Client Requirements Sheet for determination.

12.7.1.1 For non-detect (ND) results, report from the A channel, unless there is evidence of chromatographic interference in the A channel's performance.

12.7.1.2 If one result is significantly higher (e.g., > 40%), check the chromatograms to see if an obviously overlapping peak is causing an erroneously high result. If no overlapping peaks are noted, examine the baseline parameters established by the instrument data system (or operator) during peak integration. If no anomalies are noted, review the chromatographic conditions. If there is no evidence of chromatographic

problems, report the lower result. The data user should be advised of the disparity between the results on the two columns.

12.7.1.3 Use the higher result if there is obvious chromatographic interference on the column with the lower result.

12.1.1.2 12.7.1.4 If the CCV performance on one of the two channels is outside acceptance criteria due to confirmed matrix interference, report sample data from the column with acceptable performance, irrespective of it being the higher or lower result.

12.7.2 The QC should be reported from the column that reflects the column used for the majority of the samples associated with the QC.

12.7.3 The surrogate should be reported from the column that reflects the column used for the majority of the analytes associated with a sample.

13.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA; CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

13.1 The data assessment and corrective action process is detailed through the LIMS Nonconformance Memorandum (NCM) process. The NCM process is described in SOP: STL-QA-0036.

13.2 Method Blank

13.2.1 Acceptance Criteria:

13.2.1.1 No target analytes may be present in the method blank above the reporting limit.

13.2.1.2 Project specific requirements if more stringent than our routine procedure (e.g. no target analytes present above ½ RL), will be noted on the client requirements sheet.

13.2.1.3 The method blank must have acceptable surrogate recoveries.

13.2.2 Corrective Action for Method Blanks not meeting acceptance criteria:

13.2.2.1 Method Blank Contamination – Blank contamination above the RL (>½ RL for some programs – see specific Client Requirement Memos for details) requires re-prep of batch unless all associated samples are < RL or greater than 10 times the amount detected in the method blank.

13.2.2.2 Method Blank Surrogate excursion – If excursion is limited to the blank, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-analysis is required. In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM.

13.3 Laboratory Control Sample (LCS)

13.3.1 Acceptance Criteria:

13.3.1.1 All control analytes should be within established control limits for accuracy (%Recovery) and precision (RPD).

13.3.1.1.1 For long analyte spike list, marginal exceedances (ME) are allowed as follows:

13.3.1.1.2 < 11 analytes in LCS, no analytes allowed in ME of the LCS control limit.

13.3.1.1.3 11 – 30 analytes in LCS, 1 analytes allowed in ME of the LCS control limit.

13.3.1.1.4 31 – 50 analytes in LCS, 2 analytes allowed in ME of the LCS control limit.

13.3.1.1.5 51 – 70 analytes in LCS, 3 analytes allowed in ME of the LCS control limit.

13.3.1.1.6 71 – 90 analytes in LCS, 4 analytes allowed in ME of the LCS control limit.

13.3.1.1.7 > 90 analytes in LCS, 5 analytes allowed in ME of the LCS control limit.
13.3.1.1.8 No LCS recoveries may be outside the Marginal Exceedance limit.
13.3.1.1.9 Marginal exceedances must be random. If the same LCS analyte exceeds the control limit repeatedly, it is an indication of a systemic problem. The source of the error must be located and corrective action taken.
13.3.1.1.10 The LCS should have acceptable surrogate recoveries.

13.3.2 Corrective Action for LCS not meeting acceptance criteria:
13.3.2.1 LCS Spike Recovery excursion (high) – Samples that are non-detect may be reported with an NCM (unless prohibited by client requirements). Samples with detects for the analyte recovered high in the LCS are re-prepped and re-analyzed. In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM
13.3.2.2 LCS Spike Recovery excursion (low) – batch is re-prepped and re-analyzed.
13.3.2.3 LCS Surrogate Recovery excursion – If excursion is limited to the LCS, data may be reported with an NCM. If target analytes are in control in the LCS, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-analysis is required.
13.3.2.4 RPD excursion for LCS/LCSD – If target analytes recoveries are in control, data may be reported with an NCM

13.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD)
13.4.1 Analytes should be within control limits for accuracy (%Recovery) and precision (RPD)
13.4.2 Corrective Action for MS/MSD not meeting acceptance criteria:
13.4.2.1 MS/MSD Spike Rec. excursion may not necessarily warrant corrective action other than narration. If affected analyte concentration in the original sample is greater than four times the amount spiked, percent recovery information is ineffective. Data is reported with an NCM. If the excursion is due to a physically evident matrix interference, the data is reported with an NCM (the physical interference must be described in the NCM). If there is no evidence of interference and the RPD as well as spike recoveries out outside limits out, sample re-prep and re-analysis are required.

.

13.5 Surrogate
13.5.1 All Surrogates should be within established control limits for accuracy (%Recovery).
13.5.2 Corrective Action for Surrogate not meeting acceptance criteria:
13.5.2.1 Surrogate Spike Rec. excursion may not necessarily warrant corrective action other than narration.

13.6 Sample result evaluation
13.6.1 Dilutions
13.6.1.1 If the response for any compound exceeds the working range of the analytical system, a dilution of the extract is prepared and analyzed. An appropriate dilution should be in the upper half of the calibration range.
13.6.1.2 Dilution: Sample – An NCM is written to document the reason for the dilution.
13.6.1.3 .Dilution: Surrogates(s) and/or Spike(s) diluted out – Dilution: Surrogate(s) and/or spike(s) diluted out – An NCM is written to document the reason for the dilution
13.6.2 Carryover
13.6.2.1 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, or if the chromatographic profile resembles the previous sample, the results are questionable. This sample must be reanalyzed under conditions in which carryover can be demonstrated to not have occurred.

13.6.2.1.1 The carryover affected analyses are not reported, unless specifically requested by the client or there was insufficient extract/sample remaining to reanalyze.

13.6.3 Insufficient Sample

13.6.3.1 For any prescribed re-preparation corrective action, if there is insufficient sample to repeat the analysis a narrative comment stating such is included in the report narrative. An NCM is written to document the insufficient volume..

14.0 METHOD PERFORMANCE AND DEMONSTRATION OF CAPABILITY

14.1 Method performance data, Reporting Limits, and QC acceptance limits, are maintained in the LIMS.

14.2 Demonstration of Capability

14.2.1 Initial and continuing demonstrations of capability requirements are established in the ST-QAM.

14.3 Training Qualification

14.3.1 The manager/supervisor has the responsibility to ensure that this procedure is performed by an analyst who has been properly trained in its use and has the required experience.

14.3.2 The analyst must have successfully completed the initial demonstration capability requirements prior to working independently. See requirements in the ST-QAM.

14.4 Annually, the analyst must successfully demonstrate proficiency to continue to perform this analysis. See requirements in the ST-QAM.

15.0 VALIDATION

15.1 Laboratory SOPs are based on published methods (EPA, DOE, ASTM, Eichrom, Standard Methods) and do not require validation by the laboratory. The requirements for laboratory demonstration of capability are included in the ST-QAM. Laboratory validation data would be appropriate for performance based measurement systems, non-standard methods and significant modifications to published methods. Data from said validations is held in the QA department.

16.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

16.1 All waste will be disposed of in accordance with Federal, State and Local regulations. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in section 13 of the Corporate Environmental Health and Safety Manual for “Waste Management and Pollution Prevention.”

16.2 Waste Streams Produced by the Method

16.2.1 The following waste streams are produced when this method is carried out.

16.2.1.1 Solvent waste generated. Solvent waste must be accumulated in the appropriate waste accumulation container, labeled as Drum Type “D”.

16.2.1.2 Vials containing sample extract will be accumulated in the appropriate waste accumulation container, labeled as Drum Type “C”.

17.0 REFERENCES

17.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Methods 8000B and 8000C.

17.2 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Method 8081B.

17.3 USEPA Wastewater Method 608.

17.4 TestAmerica Quality Assurance Manual (ST-QAM), current revision

17.5 TestAmerica Corporate Environmental Health and Safety Manual (CW-E-M-001) and St. Louis Facility Addendum (SOP ST-HS-0002), current revisions.

17.6 TestAmerica Policy CA-Q-S-002, Acceptable Manual Integration Practices

17.7 TestAmerica Policy CA-T-P-0002, Selection of Calibration Points

17.8 Associated SOPs, current revisions;

- 17.8.1 ST-OP-0001, Labware Preparation for Organic Analysis
- 17.8.2 ST-OP-0002, Extraction and Cleanup of Organic Compounds from Water and Soils, Based on SW-846 3500 Series, 3600 Series, and 600 Series
- 17.8.3 ST-PM-0002, Sample Receipt and Chain of Custody
- 17.8.4 ST-QA-0002, Standard and Reagent Preparation
- 17.8.5 ST-QA-0005, "Calibration and Verification Procedure for Thermometers, Balances, Weights and Pipettes."
- 17.8.6 ST-QA-0014, Evaluation of Analytical Accuracy and Precision Through the Use of Control Charts
- 17.8.7 ST-QA-0016, IDL/MDL Determination
- 17.8.8 ST-QA-0036, Non-conformance Memorandum (NCM) Process

18.0 CLARIFICATIONS, MODIFICATIONS TO THE REFERENCE METHOD

18.1 Chapter 1 of SW-846 states that the method blank should not contain any analyte of interest at or above the Method Detection Limit. This SOP states that the Method Blank must not contain any analyte of interest at or above the reporting limit. Common lab contaminants are allowed to be up to 5 times the reporting limit in the blank following consultation with the client.

18.2 The surrogate calibration curve is calculated from the Pesticide mix standard. Surrogates are not included in the Technical Chlordane and Toxaphene standards.

18.3 SW846 requires that new retention time windows be established if a GC column has been shortened during maintenance. Given the matrices of the sample the laboratory receives, and the number of times the GC column may require clipping, TestAmerica St. Louis does not perform a RT study after clipping a column. RT studies done by the laboratory show that, historically, RT windows have not been greater than the method allowed 0.03 minutes. The lab defaults to a 0.03 minute RT window as allowed by the method.

18.4 Method 608 only requires a 3 point calibration. The laboratory routinely performs a 5 point calibration.

19.0 CHANGES TO PREVIOUS REVISION

19.1 Updated section 4.2 by removing Gel Permeation Chromatography (Method 3640) and Sulfur cleanup (Method 3660).

19.2 Rev 11:

- 19.2.1 Annual Review, No Changes.

19.3 Rev 12:

- 19.3.1 Annual Review, No Changes.

19.4 Rev 13:

19.4.1 Added new equipment and supplies to section 6.0.

19.4.2 Updated information regarding reagent log in section 7.0.

19.4.3 Updated instructions for initial calibrations in section 10.3.

19.4.4 Updated non-linear calibration point requirements in section 10.4.

19.4.5 Updated requirements for performing RT window studies.

19.5 Rev 14:

19.5.1 Added new safety concerns in section 5.2

19.5.2 Updated location of where GC column type information can be found in section 6.0

19.5.3 Added software information to Section 6

19.5.4 Added method blank and LCS composition to Section 9..

19.5.5 Updated initial calibration peak calculations in section 10.3.

19.5.6 Updated quadratic calibration curve requirements in section 10.4.4.

19.5.7 Removed references to QuantIMS and Clouseau – replaced with LIMS.

19.5.8 Added reporting limit calculations to Section 12.

19.5.9 Added specific corrective actions to Section 13.

Table 1	
Column Degradation Evaluation Mix	
Component	Concentration (ug/L)
4,4'-DDT	100.000
Alpha-BHC	10.000
Beta-BHC	10.000
Endrin	50.000
Gamma-BHC	10.000
Methoxychlor	250.000
Tetrachloro-m-xylene (Surrogate)	20.000
Decachlorobiphenyl (Surrogate)	20.000

Analytical Sequence

Initial Calibration

Conditioning Standard	
Hexane Blank	
Instrument Blank	
Breakdown Mix (PEM)	
Individual mix	All levels
Individual mix ICV	
Technical Chlordane	All levels
Technical Chlordane ICV	
Toxaphene	All levels
Toxaphene ICV	
2,4'-DD* Mix	All levels
2,4'-DD* Mix ICV	
Hexachlorobenzene	All levels
Hexachlorobenzene ICV	
Sample injections (maximum 10)	
Continuing Calibration Verification (CCV)	Mid level (for needed target analytes)
Sample injections (maximum 10)	
Continuing Calibration Verification (CCV)	Mid level (for needed target analytes)

Breakdown check (beginning of an analytical run and subsequently every 12 hours of continuous analysis)

Title: PCB GC ANALYSIS [SW-846 8000C/8082A; EPA 608]

Approvals (Signature/Date):

Ben Hicks — Date 2/12/13
Organics Department Manager

Michael Ridenhower — Date 2/14/13
Health & Safety Manager / Coordinator

Marti Ward — Date 2-12-13
Quality Assurance Manager

Elaine Wild — Date 2/12/13
Laboratory Director

This SOP was previously identified as SOP No. ST-GC-0015 Rev. 10

Facility Distribution No.: 0 **Distributed To: See Electronic Distribution Sheet**

1.0 SCOPE AND APPLICATION

1.1 This SOP describes procedures to be used for the analysis of polychlorinated biphenyls (PCB) by GC/ECD. The PCBs are determined and quantitated as multi-component Aroclor mixes.

1.2 Sample preparation techniques are described in SOP ST-OP-0002.

1.3 This SOP is based on EPA SW-846 Methods 8000C and 8082A, and EPA Method 608.

1.4 The laboratory target analytes supported by this method, the reporting limits, method detection limits and QC limits are maintained in the Laboratory Information Management System (LIMS).

1.4.1 Additional compounds may be amendable to this method. The minimum requirement for non-standard analytes is that the reporting limit be set at the lowest required concentration that can actually be detected by the instrument, and when an MDL study can not be conducted, the MDL be set equal to the reporting limit.

2.0 SUMMARY OF METHOD

2.1 Aqueous samples are prepared for analysis using continuous or separatory funnel liquid / liquid extraction. Solid samples are prepared using sonication. Wipes are extracted by autoshaker.

2.2 After the initial preparation step, the sample is introduced to the GC and concentrations of target analytes are measured by the detector response within a defined retention time window, relative to the response to standard concentrations. The external standardization procedure is used.

3.0 DEFINITIONS

3.1 See the TestAmerica St. Louis Quality Assurance Manual (ST-QAM) for a glossary of common laboratory terms and data reporting qualifiers.

4.0 INTERFERENCES

4.1 Interferences in GC analysis arise from many compounds amenable to gas chromatography that give a measurable response on the electron capture detector. Phthalate esters, which are common plasticizers, can pose a major problem in the determinations. Interferences from phthalates are minimized by avoiding contact with any plastic materials.

4.2 Interferences co-extracted from samples will vary considerably from source to source. The presence of interferences may raise quantitation limits for individual samples. Specific cleanups may be performed on the sample extracts, including florisil cleanup (Method 3620), Gel Permeation Chromatography (Method 3640), and Sulfur cleanup (Method 3660). For PCBs the most common cleanup procedure is the Sulfuric Acid cleanup (Method 3665A).

4.3 Contamination by carryover can occur when a low concentration sample is analyzed after a high concentration sample. Co-elution of target analytes with non-targets can occur, resulting in false positives or high biased results.

4.4 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and interferences to sample extracts. Strict attention to glassware cleaning and handling and demonstration of solvent purity will lead to minimization of these interferences.

5.0 SAFETY

5.1 Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001), Radiation Safety Manual and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.2 SPECIFIC SAFETY CONCERNS OR REQUIREMENTS

5.2.1 The gas chromatograph contains zones that have elevated temperatures. The analyst needs to be aware of the locations of those zones, and must cool them to room temperature prior to working on them.

5.2.2 There are areas of high voltage in the gas chromatograph. Depending on the type of work involved, either turn the power to the instrument off, or disconnect it from its source of power.

5.3 PRIMARY MATERIALS USED

5.3.1 The following is a list of the materials used in this method, which have a serious or significant hazard rating. **NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table.** A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	OSHA Exposure Limit (2)	Signs and symptoms of exposure/Unusual Hazards
Hexane	Flammable Irritant	500 ppm-(TWA)	Inhalation of vapors irritates the respiratory tract. Overexposure may cause lightheadedness, nausea, headache, and blurred vision. Vapors may cause irritation to the skin and eyes.
Methanol	Flammable Poison Irritant	200 ppm (TWA)	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limits refer to the OSHA regulatory exposure limit.			
TWA – Time Weighted Average			

6.0 EQUIPMENT AND SUPPLIES

6.1 GC/ECD system: The lab utilizes a Hewlett Packard GC 5890 dual ECD system and an Agilent GC 6890 dual micro ECD system with autosampler.

6.1.1 GC column types, and instrument run conditions are posted on the individual GC instruments.

6.2 Data System – Chemstation for acquisition and Target™ for data processing.

6.3 Amber and/or clear glass vials. Crimp top seals.

6.4 Disposal pipettes.

6.5 Micro syringes- 10µL, 250µL, 500µL, 1000µL. Hamilton 1700 series.

6.6 Volumetric flasks, Class A

7.0 REAGENTS AND STANDARDS

7.1 All standards and reagent preparation, documentation and labeling must follow the requirements of SOP ST-QA-0002, current revision.

7.2 PCB primary standard solutions:

7.2.1 Primary standards are prepared by dilution of neat liquid Aroclor mix 1016/1260, and from single aroclor mixes in hexane. Primary standards must be replaced after 6 months or the manufacturer's expiration date whichever is shorter. Standards must be stored in refrigerator or freezer at $\leq 6^{\circ}$C.

7.3 Working standards:

7.3.1 The working standards are prepared in hexane from the primary standard solution for a minimum of five concentration levels of the Aroclor mix 1016/1260 and one level of the single aroclors. Working standards must be replaced after 6 months or manufacturer's expiration date whichever is shorter. All working standards expire after six months or at the expiration date of their stock standards, whichever comes sooner.

7.4 Gases for carrier and make-up: Hydrogen carrier, Nitrogen make-up.

7.5 Decachlorobiphenyl (surrogate)

7.6 Copper powder

7.6.1 Remove oxides (if powder is dark) by treating with dilute nitric acid, rinse with organic-free reagent water to remove all traces of acid, rinse with acetone, and dry under a stream of nitrogen.

7.7 Initial Calibration Verification (ICV) spiking standard is similar to calibration standards, but are from a different source or vendor and are prepared and stored in the same way as calibration standards.

8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1 TestAmerica St. Louis supplies sample containers and chemical preservatives in accordance with the method. TestAmerica St. Louis does not perform sample collection. Samplers should reference the methods referenced and other applicable sample collection documents for detailed collection procedures. Sample volumes and preservative information is given in ST-PM-0002.

8.2 Water samples are unpreserved and stored at $4 \pm 2^{\circ}$ C.

8.3 Soil samples are refrigerated at $4 \pm 2^{\circ}$ C.

8.4 Extracts must be refrigerated at $\leq 6^{o}$C.

8.5 Sample extracts need to be isolated from all potential contaminants and all standards.

9.0 QUALITY CONTROL

9.1 **Batch**

9.1.1 A sample batch is a maximum of 20 environmental samples, which are prepared together using the same process and same lot(s) of reagents.

9.1.2 A preparation batch is composed of one to 20 environmental samples of a similar matrix, meeting the above mentioned criteria. Where no preparation method exists (example, volatile organics, water) the batch is defined as environmental samples that are analyzed together with the same process and personnel, using the same lots of reagents, not to exceed 20 environmental samples, and/or 24 hours (12 hours for GC/MS).

9.1.3 An analytical batch is composed of prepared environmental samples, extracts, digestates or concentrates that are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples.

9.1.4 Instrument conditions must be the same for all standards, samples and QC samples.

9.1.5 Each analytical batch may contain up to 20 environmental samples, a Method Blank (MB), a single Laboratory Control Sample (LCS) and a Matrix Spike/Matrix Spike Duplicate (MS/MSD) pair. In the event that there is insufficient sample to analyze an MS/MSD, an LCS Duplicate (LCSD) is prepared and analyzed.

9.1.6 Samples having different QC codes, due to non-standard client specific QC requirements, must be batched separately in the LIMS. A method blank and LCS may be shared across QC codes provided the actual "sample batch" does not exceed 20 environmental samples. Duplicates (and MS/MSD if applicable) must be performed for each separate QC code.

9.2 **Method Blank (MB)**

9.2.1 A method blank is a blank matrix processed simultaneously with, and under the same conditions as, samples through all steps of the procedure.

9.2.2 A method blank must be prepared with every batch (20 or fewer samples of the same matrix).

9.2.3 DI water is used as the blank matrix for water batches.

9.2.4 Sodium sulfate is used as the blank matrix for solid batches.

9.3 **Laboratory Control Sample (LCS)**

9.3.1 An LCS is a blank matrix spiked with a known amount of analyte(s), processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.3.2 An LCS must be prepared with every batch.

9.3.3 DI water, spiked with the analytes of interest is used as the LCS for water batches.

9.3.4 Sodium sulfate, spiked with the analytes of interest is used as the LCS for solid batches

9.4 **Matrix Spike/Matrix Spike Duplicate (MS/MSD)**

9.4.1 A Matrix Spike is an aliquot of a field sample to which a known amount of target analyte(s) is added, and is processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.4.2 Additional MS/MSDs do not count towards the 20 samples in an analytical batch.

9.4.3 An MS/MSD can be prepared with every batch, although it is not a method requirement. If there is insufficient sample to perform an MS/MSD, a duplicate LCS is analyzed.

9.5 **Procedural Variations/Nonconformance and Corrective Action**

9.5.1 Any variation shall be completely documented using a Nonconformance Memo and approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

9.5.2 Any deviations from QC procedures must be documented as a nonconformance, with applicable cause and corrective action approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

10.0 CALIBRATION AND STANDARDIZATION

10.1 External standard calibration is used.

10.2 Initial Calibration

10.2.1 Prepare an Aroclor 1016/1260 and Decachlorobiphenyl (surrogate) standard at a minimum of five concentration levels. (Six points are required if a quadratic (second order) curve is used.) The low level standard should be at or below the reporting limit. The other standards define the working range of the detector. Recommended calibration levels are given in Table 1.

10.2.1.1 If a specific Aroclor is of interest for a particular project, that Aroclor may be used for the five point calibration rather than the 1016 / 1260 mix. See Client Requirements Sheet or Memo.

10.2.1.2 A single point calibration for Aroclor 1221, 1232, 1242, 1248, 1254, 1262, and 1268 is performed with every initial calibration for pattern recognition.

10.2.1.2.1If any of the above single point Aroclors are detected, samples may be required to be re-analyzed under a five point calibration for the aroclor found. See Client Requirement Sheet to determine if this is needed.

10.2.1.3 Select 3-5 major peaks in the analyte pattern. Calculate the response using the area of these individual peaks.

10.2.1.3.1Aroclor 1221 uses only 3 peaks due to the limited amount of peaks available to choose from.

10.2.2 A new calibration curve must be generated after major changes to the system or when the continuing calibration criteria cannot be met. Major changes include new columns, any significant changes in instrument operating parameters, and major instrument maintenance (e.g., ECD replacement).

10.2.3 Except in specific instances, it is NOT acceptable to remove points from a calibration curve for the purpose of meeting criteria. Refer to the TestAmerica Corporate policy, "Calibration Point Selection", CA-Q-T-002.

10.3 SW 8082 criteria

10.3.1 The Relative Standard Deviation (RSD) of the calibration points from the curve used must be $\leq$ 20%.

10.3.2 If the %RSDs in the initial calibration is > 20%, then calibration using a linear regression may be employed.

10.3.2.1 If a linear regression curve is used, the intercept of the curve at zero response must be less than + or – the reporting limit for the analyte. It is recommended that for linear regression curves the line be set through the origin.

10.3.2.2 If a linear regression curve is used, r must be $\geq$ 0.99

10.3.2.3 Weighting of data points

10.3.2.3.1In linear, the points at the lower end of the calibration curve have less absolute variance than points at the high concentration end of the curve. This can cause severe errors in quantitation at the low end of the calibration. However, in environmental analysis, accuracy at the low end of the curve is very important. For this reason it may preferable to increase the weighting of the lower concentration points. $1/Concentration^2$ weighting (often called $1/X^2$ weighting) will improve accuracy at the low end of the curve and should be used if the data system has this capability.

10.4 608 Criteria

10.4.1 Method 608 only requires a 3 point calibration. We routinely perform a 5 point calibration; however, 2 points may be removed from a curve if necessary to meet 608 calibration criteria. The lowest level of the curve must be at or below the reporting limit. The other standards define the working range of the detector.

10.4.1.1 Refer to the TestAmerica Corporate policy, "Calibration Point Selection", CA-Q-T-002.

10.4.2 The Relative Standard Deviation (RSD) of the calibration points from the curve used must be $\leq$ 10%.

10.4.3 If the %RSDs in the initial calibration is > 10%, then calibration using a linear regression may be employed.

10.4.3.1 If a linear regression curve is used, the intercept of the curve at zero response must be less than + or – the reporting limit for the analyte. It is recommended that for linear regression curves the line be set through the origin.

10.4.3.2 If a linear regression curve is used, r must be $\geq$ 0.995

10.4.3.3 Use of $1/Concentration^2$ weighting is recommended to improve the accuracy of quantitation at the low end of the curve. The analyst should consider instrument maintenance to improve the linearity of response.

10.4.3.3.1 Weighting of data points

10.4.3.3.2 The points at the lower end of the calibration curve have less weight in determining the curve generated than points at the high concentration end of the curve. However, in environmental analysis, accuracy at the low end of the curve is very important. For this reason it is preferable to increase the weighting of the lower concentration points. $1/Concentration^2$ weighting (often called $1/X^2$ weighting) will improve accuracy at the low end of the curve and should be used if the data system has this capability.

10.5 Initial Calibration Verification (ICV)

10.5.1 An initial calibration verification standard must be a different standard source than the one used for the initial calibration.

10.5.1.1 The ICV is not performed for the single point aroclors.

10.5.2 An ICV must be performed with every initial calibration.

10.5.2.1 A passing ICV may be used as the opening CCV for a set of samples run following the ICV.

10.5.3 The ICV performance must be within +/- 20% D criteria.

10.5.3.1 Only the analytes present in the ICAL are evaluated for the 20% criteria.

10.5.3.2 Not meeting this requirement may be indicative of serious system malfunction or inaccuracies in the standards used for the initial calibration curve or ICV standard. Corrective action must be taken (including reanalysis of the ICV or analysis of a different ICV).

10.5.3.3 Any decision to proceed with analysis of samples when the ICV is out-of-control must be taken with great care and in consultation with the QA department and the laboratory director. Any such action must be documented in an NCM.

10.6 Continuing Calibration Verification (CCV)

10.6.1 A CCV may be a second source or the same source as the initial calibration standards and should be made to represent the midpoint of the curve.

10.6.2 Analyte response factors must be verified at the beginning of each analytical run (by either an ICV or a CCV), after every 10 samples and at the end of the analysis run through the analysis of a CCV.

10.6.3 It is adequate to verify calibration with a single mixture of Aroclors 1016 and 1260.

10.6.3.1 For projects with specific Aroclor requirements, a specific Aroclor may be included in the daily calibration check.

10.6.4 The calibration verification is acceptable if the %D for both 1016/1260 and the surrogate (DCB) is $\leq$ 20%.

10.6.4.1 The same criterion is used if other Aroclor verifications are performed.

10.6.4.2 If a CCV has failed and the analyst can document the reason for failure (e.g. broken vial, carryover from the previous sample etc.) then a second CCV may be analyzed without any adjustments to the instrument.

10.6.4.3 If this CCV meets criteria then sample analysis may continue; however the preceding samples must be reanalyzed.

10.6.4.4 If this second CCV does not meet criteria, the analysis run is terminated. Instrument maintenance is performed and the instrument may require re-calibration (i.e. initial calibration).

10.7 Retention Time (RT) Windows

10.7.1 Retention Time (RT) windows must be determined for all analytes.

10.7.2 Establishing RT windows:

10.7.2.1 Make an injection of all analytes of interest each day over a three day period. Calculate the standard deviation of the three retention times for each analyte (relative retention times may also be used).

10.7.2.2 The width of the retention time window for each analyte, surrogate, and major constituent in multi-component analytes is defined as ± 3 times the standard deviation of the mean absolute retention time established during the 72-hour period or 0.03 minutes, whichever is greater.

10.7.2.3 The center of the retention time window is the retention time from the average of three standards used to calculate the RT window.

10.7.2.4 The center of the window is updated with the midpoint standard of the initial calibration.

10.7.2.5 A new retention time window is established annually or each time a new column is installed.

10.7.2.5.1 The new windows must be generated within one week of the installation of the new column.

10.7.2.5.2 Until these standards have been run on the new column, the retention time windows from the old column may be used, updated with the retention times from the new initial calibration.

10.7.3 Retention Time Criteria

10.7.3.1 The retention times of AR 1016/1260 (and other aroclors if applicable) in each continuing calibration must be within the retention time windows established.

11.0 PROCEDURE

11.1 Allow standards, samples and sample extracts to reach ambient temperature before analysis.

11.2 Sulfur Removal

11.2.1 Sulfur Removal with Copper Powder

11.2.1.1 Transfer 1.0 mL of sample extract, and associated QC, into labeled vials.

11.2.1.2 Add approximately 2g cleaned copper powder to the vial.

11.2.1.3 Mix for one minute on a mechanical shaker.

11.2.1.4 Allow phases to separate.

11.2.1.5 Separate extract from copper by drawing the extract off with a disposable pipette.

11.2.1.6 Transfer the supernate to a clean, labeled vial.

11.3 All analysis conditions and injection volumes for samples must be the same as for the calibration standards.

11.4 Sample Introduction

11.4.1 Semivolatile analytes are introduced by direct injection of the extract. Samples, standards, and QC must be introduced using the same procedure.

11.5 Perform all qualitative and quantitative measurements. When the standards and extracts are not being used, refrigerate them at $\leq 6^{o}$C, protected from light in screw cap vials equipped with unpierced Teflon lined septa.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 Commonly used calculations (e.g. % recovery and RPD) and standard instrument software calculations are given in the TestAmerica St. Louis ST-QAM.

12.2 External Standard Calculations

12.2.1 *Analyte Concentration (µg/L) in sample*

Concentration (µg/L):

$$[C] = \frac{A_x * V_t * D}{\overline{CF} * V_i * V_s}$$

Where:

$[C]$	=	*Analyte Concentration in sample (µg/L)*
A_x	=	*Area of peak (response)*
V_t	=	*Total volume of extract (µL)*
D	=	*Dilution factor*
$\overline{CF}$	=	*Calibration factor ($\overline{RF}$ in target) – Response factor*
V_i	=	*Volume of extract injected (µL)*
V_s	=	*Volume of sample extracted*

12.2.2 *On column concentration*

On Column Concentration (µg/mL):

$$[OC] = \frac{A_x}{\overline{CF}}$$

Where:

$[OC]$ = *On Column Concentration [typically expressed in µg/mL (ppm)]*

Then substitute/derive

$$[C] = [OC]\left(\frac{V_t * D}{V_i * V_s}\right)$$

When *on column concentration* $[OC]$ is equal to the *CAL-AMT (calibration amount)* of the low level standard needed to support the *reporting limit (µg/L)* and we solve the equation for *concentration (µg/L)*

Then

$$[C] \equiv RL \equiv [OC]\left(\frac{V_t * D}{V_i * V_s}\right)$$

Where:

RL = Reporting Limit

12.2.3 See Target software for additional calculations.

12.3 Manual Integrations

12.3.1 Identified compounds are reviewed for proper integration. Manual integrations are performed if necessary and are documented by the analyst or automatically by the data system. See TestAmerica policy: CA-Q-S-002, "Manual Integrations". Manual integrations are denoted with an "M" flag on the Target quantitation report.

12.4 Identification of Aroclors

12.4.1 Tentative identification of an Aroclor occurs when multi-component peaks are found within their respective retention time window for an analyte, at a concentration above the reporting limit, or above the MDL if J flags are required.

12.4.2 Definitive Aroclor identification is based primarily on pattern recognition. Retention times and retention time windows are used to tentatively identify Aroclors, but the fingerprint produced by major peaks of those analytes in the standard is used in tandem with the retention times for identification. The ratios of the areas of the major peaks are also taken into consideration. Identification may be made even if the retention times of the peaks in the sample fall outside of the retention time windows of the standard, if in the analyst's judgment the fingerprint (retention time and peak ratios) resembles the standard chromatogram.

12.4.3 When samples are analyzed from a source known to contain specific Aroclors, the results from a single-column analysis may be confirmed on the basis of a clearly recognizable Aroclor pattern. Source-specific information, such as historical data, indicating the anticipation of Aroclors must be documented. The pattern of peaks can serve as confirmation depending of the client specific project requirements.

12.5 Quantitation of Aroclors

12.5.1 Use three to five major peaks when calibrating Aroclors. Choose peaks distinctive of the individual Aroclor. Any manual integration made in the ICAL levels must be noted and be made in any subsequent samples to maintain consistency with the initial calibration. These same three to five peaks are then used to calculate the response/concentration of the Aroclor(s) when present in a sample.

12.5.1.1 For Aroclor 1221 only three peaks are used due to the limited number of peaks available.

12.5.1.2 In instances where less than five peaks are used those peaks that are not used are said to be "dropped" and an NCM must be written. When quantitating Aroclors 1016/1260 in an LCS/D and/or MS/MSD, all five peaks must be used. In samples, less than the standard five peaks may be used to quantitate target analytes if there is demonstrated matrix interferences and/or if multiple, overlapping Aroclors are present. If there is a predominance of one Aroclor that elutes next to and shares peaks with another Aroclor and it is apparent to the analyst that the lesser Aroclor's concentration is elevated significantly by the more dominant Aroclor, then three peaks may be dropped and an NCM written. It is never allowable to quantitate an Aroclor using only one peak.

12.5.2 If well distinguishable Aroclor patterns are present, then multiple Aroclors are quantitated and reported.

12.5.2.1 Aroclor elution times may overlap and one or more Aroclor peaks may be "shared" with another Aroclor. When this occurs, only the predominant Aroclor is quantitated and reported. Aroclors sharing elution time and peaks include: 1016, 1232, 1242, 1248 – these cannot be identified together (unless quantitating an MS/D where Aroclor 1016 is known to be present). Aroclors 1260 and 1262 also share peaks; only one of these can be reported (unless quantitating and MS/D where 1260 is known to be present).

12.5.3 Dual Column Quantitation

12.5.3.1 Dual column confirmation is required for positive Aroclor identification. A secondary column using an alternate phase is employed and the sample is injected simultaneously into both a primary and secondary column. Elution times often differ, as does overall pattern/fingerprint of Aroclors between the two columns. Determination of target analytes on the secondary column is made in the same way as on the primary column. Target analytes may be reported from either column.

12.5.3.2 Report the lower result of the two columns, unless the Client SOW requires that the higher result be reported. See Client Requirement Sheet for determination.

12.5.3.2.1 For non-detect (ND) results, report from the primary channel if all QC and CCVs are acceptable. If the QC and CCVs are only acceptable on the secondary column, report the non-detects from this column.

12.5.3.2.2 If the %D between the two columns is greater than 40%, report the higher result if there are obvious chromatographic interferences on the column with the lower result.

12.5.3.2.3 If one result is significantly higher (e.g., >40%), check the chromatograms to see if an obviously overlapping peak is causing an erroneously high result. If no overlapping peaks are noted, examine the baseline parameters established by the instrument data system (or operator) during peak integration. If no anomalies are noted, review the chromatographic conditions.

12.5.3.2.3.1 If there is no evidence of chromatographic problems, report the lower result. The data user should be advised of the disparity between the results on the two columns.

12.5.3.2.3.2 Use the higher result if there is obvious chromatographic interference on the column with the lower result.

12.5.3.3 The QC should be reported from the column that reflects the column used for the majority of the samples associated with the QC.

12.5.3.4 The surrogate should be reported from the column used for the reporting of the sample results.

12.6 Dilutions

12.6.1 If concentrations of any analytes exceed the working range as defined by the calibration standards, then the sample data is “E” flagged and the sample must be diluted and reanalyzed. Dilutions should target the most concentrated analyte in the upper half (over 50% of the high level standard) of the calibration range. Target analytes with resulting concentrations lower than the dilution adjusted RL should be flagged with a “J” qualifier.

12.6.2 It may be necessary to dilute samples due to matrix.

12.7 Carryover

12.7.1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.

12.7.1.1 If a sample analyzed after a sample with high concentrations has negative results, carryover did not occur.

12.7.1.2 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, or if the chromatographic profile resembles the previous sample, the results are questionable. This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

13.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA; CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

13.1 The data assessment and corrective action process is detailed through the LIMS Nonconformance Memorandum (NCM) process. The NCM process is described in SOP: ST-QA-0036.

13.2 Method Blank (MB)

13.2.1 Acceptance Criteria:
13.2.1.1 No target analytes may be present in the method blank above the reporting limit.
13.2.1.2 Project specific requirements if more stringent than our routine procedure (e.g. no target analytes present above ½ RL), will be noted on the client requirements sheet.
13.2.1.3 The Method Blank must have acceptable surrogate recoveries.
13.2.2 Corrective Action for Method Blanks not meeting acceptance criteria:
13.2.2.1 Method Blank Contamination – Blank contamination above the RL (>1/2 RL for some programs – see specific Client Requirement Memos for details) requires re-prep of batch unless all associated samples are < RL or greater than 10 times the amount detected in the method blank.
13.2.2.2 Method Blank Surrogate excursion – If excursion is limited to the blank, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-analysis is required. In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM.

13.3 Laboratory Control Sample (LCS)
13.3.1 Acceptance Criteria:
13.3.1.1 All control analytes must be within established control limits for accuracy (%Recovery) and precision (RPD).
13.3.1.2 The LCS must have acceptable surrogate recoveries.
13.3.2 Corrective Action for LCS not meeting acceptance criteria:
13.3.2.1 LCS Spike Recovery excursion (high) – Samples that are non-detect may be reported with an NCM (unless prohibited by client requirements). Samples with detects for the analyte recovered high in the LCS are re-prepped and re-analyzed. In cases where the surrogate recovery is high and the samples are non-detect, the data may be reported with an NCM
13.3.2.2 LCS Spike Recovery excursion (low) – batch is re-prepped and re-analyzed.
13.3.2.3 LCS Surrogate Recovery excursion – If excursion is limited to the LCS, data may be reported with an NCM. If target analytes are in control in the LCS, data may be reported with an NCM. If surrogates are also outside criteria in samples, re-prep and re-analysis is required.
13.3.2.4 RPD excursion for LCS/LCSD – If target analytes recoveries are in control, data may be reported with an NCM.

13.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD)
13.4.1 All analytes should be within established control limits for accuracy (%Recovery) and precision (RPD).
13.4.2 Corrective Action for MS/MSD not meeting acceptance criteria:
13.4.2.1 MS/MSD Spike Rec. excursion may not necessarily warrant corrective action other than narration. If affected analyte concentration in the original sample is greater than four times the amount spiked, percent recovery information is ineffective. Data is reported with an NCM. If the excursion is due to a physically evident matrix interference, the data is reported with an NCM (the physical interference must be described in the NCM). If there is no evidence of interference and the RPD as well as spike recoveries out outside limits out, sample re-prep and re-analysis are required.

13.5 Surrogate
13.5.1 All Surrogates should be within established control limits for accuracy (%Recovery).
13.5.2 Corrective Action for Surrogate not meeting acceptance criteria:
13.5.2.1 Surrogate Spike Rec. excursion may not necessarily warrant corrective action other than narration.

13.6 Sample Result Evaluation

13.6.1 Dilutions

13.6.2 If the response for any compound exceeds the working range of the analytical system, a dilution of the extract is prepared and analyzed. An appropriate dilution should be in the upper half of the calibration range.

13.1.1.1 Dilution: Sample– An NCM is written to document the reason for the dilution

13.1.1.2 Dilution: Surrogate(s) and/or spikes diluted out– Dilution: Surrogate(s) and/or spike(s) diluted out– An NCM is written to document the reason for the dilution.

13.6.3 Carryover

13.6.3.1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.

13.6.3.2 If a sample analyzed after a sample with high concentrations has negative results, carryover did not occur.

13.6.3.3 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, or if the chromatographic profile resembles the previous sample, the results are questionable. This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

13.7 Insufficient Sample

13.7.1 For each prescribed re-preparation corrective action, if there is insufficient sample to repeat the analysis a narrative comment stating such is included in the report case narrative.

14.0 METHOD PERFORMANCE AND DEMONSTRATION OF CAPABILITY

14.1 Method performance data, Reporting Limits, and QC acceptance limits, are maintained in the LIMS.

14.2 Demonstration of Capability

14.2.1 Initial and continuing demonstrations of capability requirements are established in the ST-QAM.

14.3 Training Qualification

14.3.1 The manager/supervisor has the responsibility to ensure that this procedure is performed by an analyst who has been properly trained in its use and has the required experience.

14.3.2 The analyst must have successfully completed the initial demonstration capability requirements prior to working independently. See requirements in the ST-QAM.

14.1 Annually, the analyst must successfully demonstrate proficiency to continue to perform this analysis. See requirements in the ST-QAM.

15.0 VALIDATION

15.1 Laboratory SOPs are based on published methods (EPA, DOE, ASTM, Eichrom, Standard Methods) and do not require validation by the laboratory. The requirements for laboratory demonstration of capability are included in the ST-QAM. Laboratory validation data would be appropriate for performance based measurement systems, non-standard methods and significant modifications to published methods. Data from said validations is held in the QA department.

16.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

16.1 All waste will be disposed of in accordance with Federal, State and Local regulations. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in section 13 of the Corporate Safety Manual for "Waste Management and Pollution Prevention."

16.2 Waste Streams Produced by the Method

16.2.1 The following waste streams are produced when this method is carried out.

16.2.1.1 Acidic sample waste generated. All acidic waste will be accumulated in the appropriate waste accumulation container, labeled as Drum Type "A" or "B".

16.2.1.2 Solvent waste generated. Solvent waste must be accumulated in the appropriate waste accumulation container, labeled as Drum Type "D".

16.2.1.3 Contaminated disposable glass or plastic materials utilized in the analysis are disposed of in the sanitary trash. If the lab ware was used for the analysis of radioactive samples and contains radioactivity at a level of 100 cpm over background as determined by a GM meter, the lab ware will be collected in waste barrels designated for solid rad waste for disposal by the EH&S Coordinator.

16.2.1.4 Expired primary and working PCB standards shall be segregated and placed into the proper satellite accumulation container specifically for PCB waste which is located within the GC lab.

17.0 REFERENCES

17.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Method 8000C.

17.2 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Method 8082A, 8081B Update IV, February 2007and EPA 608 Method.

17.3 TestAmerica St. Louis Quality Assurance Manual (ST-QAM), current revision

17.4 Corporate Environmental Health and Safety Manual (CW-E-M-001), current revision

17.5 TestAmerica Policy CA-Q-S-002, Manual Integrations

17.6 TestAmerica Policy CA-Q-T-002, Calibration Point selection

17.7 Associated SOPs

17.7.1 ST-OP-0001, Labware Preparation for Organic Analysis

17.7.2 ST-OP-0002, Extraction and Cleanup of Organic Compounds from Water and Soils, Based on SW-846 3500 Series, 3600 Series, 8151A and 600 Series

17.7.3 ST-OP-0003, Extraction of PCB in Oil

17.7.4 ST-QA-0002, Standard and Reagent Preparation

17.7.5 ST-QA-0005, "Calibration and Verification Procedure for Thermometers, Balances, Weights and Pipettes."

17.7.6 ST-QA-0014, Evaluation of Analytical Accuracy and Precision Through the Use of Control Charts

17.7.7 ST-QA-0016, IDL/MDL Determination

17.7.8 ST-QA-0036, Non-conformance Memorandum (NCM) Process

17.7.9 ST-PM-0002, Sample Receipt and Chain of Custody

18.0 MODIFICATIONS FROM REFERENCE METHOD

18.1 Chapter 1 of SW-846 states that the method blank should not contain any analyte of interest at or above the Method Detection Limit. This SOP states that the Method Blank must not contain any analyte of interest at or above the reporting limit. Common lab contaminants are allowed to be up to 5 times the reporting limit in the blank following consultation with the client.

18.2 The surrogate calibration curve is calculated from the Aroclor 1016/1260 mix. Surrogates in the other calibration standards are used only as retention time markers.

18.3 Method 608 only requires a 3 point calibration. We routinely perform a 5 point calibration; however, 2 points may be removed from a curve if necessary to meet 608 calibration criteria. The lowest level of the curve must be at or below the reporting limit.

19.0 CHANGES FROM PREVIOUS REVISION

19.1 Updated the table one regarding the levels of calibration of Aroclor 1016/1260 and the amount of the surrogate used, Decachlorobipenyl.

19.2 Rev 10:

19.2.1 Removing holding times for PCB's in section 8.0

19.3 Revision 11:

19.3.1 Removed references to QuantIMS and Clouseau – replaced with LIMS.

19.3.2 Added software information to Section 6.

19.3.3 Added composition of Method Blank and LCS to Section 9.

19.3.4 Added requirement for 6 points for non-linear curves to Section 10.

19.3.5 Added Reporting limit calculations to Section 12

19.3.6 Added specific corrective actions to Section 13

19.3.7 Updated text in Section 15 to include methods beyond those approved by EPA.

Table 1								
Calibration Levels ng/ml								
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	
Aroclor 1016/1260	50	100 Reporting Limit	250	500	1000 ICV/CCV	2000	4000	
The surrogate is included with all calibration mixes at the following levels								
Decachlorobiphenyl	2.5	5	12.5	25	50	100	200	

* Level 1 is optional.
Aroclors 1232, 1221, 1242, 1248, 1254, 1262 and 1268 may be quantitated within the range 100 to 4000 ng/mL

Analytical Sequence

Initial Calibration

Injection #		
1	Solvent blank (optional)	
2	Aroclor 1016/1260	Level 1
3	Aroclor 1016/1260	Level 2
4	Aroclor 1016/1260	Level 3
5	Aroclor 1016/1260	Level 4
6	Aroclor 1016/1260	Level 5
7	Aroclor 1232	Level 3
8	Aroclor 1242	Level 3
9	Aroclor 1248	Level 3
10	Aroclor 1221/1254	Level 3
11	Aroclor 1262	Level 3
12	Aroclor 1268	Level 3
13	Independent Calibration Verification (ICV) standard	
14-24	Sample Injections (max.10)	
25	Aroclor 1016/1260	Level 3

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Title: Gasoline Range Organics/MBTEX Analysis [Methods 8015B/8260B, AK101, NWTPH-Gx]

Approvals

Signature on File

Bisrat Tadesse Date Volatiles Department Manager	Sandra Langway Date Health & Safety Manager / Coordinator
Terri Torres Date Quality Assurance Manager	Heather Prater Date Laboratory Director

Facility Distribution No. 001 **Distributed To:** Lab Intranet

1.0 Scope and Application

1.1 Analytes, Matrix(s), and Reporting Limits

This SOP delineates the specific requirements for analyzing TPH as gasoline and for MTBE, BTEX and other aromatic compounds. This method is applicable to soil analysis via 5035, water analysis via 5030 and providing simultaneous confirmation above the RL-secondary column confirmation is not required. Gasoline may be reported without the associated individual analytes, per client request. Table 1 provides a list of target analytes and associated RLs.

On occasion clients may request modifications to this SOP. These modifications are handled following the procedures outlined in Section 12.2.1 in the Quality Assurance Manual.

2.0 Summary of Method

This method describes the analysis of Gasoline Range Organics, MTBE, BTEX and other individual compounds in soil and water matrices. Soil samples are extracted in methanol. An aliquot of this extract is diluted in water and the sample is analyzed by purge and trap GC/MS with FID. Water samples are analyzed with no dilution, or diluted with reagent water; the sample is analyzed using purge and trap GC/MS (or GC) with FID.

3.0 Definitions

3.1 Gasoline Range Organics (GRO): All chromatographic peaks eluting between the following ranges are attributed to GRO:

AK101: The area including n-Hexane to the start of n-Decane

8015B: Toluene through n-Dodecane, inclusive

Hawaii: Hexane through n-Dodecane, inclusive

California 8015B: 2-methylpentane through 1,2,4-trimethylbenzene

NWTPH-GX: at a minimum Toluene through 1-Methylnaphthalene inclusive is integrated and plotted against the known concentration of gasoline standard added.

Quantitation is based on a direct comparison of the area within this range to the total area of the calibration standard within this range.

4.0 Interferences

4.1 High levels of heavier petroleum products such as diesel fuel may contain some volatile components that produce a response within the retention time range for gasoline. Other organic compounds, including chlorinated solvents, ketones, and ethers are measurable.

4.2 Samples contaminated with a single compound that is detectable using this method may result in a biased value for the compound. This is caused by the different response factors for gasoline and other various solvents.

4.3 Samples can become contaminated by diffusion of volatile organics during shipment and storage. A trip blank prepared from reagent water or methanol and carried through sampling, storage, and handling is recommended.

4.4 Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of a solvent blank of reagent water to check for cross

contamination. For volatile samples containing high concentrations of water-soluble materials, suspended solids, high boiling compounds or organohalides, it may be necessary to wash the syringe or purging device with a detergent solution, rinse with distilled water, and then dry in a 105℃ oven between analyses. The trap and other parts of the system are also subject to contamination; therefore, frequent bake-out and purging of the entire system may be required.

4.5 Any co-eluting compound with a quantitation ion identical with the compounds of interest will affect results.

5.0 Safety

Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001) and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.1 Specific Safety Concerns or Requirements

5.1.1 Eye protection that satisfies ANSI Z87.1 (per the Corporate Safety Manual), laboratory coat, and appropriate gloves must be worn while samples, standards, solvents, and reagents are being handled. Latex, nitrile, or vinyl gloves must be worn while handling samples, standards, solvents, and reagents. Cut resistant gloves must be worn when using sharp tools or when washing glassware. Disposable gloves that have been contaminated will be removed and discarded; other gloves will be cleaned immediately.

5.1.2 Purge vessels on purge-and-trap instruments can be pressurized by the time analysis is completed. Vent the pressure prior to removal of these vessels to prevent the contents from spraying out.

5.1.3 GC VOA instruments use an ultraviolet (UV) light source, which must be shielded from view. There should also be a warning label/sticker on each instrument that identifies it as a UV light source.

5.1.4 The gas chromatograph contains zones that have elevated temperatures. The analyst needs to be aware of the locations of those zones, and must cool them to room temperature prior to working on them.

5.1.5 There are areas of high voltage in the gas chromatograph. Depending on the type of work involved, either turn the power to the instrument off, or disconnect it from its source of power.

5.1.6 *The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable. Cautions are included for known extremely hazardous materials.*

5.2 Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. **Note: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for**

each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material	Hazards	Exposure Limit (1)	Signs and symptoms of exposure
Methanol (MeOH)	Flammable Poison Irritant	200 ppm-TWA	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
1 – Exposure limit refers to the OSHA regulatory exposure limit.			

6.0 Equipment and Supplies

6.1 Instrumentation

- Gas chromatograph and detector: Varian 3400 GC equipped with an ITS-40 Mass spectrometer
- Chromatographic column: DB-624, 30 meters x 0.25 mm ID x 1.4 um film thickness (J & W Scientific) or equivalent with DB-Wax, 15 meters x 0.25 mm ID x 0.5 um film thickness (J & W Scientific) post column OR
- Agilent 5973 Network MSD with FID detector option
- Chromatographic columns: split post column DB-624, 30 meters x 0.32 mm ID x 1.4 um film thickness (J & W Scientific) or equivalent to FID, 1.0 meter 0.18 inert column to MS.
- Data acquisition system: Magnum converted for HP Chemstation
- Varian Archon Autosampler
- Purge/Trap Liquid Concentrator, Tekmar 3000 or equivalent
- Gas chromatograph and detector: Hewlett Packard 5890 Series II Gas Chromatograph or equivalent with OI model 4430 Photoionization Detector (PID) or equivalent and OI Flame Ionization Detector (FID) or equivalent
- Data System: Hewlett Packard ChemStation for Windows 95 (version G1701AA) or equivalent. Agilent's ChemStation, is used for data acquisition and storage on machine-readable media. Since no processing is done by Chemstation and since there are no audit trail functions associated with data acquisition, the audit trail feature for Chemstation may be either enabled or disabled. The other component, Chrom, is used for data processing such as the measurement of peak area or peak height. By design, the audit trail feature for Chrom is always enabled.
- Data processing: Chrom version 1.2 or higher
- LIMS system: TALS version 1.0 or higher
- Tekmar Aquatek 70 Autosampler or equivalent
- Tekmar 3100 Purge & Trap Concentrator or equivalent
- Columns: Restek RTX-VRX (75 m x 0.45 mm x 2.5 µm) or equivalent
  Note: Other columns may be used. This was the column in place at the time the SOP was prepared. The serial number of the column used is documented in the instrument maintenance logbook.
- Analytical balance, 0.0001 g accuracy
- Drying oven

6.2 Supplies

- Scintillation vials
- Volumetric flasks: 10-mL, 50-mL, and 100-mL
- Glass standard vials with screw caps and Teflon-coated septum

7.0 Reagents and Standards

7.1 Document reagent/standards and reagent/standard preparation in TALS using the reagent module as described in SOP TA-QA-0619.

7.2 Methanol, Baker Purge and Trap Grade or equivalent.

7.3 Neat standards used for surrogate/standard solution preparation should be purchased from Aldrich or other certified supplier. Analyte list below:

7.3.1 1,4-Difluorobenzene

7.3.2 1-Bromo-4-fluoro-benzene

7.3.3 Toluene-d8

7.3.4 Ethylbenzene-d10

7.3.5 Fluorobenzene

7.3.6 α,α,α-Trifluorotoluene

7.3.7 1,2,4-Trimethylbenzene

7.4 Internal Standard for Initial Calibration: A 500 mg/L standard is prepared by diluting 85.5-uL 1,4-Difluorobenzene to 200.0-mL in methanol.

7.5 Working Internal Standard plus Surrogates: A 500 mg/L standard is prepared by adding 46.7-uL 1-Bromo-4-fluorobenzene, 79.5-uL Toluene-d8, 79.0-uL Ethylbenzene-d10, and 73.2-uL Fluorobenzene to 150.0-mL of the Internal Standard for Initial Calibration solution.

7.6 TFT Stock Solution: A 10,000 mg/L solution is prepared by diluting 421.0-uL α,α,α-Trifluorotoluene to 50.00-mL in methanol.

7.7 Water Surrogate Solution: A 400 mg/L TFT solution is prepared by diluting 33.65-uL α,α,α-Trifluorotoluene to 100-mL in methanol.

7.8 TFT Preservation Solution: A 4.00 mg/L TFT solution is prepared by diluting 1.00-mL TFT Stock Solution to 1.00 L in methanol.

7.9 WA VPH Standard mix: 20,000 mg/L purchased as certified mixture from Ultra Scientific or other equivalent supplier.

7.10 Retention Time Standard: A 20.0 mg/L solution is prepared by diluting to 50.00-mL in methanol as follows:

RT Standard Component	Volume of Source (uL)	Final Volume (mL)	Final Concentration (mg/L)
WA VPH	50.0	50.00	20.0
2-Methylpentane	1.00	50.00	20.0
1,2,4-Trimethylbenzene	1.00	50.00	20.0

7.11 Unleaded Gasoline Composite Standard: 50,000-ug/mL purchased from Restek or other certified supplier.

7.12 GRO ICAL/CCAL Solution: A 1,000 mg/L solution is prepared by diluting 4-mL Unleaded Gasoline Composite Standard to 200-mL in methanol.

7.13 GRO Working Solution (ICV/LCS): A 50,000-ug/mL solution purchased from Accustandard or other certified supplier. This standard is purchased from a separate manufacturer than the ICAL/CCAL standard.

7.14 Custom RBCA List Mix Stock: 1,000 mg/L (m & p-Xylene @ 2,000 mg/L) purchased from Ultra Scientific or other certified supplier.

7.15 BTEX ICAL/CCAL Solution: A 50.0 mg/L solution is prepared by diluting 1250-uL of Custom RBCA List Mix Stock and 125.0-uL of the Surrogate Stock Solution to 25.0-mL in methanol.

7.16 RBCA ICV/LCS Stock: 1,000 mg/L (m & p-Xylene @ 2,000 mg/L) purchased from Restek or other certified supplier.

7.17 BTEX Working Solution (ICV/LCS): A 50 mg/L (m & p-Xylene @ 100 mg/L) solution is prepared by diluting the appropriate stocks to 25.0-mL in methanol as indicated in the following table or can be purchased mix from a certified supplier.

Component	Volume of Stock (uL)	Final Volume (mL)	Final Concentration (mg/L)
RBCA/ICV/LCS Stock	1250.0	25.00	50.0

7.18 GRO Initial Calibration: An initial calibration is prepared using 9 calibration points as follows:

Level	Volume of GRO ICAL/CCAL Stock (uL)	Volume of Surr. Stock (uL)	Volume of Methanol (uL)	Final Volume (mL)	Final Concentration (ug/L)
1	5.0	5.0	2500	100.0	50.0
2	10.0	10.0	2500	100.0	100.0
3	25.0	15.0	2500	100.0	250.0
4	50.0	20.0	2450	100.0	500.0
5*	100.0	25.0	2400	100.0	1000.0
6	500.0	37.5	2000	100.0	5000.0
7	1000.0	50.0	1500	100.0	10,000
8	1500.0	--	1000	100.0	15,000
9	2500.0	--	--	100.0	25,000
* This level is used as the Continuing Calibration Verification (CCV) standard.					

7.19 A GRO initial calibration verification standard is prepared at the 1,000-ug/L concentration by diluting the GRO working solution in ASTM Type II water in a 100-mL volumetric flask as follows:

Level	Volume of GRO ICAL/CCAL Stock (uL)	Volume of Surr. Stock (uL)	Volume of Methanol (uL)	Final Volume (mL)	Final Concentration (ug/L)
ICV	50.0	20.0	2500	100.0	1100.0

7.20 BTEX Initial Calibration: An initial calibration is prepared using 9 calibration points, currently these points are 0.2 ug/L, 1 ug/L, 5 ug/L, 10 ug/L, 25 ug/L, 50 ug/L and 150 ug/L. These points are prepared by diluting the working surrogate solution for initial calibration and BTEX ICAL/CCAL solution to the appropriate concentration in ASTM Type II water in 100-mL volumetric flasks. In addition, an initial calibration verification standard is prepared at the 25-ug/L concentration by diluting the BTEX working solution in ASTM Type II water in a 100-mL volumetric flask.

Level	Volume of BTEX ICAL/CCAL Stock (uL)	Final Volume (mL)	Final Concentration (ug/L)
1	0.4	100.0	0.2
2	2.0	100.0	1.0
3	4.0	100.0	5.0
4	10.0	100.0	10.0
5*	20.0	100.0	25.0
6	50.0	100.0	50.0
7	300.0	100.0	150.0
* This level is used as the Continuing Calibration Verification (CCV) standard.			

7.21 A BTEX initial calibration verification standard is prepared at the 25-ug/L concentration by diluting the BTEX working solution in ASTM Type II water in a 100-mL volumetric flask.

Level	Volume of BTEX ICAL/CCAL Stock (uL)	Volume of Working Surr. Stock (uL)	Final Volume (mL)	Final Concentration (ug/L)
ICV	50.0	25.0	100.0	25.0

7.22 Managers/supervisors or a designee are expected to check their areas on a monthly basis for expired standards/reagents and dispose of them according to SOP TA-EHS-0036.

8.0 Sample Collection, Preservation, Shipment and Storage

8.1 All samples are to be stored at 0-6℃ in 43-mL VOA vials or jars with Teflon-lined caps. Water samples should be preserved to a pH <2.0 with HCl. Unpreserved soil samples should be preserved in methanol within 48 hours of collection.

8.2 The holding time for preserved waters and soil (from date of collection to date of analysis is 14 days. Unpreserved waters should be analyzed within 7 days of collection [0 days for aromatic compounds (BTEX)]. AK101 GRO 5035 field preserved samples have a 28-day holding time limit.

8.3 VOA vials are inverted to check for air bubbles. If at all possible, samples should not be opened prior to analysis.

8.4 Field preserved soil sampling procedure. Soil samples must be collected in appropriately sized containers and submerged in *methanol or* methanol containing surrogate at 1:1 ratio. The tare weight of the sample container, the weight of the methanol, and the weight of the sample must be known in order to accurately quantitate gasoline range organics. Soil samples must be stored below 25°C. Methanol preserved soil samples must be analyzed within 28 days of collection.

9.0 Quality Control

9.1 The minimum quality controls (QC), acceptance criteria, and corrective actions are described in this section. When processing samples in the laboratory, use the LIMS QC program code and special instructions to determine specific QC requirements that apply.

9.1.1 The laboratory's standard QC requirements, the process of establishing control limits, and the use of control charts are described more completely in the TestAmerica Seattle QAM.

9.1.2 Specific QC requirements for Federal programs, e.g., USACE and Navy projects, are described in DoD QSM v4.2.

9.1.3 Project-specific requirements can override the requirements presented in this section when there is a written agreement between the laboratory and the client, and the source of those requirements should be described in the project documents. Project-specific requirements are communicated to the analyst via special instructions in the LIMS and may also come in the form of email or written notifications distributed at "project kick off" meetings.

9.1.4 Any QC result that fails to meet control criteria must be documented in a Nonconformance Memo (NCM). The NCM is approved by the supervisor and then automatically sent to the laboratory Project Manager by e-mail so that the client can be notified as appropriate. The QA group also receives NCMs by e-mail for tracking and trending purposes. The NCM process is described in more detail in SOP TA-QA-0610. This is in addition to the corrective actions described in the following sections.

9.2 Batch Definition

Batches are defined at the sample preparation stage. The batch is a set of up to 20 samples of the same matrix, plus required QC samples, processed using the same procedures and reagents within the same time period. Batches should be kept together through the whole analytical process as far as possible, but it is not mandatory to analyze prepared extracts on the same instrument or in the same sequence. The method blank must be run on each instrument and in each analytical batch.

9.3 Method Blanks

For each batch of samples, analyze a method blank. The method blank is analyzed after the calibration standards and before any samples. For aqueous samples, the method blank consists of reagent water. For solid samples, the method blank consists of 10 mL of Reagent ID: V-4TFT_EX_xxxxx and ten grams of muffled Ottawa sand (reagent ID VOA-Sand_xxxxx). Additional surrogates and internal standard are added automatically by the autosampler at the time of analysis. The method blank is carried through the entire analytical procedure.

Acceptance Criteria: The method blank must not contain any analyte of interest at or above one-half the reporting limit or above 10% of the measured concentration of that analyte in the associated samples, whichever is higher.

The method blank must have acceptable surrogate recoveries.

Corrective Actions: Reanalysis of samples associated with an unacceptable method blank is required when reportable concentrations are determined in the associated samples.

If there is no target analyte greater than the RL (less than one half the RL for LaMP and DoD clients) in the samples associated with an unacceptable method blank, the data may be reported with qualifiers. Such action should be done in consultation with the client.

If surrogate recoveries in the blank are not acceptable, the data must be evaluated to determine if the method blank has served the purpose of demonstrating that the analysis is free of contamination. If surrogate recoveries are low and there are reportable analytes in the associated samples, re-extraction of the blank and affected samples will normally be required. Consultation with the client should take place.

If reanalysis of the batch is not possible due to limited sample volume or other constraints, the method blank is reported, all affected analytes in the associated samples are flagged with a "B", and appropriate comments may be made in a narrative to provide further documentation.

9.4 Laboratory Control Samples (LCS)

An LCS is analyzed for each batch. An LCS Duplicate (LCSD) is performed only when insufficient sample is available for the MS/MSD or when requested by the client/project/contract. The LCS is analyzed after the calibration standard, and normally before any samples. The LCS is prepared from a different source than are the calibration standards. The LCS contains all the required analytes of interest (See Table 5), and must contain the same analytes as the matrix spike.

Acceptance Criteria: The LCS recovery for the control analytes must be within established control limits. Unless otherwise specified in a reference method or project requirements, the control limits are set at ± 3 standard deviations around the mean of the historical data. An LCS that is determined to be within acceptance criteria effectively demonstrates that the analytical system is in control and validates system performance for the samples in the associated batch. Recovery limits are updated at a set frequency by QA and are stored in the LIMS

Corrective Actions: If any analyte or surrogate is outside established control limits as described above, the system is out of control and corrective action must occur. Corrective action will normally be re-preparation and reanalysis of the batch.

If the batch is not re-extracted and reanalyzed, the reasons for accepting the batch must be clearly presented in the project records (via NCMs and the case narrative) and in the final report. Examples of acceptable reasons for not reanalyzing might be that the matrix spike and matrix spike duplicate are acceptable, and sample surrogate recoveries are good, demonstrating that the problem was confined to the LCS. This type of justification should be reviewed and documented with the client before reporting. (LaMP: Bias high recoveries– NCM and flag ND samples)

If re-extraction and reanalysis of the batch is not possible due to limited sample volume or other constraints, the LCS is reported, all associated samples are flagged, and appropriate comments are made in a narrative to provide further documentation.

9.5 Matrix Spike and Matrix Spike Duplicate (MS/MSD)

For each QC batch, analyze a matrix spike and matrix spike duplicate if sufficient sample volume is received. If an MS/MSD is not possible due to limited sample, then an LCS duplicate should be analyzed whenever requested by the client. The RPD between the LCS and LCSD is compared to the established acceptance limit. Spiking compounds and levels are given in Table 5. The matrix spike/duplicate must be analyzed at the same base dilution as the unspiked sample, even if the matrix spike compounds will be diluted out, dilutions (beyond the base dilution if necessary) of MS/MSD analyses are not required unless there are specific client instructions to do so. If necessary, this requirement will be passed to the laboratory through the PM by means of the mechanisms described in section 9.1.3 of this SOP.

LaMP: MS required if >10 samples. The client consultant is to identify the sample to be used.

Acceptance Criteria: The MS/MSD recovery for the control analytes must be within established control limits. Unless otherwise specified in a reference method or project requirements, the control limits are set at ± 3 standard deviations around the mean of the historical data. The relative percent difference (RPD) between the MS and the MSD must be less than the established RPD limit, which is based on statistical analysis of historical data. MS/MSD recovery and RPD limits are updated at a regular frequency by QA and are stored in the LIMS.

Corrective Actions: If any individual recovery or RPD falls outside the acceptable range, corrective action must occur. The initial corrective action will be to check the recovery of that analyte in the LCS. Generally, if the recovery of the analyte in the LCS is within limits, then the laboratory operation is in control and analysis may proceed. The reasons for accepting the batch must be documented.

If the recovery for any component is outside QC limits for both the matrix spike/matrix spike duplicate and the LCS, the laboratory is out of control and corrective action must be taken. Corrective action will normally include reanalysis of the batch, except in cases where a high bias is indicated and no target is detected above the reporting limit in any associated sample.

If an MS/MSD is not possible due to limited sample, then an LCS duplicate should be analyzed whenever requested by the client. The RPD between the LCS and LCSD is compared to the established acceptance limit.

9.6 Surrogates

Every sample, blank, and QC sample is spiked with surrogates. Surrogate recoveries in samples, blanks, and QC samples must be assessed to ensure that recoveries are within established limits. The compounds included in the surrogate spiking solutions are listed in Table 3.

Acceptance Criteria: Acceptance limits for surrogate recoveries are set at ± 3 standard deviations around the historical mean. Surrogate recovery limits are updated at a fixed frequency by QA and stored in the LIMS.

Corrective Actions: If any surrogates are outside limits, the following corrective actions must take place (except for dilutions):

- Check all calculations for error.
- Ensure that instrument performance is acceptable.
- Recalculate the data and/or reanalyze if either of the above checks reveal a problem.
- Re-prepare and reanalyze the sample or flag the data as "Estimated Concentration" if neither of the above resolves the problem.

The decision to reanalyze or flag the data should be made in consultation with the client. It is necessary to re-prepare/reanalyze a sample only once to demonstrate that poor surrogate recovery is due to matrix effect, unless the analyst believes that the repeated out of control results are not due to matrix effect.

If the surrogates are out of control for the sample, matrix spike, and matrix spike duplicate, then matrix effect has been demonstrated for that sample and re-preparation/reanalysis is not necessary. If the sample is out of control and the MS and/or MSD is in control, then reanalysis or flagging of the data is required.

NOTE: For LaMP samples, if the surrogate percent recovery fails, the recovery must be confirmed by re-extraction and reanalysis with the following exceptions:

- The lab has unequivocally demonstrated a sample matrix effect and informed the LaMP representative.
- The recovery exceeds control limits and all target analytes in the sample are non-detect.

9.7 If batch QC samples or trip blanks are re-analyzed to confirm a recovery or result, and an improvement in results would cause the re-analysis to be reported, then the associated client samples must also be re-analyzed. The only exception to this protocol would be if an obvious analytical problem occurred during the initial analysis (i.e. no internal standard added, bent autosampler needle, etc).

9.8 Any extra QC that is analyzed in a batch or sequence must be evaluated using the same criteria as the corresponding QC above.

10.0 Procedure

One-time procedural variations are allowed only if deemed necessary in the professional judgment of management to accommodate variation in sample matrix, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using an NCM. The NCM is approved by the supervisor and then automatically sent to the laboratory Project Manager by e-mail so that the client can be notified as appropriate. The QA department also receives NCMs by e-mail for tracking and trending purposes. The NCM process is described in more detail in SOP # TA-QA-0610. The NCM shall be filed in the project file and addressed in the case narrative.

10.1 Sample Preparation

10.1.1 Check the Balance logbook to determine if the daily calibration check has been completed. If it has not, the analyst must perform this check according to SOP TA-QA-0014.

10.1.2 Soil Extraction

10.1.2.1 Method 5035 Laboratory preserved:

10.1.2.2 A sample aliquot (approximately 10 g) is placed into a scintillation vial, the exact weight recorded and 10-mL of TFT Preservation Solution (section 7.8) is added to the sample. *Record vial lot number, the weight, the methanol lot number, the preparation date and the analyst who prepared it in the 5035 Extraction Log located in \\corp-fs-05\analytical4\seattle\VOA.*

10.1.2.2.1 To prepare the blank spike (LCS)/blank spike duplicate (LCSD), add 80-uL of GRO Working Solution or 160-uL of BTEX Working Solution and 10-mL of the TFT Preservation Solution to 10 g muffled Ottawa sand. *(NOTE: The same metal spatulas to weigh soil samples must be used for measuring out the Ottawa sand).*

10.1.2.2.2 To prepare the matrix spike (MS)/matrix spike duplicate (MSD), add 80-uL of GRO Working Solution or 160-uL of BTEX Working Solution and 10-mL of the TFT Preservation Solution to 10 g pre-weighed soil samples. To prepare the method blank (MB); add 10-mL of the TFT Preservation Solution to 10 g Ottawa sand. All extracts are homogenized via a vortex apparatus then placed in the shaker table for 10 minutes.

10.1.2.2.3 All spiking solutions must be added to the sample prior to the addition of the TFT Preservation Solution for batches that fall under the BP LaMP.

10.1.2.2.4 All extracts are centrifuged to remove soil particulate matter.

10.1.2.2.5 A 1075-uL aliquot of each methanol extract is added to 42.1-mL of ASTM Type II water contained in appropriately labeled 43 mL VOA vials.

10.1.2.3 Method 5035 Field preserved:

10.1.2.3.1 *Each containers tare weight is recorded in an ExcelTM spreadsheet titled "AK101/8260B container shipment log" which is located on the network. There is a shortcut to this spreadsheet on the volatiles prep area PC. Note that the entry cells on this spreadsheet must be write protected by the prep analyst after each use of the spreadsheet. Most containers will contain a bar code with the tare weight information that can be scanned for automatic entry into this spreadsheet. Sample weights are calculated in the laboratory by adding the received weight of the sample jar to the received weight column of the "AK101/8260B container shipment log" spreadsheet of the corresponding sample container ID. This can be done by either a direct read from the balance in the volatiles prep area (preferred method), or by manually entering the weight in the spreadsheet.*

10.1.2.3.2 A 1075-uL aliquot of each methanol extract is added to 42.1-mL of ASTM Type II water contained in appropriately labeled 43 mL VOA vials.

10.1.2.3.3 To prepare the blank spike (LCS)/blank spike duplicate (LCSD), add 80-uL of GRO Working Solution or 160-uL of BTEX Working Solution and 10-mL of the TFT Preservation Solution to 10 g muffled Ottawa sand. All spiking solutions must be added to the sample prior to the addition of the TFT Preservation Solution for batches that fall under the BP LaMP.

10.1.2.3.4 To prepare the **matrix spike** (MS)/**matrix spike duplicate** (MSD), add a 1075-uL aliquot of sample methanol extract and 10-uL of GRO Working Solution or 5.5-uL of BTEX Working Solution to each of two additional samples prepared as described in 10.1.2.1.6

10.1.2.3.5 To prepare the **method blank** (MB), add 1075-uL of the TFT Preservation Solution (section 7.8) to 42.1-mL of ASTM Type II water contained in appropriately labeled 43 mL VOA vials.

10.1.2.3.6 All soil samples for AK101 analysis must be field preserved and any analysis performed with less than 48 hours allowed for the sample to equilibrate in the methanol (from time of sampling to analysis) noted in an NCM in the analytical batch.

10.1.2.4 If the water solution becomes milky or cloudy in appearance, this is an indication of potential high concentrations of target and/or non-target compounds and a higher dilution may be prepared at this time.

10.1.2.5 Dry Weight. Percent solids (dry weight) is determined by weighing approximately 10 grams of sample, completely drying the sample and then re-weighing and recording the difference in weight. SOP TA-WC-0160 describes this procedure in further detail.

10.1.3 Water Prep

10.1.3.1 All aqueous samples will be spiked with 10.75-uL of Water Surrogate Solution (section 7.7) and analyzed as received.

10.1.3.2 Samples may be screened for gasoline by analyzing a spare VOA, if available.

10.1.3.3 To prepare the Laboratory Control Sample /Laboratory Control Sample Duplicate (LCS/LCSD), add 25-uL of Water Surrogate Solution and 23.25-uL of GRO Working Solution or 50-uL of BTEX Working Solution to a 100-mL volumetric flask partially filled with and brought to final volume with ASTM Type II water. The volumetric is then gently inverted several times to ensure homogenization and transferred to two appropriately labeled VOA vials.

10.1.3.4 To prepare the matrix spike/matrix spike duplicate (MS/MSD), add 10-uL of GRO Working Solution or 17.25-uL of BTEX Working Solution to each of two additional samples provided before adding surrogate. To prepare the method blank (MB), add 12.5-uL of the Water Surrogate Solution to a 50-mL volumetric flask partially filled with and then brought to volume with ASTM Type II water. The volumetric is then gently inverted several times to ensure homogenization and transferred to an appropriately labeled VOA vial.

10.1.3.5 All aqueous sample VOA vials should be inverted to check for headspace/air bubbles prior to analysis. If multiple VOA vials are submitted for analysis, the one with the least amount of headspace should be used first. Any headspace is measured and documented in an NCM in the analytical batch.

10.1.3.6 For AK101 analysis, amber glass vials should be used for aqueous samples. If clear glass vials are submitted for analysis, the samples should be protected from light.

10.2 Calibration

10.3 Summary

Prior to the analysis of samples and blanks, the GC/MS system must be tuned and calibrated. Tuning is accomplished by analyzing 4-Bromofluorobenzene (BFB) to establish that the GC/MS system meets the standard mass spectral abundance criteria. The GC/MS system must be calibrated initially at a minimum of five concentrations to determine the linearity of the response utilizing target calibration standards. The calibration must be verified each twelve-hour time period for each GC/MS system.

10.4 Recommended Instrument Conditions

10.4.1 General

Electron Energy:	70 volts (nominal)
Mass Range:	35–300 amu
Scan Time:	to give at least 5 scans/peak, ≤ 2 seconds/scan
Injector Temperature:	200 – 250 ˚C
Source Temperature:	According to manufacturer's specifications
Transfer Line:	Temperature: 250 – 300 ˚C
Purge Flow:	40 mL/minute
Carrier Gas Flow:	1-15 mL/minute, dependent upon column specifications

Note: These conditions can vary by instrument. This is only a guideline. Actual instrument conditions are posted in each maintenance logbook.

10.4.2 Gas Chromatograph Suggested Temperature Program

The following temperature programs vary with the column type used.

In-use column dimensions and serial numbers are recorded in each instrument's maintenance logbook.

BFB Analysis

Isothermal:	170 – 200 ˚C
	Or may be taken during an initial instrument blank check or during the shift continuing calibration check (CCC), and as such conditions will be the same as sample analysis.

Sample Analysis

Injector Temperature:	230˚C
Detector Temperature:	250˚C
Initial Temperature:	45˚C
Initial Hold Time:	3.5 minutes
Temperature Program:	45℃ to 75 °C at 15°C/min hold for 0.50 minutes 75°C to 130°C at 20°C/min hold for 0.50 minutes 130°C to 230°C at 25°C/min hold for 1.75 minutes Total run time is 15.00 minutes.
Final Temperature:	184 ˚C
Final Temperature:	230 ˚C
Final Hold Time:	1.75 minutes

Note: These conditions can vary by instrument. This is only a guideline. Actual instrument conditions are posted in each maintenance logbook.

10.5 Instrument Tuning (Required for BTEX analysis only)

Each GC/MS system must be hardware-tuned to meet the abundance criteria listed in Table 4 for a maximum of a 50 ng injection or purging of BFB. Analysis must not begin until these criteria are met. These criteria must be met for each twelve-hour time period. The twelve-hour time period begins at the moment of injection of BFB. The BFB must be taken from a specified BFB Tune injection or from the CCVIS or from the lowest calibration point in the sequence. If an acceptable tune is not achieved, the analyst may re-tune the MS and repeat the test until all criteria are achieved. Further guidance can be found in the TestAmerica, Inc. corporate tune policy, CA-Q-QM-002.

10.5.1 A single scan at the peak apex (defined as the highest point on the peak) or an average of the apex ± 1 scan from which a single background scan no more than 30 seconds preceding the BFB peak has been subtracted. The background spectra cannot contain any other analytes.

10.6 Initial Calibration

10.6.1 A series of five or more initial calibration standards is prepared and analyzed for the target compounds and each surrogate compound. Nominal calibration levels for GRO and BTEX are listed in sections 7.20 and 7.22. Other calibration levels may be

used depending on the capabilities of the specific instrument or program requirements. Calibration levels below the reporting limit may be removed provided that there is a minimum of five calibration points, and the lowest standard is at or below the TestAmerica Seattle reporting limit.

10.6.1.1 For GRO the following carbon ranges are determined:

AK101: The area including n-Hexane to the start of n-Decane

8015B: Toluene through n-Dodecane, inclusive

Hawaii: Hexane through n-Dodecane, inclusive

California 8015B: 2-methylpentane through 1,2,4-trimethylbenzene

NWTPH-GX: at a minimum Toluene through 1-Methylnaphthalene inclusive is integrated and plotted against the known concentration of gasoline standard added.

10.6.2 The same purge volume must be used for calibration and sample analysis, and the low level standard must be at or below the reporting limit.

10.6.3 It may be necessary to analyze more than one set of calibration standards to encompass all of the analytes required for some tests.

10.6.4 Internal standard calibration is used. The internal standard is listed in Table *2*. Each calibration standard is analyzed and the response factor (RF) for each compound or range is calculated using the area response of the characteristic ions or total summed area against the concentration for each compound and internal standard. See Section 10.14 for calculation of response factor.

10.6.5 Calibration is valid when the following conditions have been met: a correlation coefficient (r) value ≥0.995 for each target analyte, a higher order polynomial that is continuous and monotonic with a coefficient of determination (r^2) ≥ 0.990, or the mean RSD of each target analyte is less than 15 %. NOTE: When using a higher order polynomial, there must be an additional calibration standard for each degree beyond linearity (i.e. 5 for linear, 6 for quadratic, etc.). Recalibration occurs when either the continuing calibration standard value falls outside +/-20 % of the true value twice consecutively or, the linear coefficient (r) falls below 0.995, or other conditions such as a major instrument changes warrant recalibration.

10.6.6 For all DoD project the following criteria will apply to ICAL when performing method 8260B:

10.6.6.1 The RSD for each analyte is equal to or less than 15%. If this is not met then one of the following must be met.

10.6.6.2 The linear least squares regression (r) must be equal to or greater than 0.995. If the above and this criterion are not met then the following must be met.

10.6.6.3 A non-linear regression coefficient of determination (r) must be ≥ 0.995. A minimum of six calibration points must be used for second order. For non-linear curves, the coefficient of determination (r^2) must be ≥ 0.990. Third order curves are **not** used.

10.6.6.4 The ICAL must pass one of the above criteria prior to any samples being analyzed.

10.6.7 Initial surrogate calibration is performed by average RF of all standards used unless matrix effects are observed. Calculation is performed using average of response factors when less than or equal to 15 %, linear regression with coefficient value (r) >0.995 for each target analyte, or higher order polynomial that is continuous and monotonic with a coefficient value (r) > 0.995. Recalibration occurs when surrogate recoveries consistently fail to meet established control limits.

10.6.8 See Corporate SOP CA-Q-S-005 for information on acceptable initial calibration models and associated algorithms.

10.6.9 Initial Calibration Verification (ICV)

Once the initial calibration has been evaluated and determined to be valid, the calibration must be verified with an initial calibration verification (ICV) using a standard prepared from a source other than the calibration solutions. Multiple levels of ICV may be needed to validate all compounds in the initial calibration curve. Acceptance limits are as follows:

For BTEX+ compounds, the ICV must be <20% Drift.

For 8015, the ICV must be <15% Drift.

For NWTPH-Gx, the ICV must be <20% Drift.

For AK101, the ICV must be <25% Drift.

If the %Drift falls outside acceptance criteria, assess the system for possible problems (eg. Standard degradation, etc.), re-prepare the ICV and re-analyze. If the second ICV also fails, corrective action is required (e.g., System maintenance, re-preparing intermediate standards, etc.) and the calibration must be re-prepared and re-analyzed. An acceptable ICV must be achieved before analysis.

10.6.10 A daily secondary source QC check standard (LCS) is performed using a Certified Gasoline with certified individual analytes standard from a source separate from that used for the calibration. Quantitation is performed identically as samples and standards and the result compared to the true value. Acceptance criteria for each parameter is determined by performance based empirical data.

10.6.10.1 For all DoD projects a second source calibration verification will be performed immediately following the initial calibration. The value for all analytes must be within +/- 20% of the expected value. This criterion must be met before any samples are analyzed.

10.6.11 A retention time standard (7.12) is analyzed each analytical day and every 12 hours for 8015B. The standard concentration is approximately 500 ug/L and contains at a minimum n-Hexane, Toluene, n-Decane, n-Dodecane, and 1-Methylnaphthalene. Adjustments in the retention time windows for the respective hydrocarbon groups are made, if necessary, prior to any standard or sample quantitation. See Attachment 2 for an example retention time standard chromatogram.

The default retention time ranges are established as follows:

Gasoline Range Organics NWTPH-Gx:	Toluene to 1-Methylnapthalene
Gasoline Range Organics AK101:	Hexane to the start of Decane
Gasoline Range Organics CA 8015:	2-methylpentane to 1,2,4-Trimethylbenzene
Gasoline Range Organics HI 8015:	Hexane to Dodecane

10.6.11.1 For all DoD projects the retention time window position will be established for each analyte and surrogate once per ICAL and at the beginning of the analytical shift. The position must be set using the midpoint standard of the calibration curve or the value in the CCV run at the beginning of the analytical shift.

10.6.12 If time remains in the 12-hour period initiated by the BFB injection before the initial calibration, samples may be analyzed. Otherwise, proceed to continuing calibration, Section 10.7.

10.7 Continuing Calibration

10.7.1 The initial calibration must be verified every twelve hours.

10.7.2 A continuing calibration check standard is analyzed at the beginning of each analytical sequence (for both GRO and BTEX) and at the end of each analytical sequence or every 10 samples (for GRO), whichever is more frequent. The percent recovery must be within +/-15 %, 20 % or 25 % of the true value for 8015 California-G, 8015 Hawaii-G and NWTPH-Gx, and AK101, respectively. Individual analytes must be within +/-20% of the true value for 8260. If the CCV recoveries exceed the method specified upper %Recovery limits and there are no associated sample detections above the RL, the data may be qualified and reported as the system has shown a potentially high bias (this must be done in consultation with the client). If the CCV recoveries exceed method specified %D, the CCV may be re-prepared and re-analyzed. If two sequential CCVs fail the system must be re-calibrated and all samples analyzed since the last acceptable CCV must be re-analyzed (for GRO). In addition, analysis for BTEX analytes must be conducted under a valid tune as described in section 10.5.

10.7.2.1 For BP LaMP projects CCV is run at beginning and end of sequence and every 10 samples. Recoveries should be between 85% and 115%.

10.7.2.2 Instrument response should be monitored daily by recording the absolute response of an individual peak. The internal standard is the peak chosen for these instruments. The absolute response for this peak, in the CCVRT, needs to be documented in the maintenance log book on a daily basis.

10.7.3 Once the above criteria have been met, sample analysis may begin.

10.8 Sample Analysis

10.8.1 Analysis - All samples are injected into the GC/MS using the auto sampler and the purge and trap system to increase reproducibility. Data is acquired from the GC/MS detector on the Chrom data acquisition system. The resultant area amounts are compared to the calibration curve, and the concentration of each analyte is calculated.

10.8.2 The presence of Gasoline is indicated if compounds are detected in the appropriate hydrocarbon range.

10.8.3 The presence of BTEX analytes is indicated when the ion profile of each analyte is detected and matched to the ion profile in the calibration.

10.8.4 Refer to section 11.15 of SOP MV-0312 for dilution procedures.

10.8.5 An example analysis sequence log is provided as Attachment 1.

10.8.6 pH for aqueous samples

Immediately after analysis or immediately after opening the sealed VOA vial and obtaining the necessary aliquots for dilutions, the analyst must check the pH of aqueous samples with narrow range pH paper (0-2.5) to ensure the pH is <2. Record the pH of aqueous samples on the analytical batch sheets. In those cases where the pH is >2, initiate a non-conformance report and qualify the data, noting if the sample(s) was analyzed outside of the shortened seven- or zero-day hold time.

10.9 Data Reduction and Review

10.9.1 Upon completion of the analytical sequence:

10.9.1.1 Review chromatograms online and determine whether manual data manipulations are necessary.

10.9.1.2 Manual Integrations

All manual integrations must be justified and documented. See Corporate SOP CA-Q-S-002 for requirements for manual integration.

10.9.1.3 Manual integrations are processed using Chrom, which stores the before and after chromatograms and the reason for the change, and attaches the analyst's electronic signature.

10.9.1.4 Confirm that run logs have printed on them the instrument ID, the analyst **and the method** used. If this is not printed on the run logs, this must be entered by hand prior to completing the package.

10.9.1.5 Update the sequence log.

10.9.2 Compile the raw data for all the samples and QC samples in a batch. The analytical batch is defined as containing no more than 20 field samples.

10.9.2.1 Perform a level 1 data review and document the review on the data review checklist (GCMS Data Review Checklist).

10.9.2.2 Submit the data package and review checklist to the peer reviewer for the level 2 review. The data review process is explained in SOP TA-QA-0635.

10.10 All maintenance and repairs need to be documented in the instrument's maintenance logbook. The logbook must include the instrument name, serial number for each major component (e.g., GC, autosampler, column) and the date of start-up. When an instrument is not capable of analyzing samples, it needs to be tagged "Out of Service". Logbook entries must include a description of the problem and what actions were taken to address the problem. After an instrument has undergone maintenance or repairs, the system is evaluated using a tune, CCV or ICAL. If the evaluation is successful, the analyst documents in the logbook that the "System returned to control as indicated by a passing CCV" (or ICAL, MB, tune, etc as may be the case).

If columns were replaced during maintenance procedures the specific make, model and serial numbers of the columns installed need to be entered in the instruments maintenance logbook.

See section 11.15 of SOP MV-0312 for additional details about instrument maintenance.

11.0 Calculations

11.1 Accuracy

ICV / CCV, LCS % Recovery = observed concentration x 100

known concentration

MS % Recovery = (spiked sample) - (unspiked sample) x 100
spiked concentration

11.2 Precision (RPD)

Matrix Duplicate (MD) = |orig. sample value - dup. sample value| x 100
[(orig. sample value + dup. sample value)/2]

11.3 Response Factor (RF)

$$RF = \frac{A_x C_{is}}{A_{is} C_x}$$

Where:

A_x = Area of the characteristic ion for the compound to be measured.
A_{is} = Area of the characteristic ion for the specific internal standard.
C_{is} = Concentration of the specific internal standard, ng.
C_x = Concentration of the compound being measured, ng.

11.4 Standard Deviation (SD)

$$SD = \sqrt{\frac{\sum_{i=1}^{n} \left(X_i - \overline{X}\right)^2}{n-1}}$$

Where:

X_i = Value of X at i through n.
n = Number of points.
$\overline{X}$ = Average value of Xi.

11.5 Percent Relative Standard Deviation (%RSD)

$$\%RSD = \frac{SD}{\overline{RF}} \times 100\%$$

Where $\overline{RF}$ is the mean of RF values for the calibration.

11.6 Percent Drift between the initial calibration and the continuing calibration:

$$\%Drift = \frac{C_{expected} - C_{found}}{C_{expected}} \times 100\%$$

Where:

$C_{expected}$ = Known concentration in standard.
C_{found} = Measured concentration using selected quantitation

method.

11.7 **Concentration** = mg/kg or L = $\frac{C \times V \times D}{W}$

Where:
C = sample concentration in extract (ppm)
V = Volume of extract (mL)
D = Dilution Factor

W = Weight/Volume of sample aliquot extracted (grams or mLs)

NOTE: All dry weight corrections are made in LIMS at the time the final report is prepared.

11.8 **Calculation of Results for Methanol Extracts**

Sample Conc (ug/Kg) = [On Column (ug/L)] $\times$ $\frac{\text{Extraction Final Volume (mL)}}{\text{Amount of Soil Sample (g)}}$ x $\frac{\text{VOA Vial Volume (mL)}}{\text{Amt of MeOH Extract (mL)}}$ x $\frac{\text{1L (CF)}}{\text{1000mL}}$ x $\frac{\text{1000g (CF)}}{\text{1Kg}}$

VOA vial volume is 43 ml and when the extract doesn't require a dilution, 1.075 mL of the methanol extract is used. So, the equation becomes:

Sample Conc (ug/Kg) = [On Column (ug/L)] x $\frac{\text{Extraction Final Volume (mL)}^{1}}{\text{Amount of Soil Sample (g)}^{2}}$ x $\frac{\text{43 (mL)}}{\text{1.075 (mL)}}$ x $\frac{\text{1L (CF)}}{\text{1000mL}}$ x $\frac{\text{1000g (CF)}}{\text{1Kg}}$

[1]Extract Final Volume, miscible solvent corrected (mL) = ((g of samples * % moisture/100) + ml of MeOH) * 40 (used when % Moisture of the soil sample is greater than 10%).

[2]Amount of Soil, dry-weight corrected (g) = sample mass (g) * (100 - % moisture/100)

When the Extraction Final Volume is 10mL, the Soil Extract Volume expressed on Form 1 will be 400mL. [10 * (43/1.075)]
When the Extraction Final Volume is 25mL, the Soil Extract Volume expressed on Form 1 will be 1000mL. [25 * (43/1.075)]

12.0 Method Performance

12.1 Method Detection Limit Study (MDL)

The method detection limit (MDL) is the lowest concentration that can be detected for a given analytical method and sample matrix with 99% confidence that the analyte is present. The MDL is determined according to the laboratory's MDL procedure (see SOP TA-QA-0602). MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. The laboratory maintains MDL studies for analyses performed; these are verified at least annually unless method requirements require a greater frequency.

12.2 Demonstration of Capabilities

Analyst initial and continuing Demonstrations of Capability (DOC) are performed before any client samples are analyzed and are updated annually. See SOP TA-QA-0617 for details.

12.3 Training Requirements

See SOP TA-QA-0608 for detailed training requirements.

13.0 Pollution Control

It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity

needed, preparation of reagents based on anticipated usage and reagent stability). Employees must abide by the policies in Section 13 of the Corporate Environmental Health and Safety Manual (CW-E-M-001) for "Waste Management and Pollution Prevention".

14.0 Waste Management

Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes are disposed of in an accepted manner. Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to SOP TA-EHS-0036.

14.1 Waste Streams Produced by the Method

14.1.1 *Methanol with trace levels of volatile analytes described by this method is temporarily stored in appropriately constructed (i.e. plastic) satellite waste containers labeled "Hazardous Waste." When filled, the container is bulked into the mixed solvent waste drum in the waste disposal warehouse. This waste stream is sent out for fuel blending.*

14.1.2 *VOA vials are collected in large plastic satellite waste bins marked "Hazardous Waste." At or before the waste reaches 55 gallons, the contents are transferred to the sample disposal area where the vials are bulked into a 55 gallon waste barrel and sent out for incineration.*

14.1.3 *Expired Standards. Expired standards are collected in satellite containers marked "Hazardous Waste." At or before the containers reach 55 gallons the containers are taken to the waste warehouse where they are bulked into an expired standards lab pack and sent out for incineration.*

15.0 References / Cross-References

15.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition, Methods 5030B, and 8015B, 8260B.

15.2 Method AK101 for the Determination of Gasoline range organics Version 4-8-02.

15.3 NWTPH-Gx Volatile Petroleum Products Method for Soil and Water. Washington DOE Publication No. ECY 97-602, June 1997.

15.4 Department of Defense Quality Systems Manual for Environmental Laboratories, prepared by DoD Environmental Quality Workgroup, Final Version 4.2, October 2010.

16.0 Method Modifications:

Item	Method	Modification
1	NWTPH-Gx	The method states one duplicate and one method blank per 10 samples. TestAmerica Seattle batches 2 duplicate sets (if sufficient sample exists), one LCS/LCSD set, and one method blank per 20 samples
2	NWTPH-Gx	The method states 5 g of soil is to be added to 10-mL Methanol followed by a 100-uL aliquot added to 5-mL water. TestAmerica Seattle extracts 10 g of soil with 10-mL Methanol followed by an 1075-uL aliquot added to 43-mL water
3	8015B	GRO range organics are quantitated via GC/MS TIC as opposed to FID, were appropriate

17.0 Attachments

Attachment 1: Example Instrument Sequence

Attachment 2: Example Chromatogram for RT Standard

Table 1: Reporting Limits

Table 2: Internal Standard

Table 3: Surrogate Standards

Table 4: BFB Key Ion Abundance Criteria

Table 5: LCS and Matrix Spike Compounds

Tables G-4 and G-5 DoD QSM Version 4.2 for analyte criteria

18.0 Revision History

- *Revision 11, dated 13 March 2013.*
    - *Added section 10.1.2.3.1 to better describe the preparation procedures and documentation.*
    - *Added section 14.1 Waste Streams Produced by the Method.*

- Revision 10, dated 12 October 2012.
    - Added an elaborated calculation for methanolic extracts 11.8

- Revision 9, dated 20 June 2011
    - Specified software in section 6.1
    - Updated standard information in section 7
    - Incorporated ROMDs 00019 and 00026 in sections 6.1 and 10.4
    - Added hold time information for aromatics in unpreserved water samples, section 8
    - Incorporated ROMD 00025 in Section 9.4 and 9.5
    - Incorporated ROMD 00020 in section 10.4
    - Incorporated ROMD 00022 in section 10.6.8
    - Updated surrogated Methanol reagent name section 9.3
    - Changed 5% to 10% per QSM 4.2 section 9.3
    - Added spiking criteria per LaMP sections 10.1.2.1.4 and 10.1.2.2.3
    - Adjusted reagent water volume from 43 to 42.1 mL in sections 10.1.2.1.6, 10.1.2.2.2 and 10.1.2.2.5 for final volume of 43 mL.
    - Added section 10.1.2.2.6 specifying field preservation for AK101.
    - Added sections 10.1.3.5 and 10.1.3.6 to address headspace and glass for Aq.
    - Added reference to corporate tuning policy section 10.5
    - Added two consecutive CCV failures section 10.6.5
    - Added explicit ICV section 10.6.9
    - Added more detail/condensed CCV analysis in sections 10.7.2 and 10.7.2.1
    - Incorporated ROMD 00024 in section 10.7.2
    - Incorporated ROMD 00033 in section 10.7.2.2
    - Added dilution procedures (by reference) in section 10.8.4.
    - Added pH section 10.8.6
    - Added data reduction/data review (10.9) and maintenance (10.10) sections
    - Corrected section/table references and grammar where necessary.

- Revision 8, dated 16 April 2010
    - Added documentation of standards/reagents and standard/reagent preparation Section 7.1

  - Added removal of expired standards Section 7.24.
  - Added LaMP matrix spike requirements Section 9.5
  - Added BP LaMP surrogate requirements, Section 9.6.
  - Added criteria for additional QC, Section 9.7.
  - Added daily balance check to Section 10.1.1.
  - Added BP LaMP CCV criteria Section 10.7.2.2
  - Updated DoD Table (Attachment)
  - Integration for TestAmerica Bothell and TestAmerica Tacoma operations.

- Revision 7, dated 17 December 2008
  - Integration for TestAmerica and STL operations.
  - This revision is a complete rewrite and an expansion of scope.

Attachment 1. Example Instrument Sequence

Page 1

Sequence Log

Directory : i:\1\DATA\01092009

#	Filename	Sample Name	Date/Time
1	ms176640.d	Fife Rinse	01/09/09 11:43
2	ms176641.d	Rinse/Tune	01/09/09 12:04
3	ms176642.d	RT standard	01/09/09 12:26
4	ms176643.d	1000 ug/L GRO ccal	01/09/09 12:47
5	ms176644.d	25 ug/L 8260 ccal	01/09/09 13:08
6	ms176645.d	MB 580-39682/1-A	01/09/09 13:30
7	ms176646.d	LCS 580-39682/2-A	01/09/09 13:51
8	ms176647.d	580-12421-E-1-A	01/09/09 14:12
9	ms176648.d	580-12421-E-3-A	01/09/09 14:34
10	ms176649.d	580-12421-E-3-B MS	01/09/09 14:55
11	ms176650.d	580-12421-E-3-C MSD	01/09/09 15:17
12	ms176651.d	580-12421-B-5-A	01/09/09 15:38
13	ms176652.d	Rinse/Tune	01/09/09 16:00
14	ms176653.d	1000 ug/L GRO ccal	01/09/09 16:21

Attachment 2. Example Chromatogram for RT Standard

```
File        : I:\2\DATA\04282006\CS165056.D
Operator    : jc
Acquired    : 4-28-2006 09:33:19 AM using AcqMethod GBTEX.M
Instrument :
  Instrumen
Sample Name: rt std
Misc Info   : 1369-18-1
Vial Number: 3
```

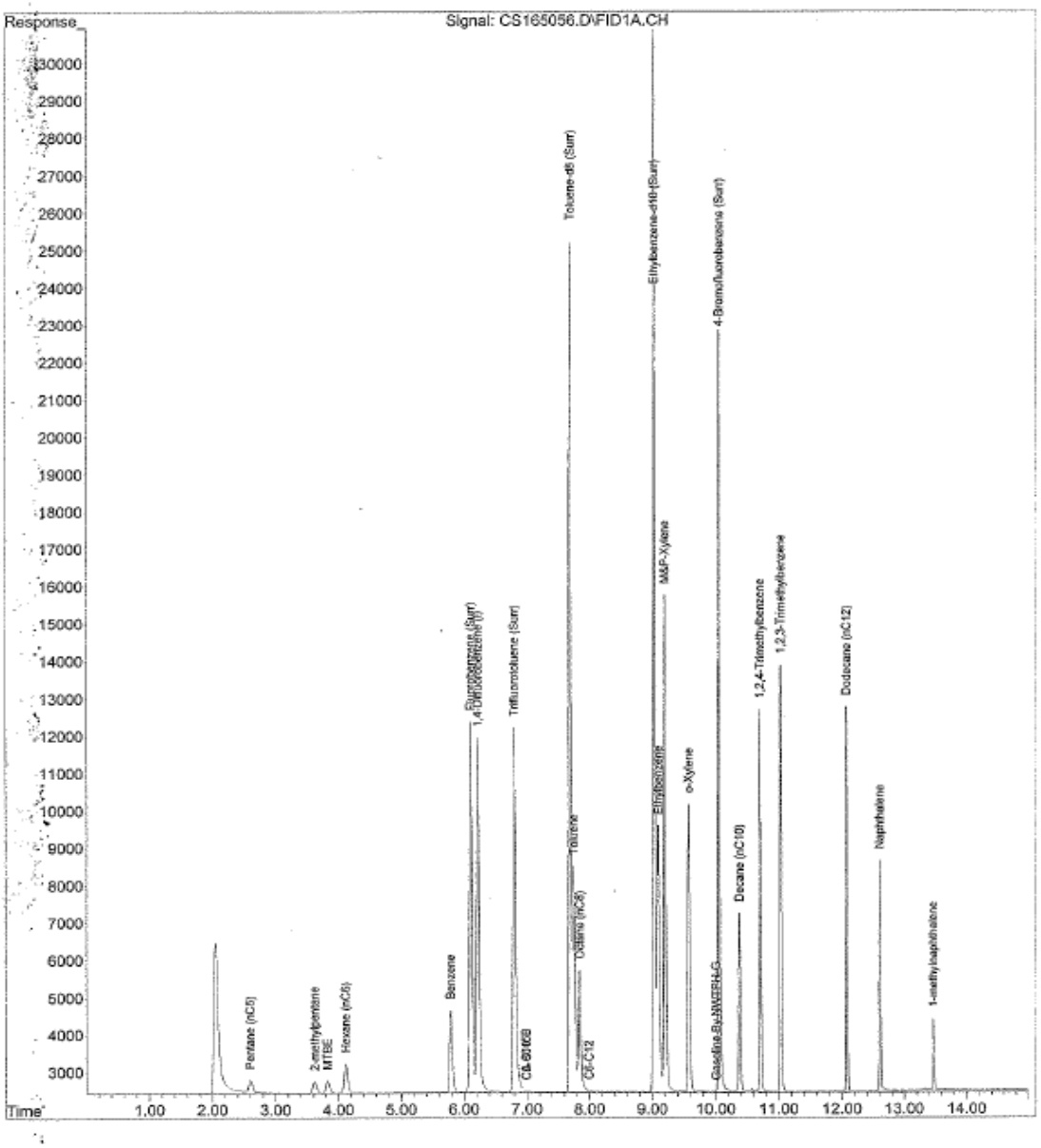


Table 1. Reporting Limits

Compound	CAS Number	Reporting Limits[1]	
		Water (µg/L)	Soil (mg/kg)
Gasoline Range Organics, NWTPH-Gx	STL00228	100	4.0
Gasoline Range Organics, AK101	8006-61-9	50	4.0
Gasoline Range Organics, Hawaii-Gx	STL00061	50	2.0
Gasoline Range Organics, CA 8015B	STL00215	50	4.0
Benzene	71-43-2	0.5	0.008
Toluene	108-88-3	1.0	0.040
Ethylbenzene	100-41-4	1.0	0.040
M&p-Xylene	136777-61-2	2.0	0.080
o-Xylene	95-47-6	1.0	0.040
Xylenes, Total	1330-20-7	1.0	0.040
Methyl tert-butyl ether (MTBE)	1634-04-4	1.0	0.040
Hexane	110-54-3	1.0	0.040
Cyclohexane	110-82-7	1.0	0.040
1,2-Dichloroethane	107-06-2	1.0	0.008
Isopropylbenzene	98-82-8	1.0	0.040
n-Propylbenzene	103-65-1	1.0	0.040
1,3,5-Trimethylbenzene	108-67-8	1.0	0.040
1,2,4-Trimethylbenzene	95-63-6	1.0	0.040
Naphthalene	91-20-3	1.0	0.040

[1] Reporting limits listed for soil/sediment are based on wet weight. The reporting limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

Table 2. Internal Standard

Internal Standard	Standard Concentration (mg/L)	Quantitation Ion
vwrkIS_xxxxx		
1,4-Difluorobenzene	500	

Table 3. Surrogate Standards

Surrogate Compounds	Standard Concentration (mg/L)
Fluorobenzene	4000
Trifluorotoluene	4000
Ethylbenzene-d_{10}	4000
Toluene-d_8	4000
4-Bromofluorobenzene	4000

NOTES:

1) Recovery and precision limits for the surrogates are generated from historical data and are maintained by the QA department.

Table 4. BFB Key Ion Abundance Criteria

Mass	Ion Abundance Criteria
50	15 to 40 % of Mass 95
75	30 to 60 % of Mass 95
95	Base Peak, 100 % Relative Abundance
96	5 to 9 % of Mass 95
173	Less than 2 % of Mass 174
174	Greater than 50 % of Mass 95
175	5 to 9 % of Mass 174
176	Greater than 95 %, but less than 101 % of Mass 174
177	5 to 9 % of Mass 176

Table 5. LCS and Matrix Spike Compounds

Compound	Standard Concentration (mg/L)
Gasoline Range Organics	5500
1,2,4-Trimethylbenzene	200
1,2-Dichloroethane	200
1,3,5-Trimethylbenzene	200
Benzene	200
Cyclohexane	200
1,2-Dibromoethane	200
Ethylbenzene	200
Hexane	200
Isopropylbenzene	200
m- & p-Xylene	200
Methyl tert-butyl ether (MTBE)	200
Naphthalene	200
n-Propylbenzene	200
o-Xylene	200
Toluene	200

NOTES:

1) Recovery and precision limits for the LCS, MS, and MSD are generated from historical data and are maintained by the QA department.

Taken from Table G-4 and G-5 DoD QSM Version 4.2 for Analyte Criteria

Table D-4 LCS Control Limits for Volatile Organics Compounds SW-846 Method 8260 Water Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Benzene	102	7	80	120	75	130
Toluene	100	7	75	120	70	130
Ethyl Benzene	100	9	75	125	65	135
m&p-Xylene	102	9	75	130	65	135
o-Xylene	100	7	80	120	75	130
MTBE	94	10	65	125	55	135

Table D-5 LCS Control Limits for Volatile Organics Compounds SW-846 Method 8260 Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit	Lower ME Limit	Upper ME Limit
Benzene	99	9	75	125	65	135
Toluene	99	9	70	125	60	135
Ethyl Benzene	101	9	75	125	65	135
m&p-Xylene	102	8	80	125	70	135
o-Xylene	101	8	75	125	70	135

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Title: Semivolatile Petroleum Products Method for Soil and Water [Method NWTPH-Dx mod]

Approvals

Signatures on File

Colin McKean Date	Sandra Langway Date
Semivolatile Organic Department Manager	Health & Safety Manager / Coordinator
Terri Torres Date	Heather Prater Date
Quality Assurance Manager	Laboratory Director

Facility Distribution No. 001 **Distributed To:** Lab Intranet

1.0 Scope and Application

1.1 Analytes, Matrix(s), and Reporting Limits

1.1.1 This SOP delineates the procedure for the identification and quantitation of semivolatile petroleum products using the WA DOE NWTPH-Dx method. This method is applicable to both soils and waters. Waters may be collected in either 1-liter or 125-mL sample jars.

1.1.2 This SOP does not include the procedures for extracting soil and water samples. Refer to the following SOPs for sample extraction procedures.

TA-OP-0301	Liquid-Liquid Extraction by Separatory Funnel, SW846 3510C
TA-OP-0323	Continuous Liquid-Liquid Extraction, SW846 3520C
TA-OP-0302	Sonication Procedure, SW846 3550B
TA-OP-0367	*Microwave Extraction 3546*

1.1.3 Reporting Limits

1.1.3.1 Soil: 25 mg/kg (diesel) and 50 mg/kg (motor oil)

1.1.3.2 Water: 0.125 mg/L (diesel) and 0.25 mg/L (motor oil)

1.2 On occasion clients may request modifications to this SOP. These modifications are handled following the procedures outlined in Section 12.2.1 in the Quality Assurance Manual.

2.0 Summary of Method

This method is used to identify, by pattern matching ("fingerprinting"), and quantitate semivolatile petroleum products. These products include kerosene, jet fuels, diesel oils, fuel oils, lubricating oils, hydraulic fluids, mineral oils and insulating oils such as transformer oils. Soil samples are weighed, dried, surrogate is added and extracted with methylene chloride. Water samples (1-liter or 100-mL volume) are acidified, surrogate is added and extracted with methylene chloride. Extracts are then concentrated and an aliquot of sample is analyzed by GC-FID. The hydrocarbons are quantitated against diesel (nC10-nC24) and motor oil (>nC24-nC36) standards (default) used for calibration and identified by pattern matching to the calibration standard or appropriate library spectra.

3.0 Definitions

3.1 Diesel Range Organics (DRO): The sum of compounds producing chromatographic peaks, both resolved and unresolved, eluting between n-decane (C_{10}) and tetracosane (C_{24}).

3.2 Motor Oil (MO): The sum of the compounds producing chromatographic peaks, both resolved and unresolved, eluting between tetracosane (C_{24}) and n-hexatriacontane (C_{36}).

3.3 Jet Propellant-4 (JP-4): The range is determined by injecting a standard purchased from a vendor and choosing the retention times from the initial low point of the chromatographic peaks to the end of the resolved and unresolved peaks. The hydrocarbon range for this fuel is typically from Toluene to C_{12}; however, LIMS defines this range as n-octane through n-octadecane.

3.4 Jet Propellant-8 (JP-8): The range is determined by the same method as used for JP-4. The hydrocarbon range for this fuel is typically from Toluene to C_{12}; however, LIMS defines this range as n-octane through n-hexadecane.

3.5 Mineral Oil (Transformer Oil): The sum of the compounds producing chromatographic peaks, both resolved and unresolved, eluting between dodecane (C_{12}) and tetratriacontane (C_{34}).

3.6 Bunker C (Fuel Oil 6): The sum of the compounds producing chromatographic peaks, both resolved and unresolved, eluting between n-decane (C_{10}) and n-hexatriacontane (C_{36}); however, LIMS defines this range as n-dodecane (C_{12}) through n-octatriacontane (C_{38}).

4.0 Interferences

4.1 Solvents, reagents, glassware, and other equipment coming in contact with the extract may yield interferences.

4.2 Non-petroleum hydrocarbons (non-polar) will also be extracted using this procedure. Hydrocarbons eluting in the ranges described above for fuel hydrocarbons will be detected and reported as false positives. All semi-volatile results must be reported; atypical results should be qualified appropriately.

4.3 Phthalate esters are found in many materials commonly found in the laboratory. In particular, plastics should be avoided because phthalates are routinely used as plasticizers and are easily extracted from the plastic materials.

5.0 Safety

Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001) and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.1 Specific Safety Concerns or Requirements

5.1.1 The gas chromatograph contains zones that have elevated temperatures. The analyst needs to be aware of the locations of those zones, and must cool them to room temperature prior to working on them.

5.1.2 There are areas of high voltage in both the gas chromatograph. Depending on the type of work involved, either turn the power to the instrument off, or disconnect it from its source of power.

5.2 Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. **Note: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table.** A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Methylene Chloride	Carcinogen Irritant	25 ppm-TWA 125 ppm-STEL	Causes irritation to respiratory tract. Has a strong narcotic effect with symptoms of mental confusion, light-headedness, fatigue, nausea, vomiting and headache. Causes irritation, redness and pain to the skin and eyes. Prolonged contact can cause burns. Liquid degreases the skin. May be absorbed through skin.
Sulfuric Acid	Corrosive Oxidizer Dehydrator Poison Carcinogen	1 Mg/M3-TWA	Inhalation produces damaging effects on the mucous membranes and upper respiratory tract. Symptoms may include irritation of the nose and throat, and labored breathing. Symptoms of redness, pain, and severe burn can occur. Contact can cause blurred vision, redness, pain and severe tissue burns. Can cause blindness.
Acetone	Flammable	1000 ppm-TWA	Inhalation of vapors irritates the respiratory tract. May cause coughing, dizziness, dullness, and headache.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			

6.0 Equipment and Supplies

6.1 Instrumentation

- Gas Chromatograph, Hewlett Packard 6890 or equivalent with autosampler equipped with a capillary split/splitless injector and an FID.
- Chromatographic column types:

6.1.1 Phenomenex ZB-1: 30 meters x 0.25 mm ID x 0.10 um film thickness cut in half to give two (2) 15 meter columns for dual column capable instruments.

6.1.2 Phenomenex ZB-1: 15 meters x 0.25 mm ID x 0.10 um film thickness.

These are the primary types of columns currently in use. Equivalent versions/types from a different vendor may be substituted. Note that elution chromatography may vary based on the actual column in place.

6.1.3 Analytical Balance, accurate to at least 0.0001g

6.2 Software

6.2.1 Data acquisition system: Agilent's ChemStation, is used for data acquisition and storage on machine-readable media. Since no processing is done by ChemStation and since there are no audit trail functions associated with data acquisition, the audit trail feature for ChemStation may be either enabled or disabled. The other component, Chrom, is used for data processing such as the measurement of peak area or peak height. By design, the audit trail feature for Chrom is always enabled.

6.2.2 Data processing: Chrom version 1.2 or higher

6.2.3 TestAmerica LIMS (TALS), current version

6.3 Supplies

- Volumetric Flasks, 10 mL, 25 mL, 50 mL, 100 mL, 250 mL, Class A, ground glass stoppered
- Scintillation vials with Teflon-lined screw caps
- Glass standard vials with screw caps and Teflon-lined septum
- Autosampler vials, 1.5 mL, crimp top or equivalent
- 20 mL scintillation vials, with Teflon-lined lids or equivalent
- Centrifuge
- Pasteur pipette, disposable

7.0 Reagents and Standards

7.1 Document reagents/standards and reagent/standard preparation in TALS using the reagent module as described in SOP TA-QA-0619.

7.2 Methylene Chloride (CH_2Cl_2), analytical reagent grade or equivalent.

7.3 Sodium sulfate, anhydrous powder, reagent grade or equivalent.

Note: Sodium sulfate must be muffled at 400 ℃ for 4 hours prior to use to avoid phthalate contamination.

7.4 Sulfuric acid, concentrated, trace metals grade or equivalent.

7.5 Petroleum product standards, Accustandard FUEL-SET, 20 mg/mL in CH_2Cl_2 or equivalent.

7.6 Check the Balance logbook to determine if the daily calibration check has been completed. If it has not, the analyst must perform this check according to SOP TA-QA-0014.

7.7 Surrogate Stock Standard. Approximately 0.2 g of o-Terphenyl (99%, Aldrich) and 0.2g n-triacontane-d62 (both weighed to the nearest 0.0001 g), and 8 mL of 4-Bromofluorobenzene (EXT-4-BFB_S_0000X from O2Si, Catalog number 020135-08) are diluted to a final volume of 100 mL with an 80:20 mix of DCM:acetone, providing a stock spiking solution of approximately 2,000 mg/L.

Note: n-Triacontane tends to precipitate out of acetone; therefore, the vial of surrogate should be checked for this, and mixed on the vortex until all crystals are back in solution.

7.8 Reference/Stock Standards. Prepare individual petroleum product reference/stock standards; kerosene, JP-5, transformer oil, and bunker crude fuel oil.

7.8.1 Add 5 to 10 drops or the pure petroleum product to a tared 10 mL volumetric flask. Record the weight to the nearest 0.0001g and bring to volume in methylene chloride, stopper and mix by inverting several times. Calculate the concentration of the standard using the equation below.

7.8.1.1 Stock Conc., ug/ml = $\frac{\text{(final wt, mg)-(tare wt, mg)}}{\text{10 mL}} \times \frac{\text{1,000 ug}}{\text{mg}}$

7.8.1.2 These standards are also used to ensure the proper identification of petroleum products by chromatographic pattern matching.

7.8.2 The use of commercially available standards is an acceptable alternative to the above procedure.

7.9 Calibration Working Standards. Using the stock standards, prepare calibration working standards for the identified petroleum product(s) to be quantitated. Serially dilute the reference/stock standard(s) to prepare calibration curve(s). Calibration standards must, at

a minimum, provide a minimum 5 (five) point calibration curve, include a sufficiently low standard to provide necessary detection limits, and define a linear working range of the instrument. A mid-range calibration standard should also be prepared for calibration curve verification. The mid-range calibration standard concentration is varied within the instrument calibration range.

7.9.1 In order to be acceptable, each calibration curve must have a*n average %RSD value ≤ 15%, or a* linear correlation coefficient (r) of at least 0.990 and none of the standards may vary from their true value by more than ± 15%. #2 diesel oil and motor oil are the default petroleum product for reporting purposes.

7.10 Retention Time Window Standard. The retention time standard is prepared by appropriately diluting the EPH aliphatic stock standard (EPH AL calstk_0000X), and TPH surrogates (TPH_SURR_0000X) to a final concentration of 20 ug/mL each, with a final volume of 25 mL. The standard contains nC8-nC40 plus surrogates, sans nC39.

7.10.1 Establishing Retention Time Windows. The retention time window for each hydrocarbon range is established using the lower limit of the first eluting compound and the upper limit of the last eluting compound. The upper and lower limits are established by adding or subtracting 3σ from the absolute retention time of the appropriate compound. Alternatively a default standard deviation of 0.01 may be used for a retention time window of 0.03 minutes (EPA Method 8000C section 11.6)

7.11 Diesel and Motor Oil Spiking Solution. A 50,000 ug/mL #2 diesel fuel and motor oil composite standard is prepared and ordered as a custom standard from Restek, part number CS-13305, in a 5:1 DCM:acetone solvent mixture. This standard is logged into the LIMS system as “TPH Spike_RZ_0000X”.

7.12 Other spiking solutions may be prepared using different petroleum products by appropriately diluting a stock standard to a 5,000 ug/mL working solution. #2 diesel and motor oil will be the default spiked products if sample contaminant is unknown.

7.13 Managers/supervisors or a designee are expected to check their areas on a monthly basis for expired standards and dispose of them according to SOP TA-EHS-0036.

8.0 Sample Collection, Preservation, Shipment and Storage

8.1 Water samples may be collected in 1-liter or 125 mL amber glass bottles. Soil samples are typically collected in 4-oz. or 8-oz. glass jars. All sample containers must have Teflon-lined caps.

8.2 All samples shall be stored at 0-6℃ after collecti on. Water samples should be preserved with 1+1 HCl to a pH of ≤ 2.

8.3 Holding time, from the date of sampling to extraction, is 14 days for soil and 14 days for water. Holding time from extraction to analysis is 40 days.

Matrix	Sample Container	Min. Sample Size	Preservation	Holding Time	Reference
Water	Glass	1000 mLs	1:1 HCl, pH < 2; Cool 0-6^{o}C	14 Days, Extraction 40 Days, Analysis	40 CFR Part 136.3
Soil	Glass	10 grams	Cool 0-6^{o}C	14 Days, Extraction 40 Days, Analysis	N/A

9.0 Quality Control

9.1 The minimum quality controls (QC), acceptance criteria, and corrective actions are described in this section. When processing samples in the laboratory, use the LIMS QC program code and special instructions to determine specific QC requirements that apply.

9.1.1 The laboratory's standard QC requirements, the process of establishing control limits, and the use of control charts are described more completely in SOP TA-QA-0620, Quality Control Program.

9.1.2 Project-specific requirements can override the requirements presented in this section when there is a written agreement between the laboratory and the client, and the source of those requirements should be described in the project documents. Project-specific requirements are communicated to the analyst via special instructions in the LIMS.

9.1.3 Any QC result that fails to meet control criteria must be documented in a Nonconformance Memo (NCM). The NCM is approved by the supervisor and then automatically sent to the laboratory Project Manager by e-mail so that the client can be notified as appropriate. The QA group also receives NCMs by e-mail for tracking and trending purposes. The NCM process is described in more detail in SOP TA-QA-0610. This is in addition to the corrective actions described in the following sections.

9.2 Quality Control Batch

The batch is a set of up to 10 samples of the same matrix processed together using the same reagents and standards. Each quality control batch must contain a method blank (MB), a laboratory control sample (LCS), matrix spike (MS), and duplicate (DUP) pair. Matrix spike/matrix spike duplicate pairs are only performed for Tier 4 projects or by client request. For more details see SOP TA-QA-0620.

9.3 Method Blank (MB)

One method blank is analyzed with every preparation batch or every 20 samples, whichever is more frequent. The method blank consists of either 1 liter of organic-free water (for batches of aqueous samples) or 10 grams of Ottawa sand (for batches of soil samples). The method blank is processed exactly as samples in the batch, and is used to assess whether the laboratory processes have contaminated the samples in the batch.

Acceptance Criteria: Surrogate recoveries must fall within acceptance criteria and the results for the method blank must be less than or equal to the reporting limit concentration or less than 5% of the lowest concentration found in the associated samples. DOD and BP LaMP require MB to be ≤ ½ RL.

Corrective Action: If the method blank acceptance criteria are not met, identify and correct the source of contamination, and re-prepare and reanalyze the associated samples.

9.4 Laboratory Control Sample (LCS)

One LCS is analyzed with every preparation batch or every 20 samples, whichever is more frequent. The LCS (and LCSD as appropriate) consists of either 1 liter of organic-free water (for batches of aqueous samples) or 10 grams of Ottawa sand (for batches of soil samples), to which 100 µL of spike solution is added. See Table III for spike levels. The LCS is processed exactly as samples in the batch and is used to assess the accuracy of the analytical system. In the case where insufficient volume is provided for the extraction of an MS/MSD or duplicate sample, an LCSD will also be prepared.

Acceptance Criteria: The percent recovery of the analytes of interest must fall within the established control limits. For all other methods, the control limits are set at ± 3 standard deviations around the calculated mean of the historical LCS recovery data, unless project-specific control limits apply. Current control limits are stored in the laboratory LIMS. See SOP TA-QA-0620 for further details.

Corrective Action: If LCS acceptance limits are not met, the LCS should be reanalyzed once to confirm that the original analysis is reliable. If the results are still outside control limits, the associated samples must be re-extracted and reanalyzed. If the LCS recovery is above the upper control limit, and the associated samples are all below reportable concentrations, the deviation may be described in an NCM, if this is acceptable to the client or allowed by the specific program or project.

9.5 Matrix Spike and Matrix Spike Duplicate (MS/MSD)

When specifically requested, one matrix spike (MS) and one matrix spike duplicate (MSD) are prepared by spiking replicate portions of the selected field sample with the same spiking standard that is used for the LCS. Field blanks and equipment rinses may not be used to prepare the MS and MSD. The MS and MSD are processed exactly as samples in the batch, and are used to assess the effects of sample matrix on the accuracy and precision of the analytical system.

Acceptance Criteria: The percent recovery of the analytes of interest must fall within the established control limits. The control limits are set at ± 3 standard deviations around the calculated mean of the historical MS recovery data, unless project-specific control limits apply. Current control limits are stored in the laboratory LIMS. See Policy QA-0620 for further details.

The relative percent difference (RPD) between the MS and MSD must be less than the established control limit, which is based on 3 standard deviations of the mean of the historical data. RPD control limits are maintained in the laboratory LIMS.

Corrective Action: If the analyte recovery in the MS and/or the RPD between the MS and MSD fails acceptance criteria, but all other QC criteria are met, the MS/MSD failure may be attributed to matrix effects and the associated sample results may be reported as qualified. However, some programs (e.g., USACE) require reanalysis to confirm that presumed matrix effects are reproducible.

9.6 Duplicate Sample Analysis

A duplicate pair is required with each analytical batch. The RPD between samples should be ≤35%.

Corrective Action: If the RPD fails the acceptance criterion and the fuel pattern is inconsistent between chromatograms, the sample should be re-extracted and reanalyzed. If only the RPD value exceeds the acceptance criterion, the failure may be attributed to matrix effects or sample inhomogeneity and the associated sample results may be reported as qualified.

9.7 Surrogate Spikes

The o-terphenyl surrogate has chemistry similar to the analytes of interest, but *is* not expected to be found in environmental samples. 100-µL of the surrogate spike solution is added to each field and QC sample in the batch prior to sample extraction and all instrument blanks. See Table III for spike levels. Surrogate results are used to assess the performance of the analytical system for each field and QC sample and instrument blank.

Acceptance Criteria: The percent recovery of the surrogates must fall within 50-150% recovery.

Corrective Action: If surrogate recoveries are outside the established limits, verify calculations, dilutions, and standard solutions. Also verify that the instrument performance is acceptable. High recoveries may be due to co-eluting matrix interference and the chromatogram should be examined for evidence of this. Low recoveries may be due to adsorption by the sample matrix (e.g., clay particles, peat, or organic material in the sample). Recalculate the results and/or reanalyze the extract if the checks reveal a problem.

If the surrogate recovery is outside the established limits due to well-documented matrix effects, the results must be flagged and an explanation included in the report narrative. As with matrix spike failures, some programs (e.g., USACE) may require additional analyses to confirm suspected matrix interferences. The decision to reanalyze or flag the data should be made in consultation with the client. It is only necessary to re-prepare / reanalyze a sample once to demonstrate that a matrix effect is reproducible.

NOTE: For LaMP samples, if the surrogate percent recovery fails, the recovery must be confirmed by re-extraction and reanalysis with the following exceptions:

- The lab has unequivocally demonstrated a sample matrix effect and informed the LaMP client representative.
- The recovery exceeds control limits and all target analytes in the sample are non-detect.

9.8 RT Reference Standard

The retention time window is established by injecting a mixture of n-alkanes from Toluene to n-hexatriacontane (C_{36}) three times over a 72 hour period. The mean and standard deviation for the three retention times are calculated. The width of the RT window is set at ±3 times the standard deviations of the mean RT. If the resulting RT window is less than 0.03 minutes, then a window of 0.03 minutes is used.

Acceptance Criteria: Toluene must be resolved from the solvent peak.

Corrective Action: If the acceptance criteria are not met, check instrument conditions and calibration materials, correct as necessary and repeat analysis of the reference standard before proceeding with the analysis of samples.

9.9 **Instrument QC**

9.10 A PIBLK (an instrument blank with surrogate added) needs to be run after each CCV, unless the CCV is followed by a Method Blank. If the PIBLK is analyzed, it needs to be evaluated. The acceptance criterion for the PIBLK is the same as the method blank.

9.11 Initial Calibration (ICAL)

9.11.1 A new calibration curve must be generated initially, after major changes to the system, or when continuing calibration criteria cannot be met. Major changes include installation of new columns and changing FID jets.

9.11.2 The ICAL is performed using the concentration levels described in Table II. A total of four separate initial calibration curves (ICALs) is required to calibrate for all the mixtures. An ICAL must always be analyzed for the diesel fuel as these standards contain the surrogate compounds. ICALs for the other mixtures are analyzed as needed, depending upon the requested parameters. Samples may be calculated as one or more mixtures, dependent upon the project requirements. The lowest calibration concentration is equal to the laboratory reporting limit (RL) concentration. The highest standard defines the highest sample extract concentration that may be reported without dilution. It is not acceptable to remove points from a calibration curve for the purpose of meeting criteria.

9.11.3 The external standardization method is used. Tabulate the area response for each calibration level against the concentration injected. The ratio of the response to the concentration injected, defined as the calibration factor (CF), is calculated for the standard at each concentration as follows:

$$CF_i = \frac{A_{fuel}}{C_{fuel}}$$

Where:

CF_i = Calibration factor for the i^{th} calibration level.
A_{fuel} = Total area of the fuel calibration standard peak.
C_{fuel} = Concentration of fuel calibration standard, mg/mL

9.11.4 If the percent relative standard deviation (%RSD) for the average (mean) of the calculated calibration factors is less than *15*%, the average calibration factor can be used for sample quantitation.

$$\text{Average Response Factor} = \overline{CF} = \frac{\sum_{i=1}^{n} CF_i}{n}$$

Where:

CF_i = Calibration factor for the i[th] calibration level.
n = The number of calibration levels.

9.11.5 If %RSD for the mean calibration factor is greater than *15*%, a linear least-squares regression may be used to fit the calibration data. The linear fit calculates the slope and intercept of a straight line that relates the concentration of each calibration standard to a chromatographic peak area, as follows:

$$A_s = mC_s + b$$

Where:

A_s = Area of the chromatographic peak for the target fuel.
m = Slope of the line as determined by the least-squares regression.
C_s = Concentration of the target fuel in the calibration standard, mg/mL.
b = Intercept of the line as determined by the least-squares regression.

9.11.6 The correlation coefficient of the fitted line must be ≥ 0.990. Note that some programs (e.g., AFCEE and USACE) require that the correlation coefficient is ≥ 0.995, unless approval is given in the project QAPP to use 0.990.

9.11.7 If the ICAL %RSD or correlation coefficient linearity criteria are not met, sample analysis cannot be performed using the calibration. Confirm that the instrument is performing properly, adjust as needed, and confirm that the standards are made correctly. After correcting the problem(s), prepare and reanalyze a new set of calibration standards.

9.11.8 See Corporate SOP CA-Q-S-005 for information on acceptable initial calibration models and associated algorithms.

9.12 Second-Source Initial Calibration Verification (ICV)

A second-source initial calibration verification (ICV) standard is prepared and analyzed immediately after each ICAL. This standard can also be used as the continuing calibration verification (CCV) standard. The response for this standard must be within ± 15% of the response predicted from the ICAL. The percent difference between the measured ICV calibration factor (or the measured concentration of the ICV standard) and the ICAL calibration factor (or the known concentration of the ICV standard) is calculated as follows:

$$\text{Percent Difference} = \frac{\text{R1} - \text{R2}}{\text{R1}} \times 100\%$$

Where:

R1 = Average calibration factor from the calibration curve or the ICV known value.

R2 = Calculated calibration factor for the ICV analysis or the measured ICV value.

If the percent difference for the second-source verification falls outside of ± 15%, then sample analysis cannot be performed. Reanalyze the second-source verification standard to confirm the original result. If the second result fails, then re-prepare the verification standard, and/or re-prepare and rerun the ICAL.

9.13 Continuing Calibration Verification (CCV)

9.13.1 A CCV standard is analyzed at the beginning of the analytical sequence, every 12 hours of operation, or every 10 samples (whichever is more frequent), and at the end of the analytical sequence. The response for this standard must be within ± 15% of the response predicted from the ICAL.

In the event of calibration verification failure, corrective action must be taken prior to sample analysis. If routine corrective action procedures fail to produce a second consecutive (immediate) calibration verification within acceptance criteria, then either the lab has to demonstrate acceptable performance after corrective action with two consecutive calibration verifications (using fresh calibration solutions, at low and high concentrations) or, alternatively, a new initial calibration must be established according to Section 10.2. If one of these calibration verification injections fails, a new initial calibration curve must be processed. If a verification standard is not acceptable, all samples analyzed after the last acceptable verification standard must be reanalyzed. Any samples associated with failed closing calibration verifications where the response for an analyte in the calibration verification standard is above the acceptance limit and the analyte was not detected in any of the samples analyzed since the previous passing verification, do not need to be reanalyzed as the verification standard has demonstrated that the analyte would have been detected were it present (see Note below for information relative to DOD samples). Re-analysis is required for all other situations. If for some reason (i.e., lack of sample) re-analysis can't take place, a NCM needs to be initiated and the sample and QC results associated with the failing CCV need to qualified in the final report. Sample results associated with a CCV failure that are uploaded into the LIMS need to be qualified at the analyte level as appropriate. Additional information related to the CCV failure or corrective actions taken should be summarized in a NCM.

NOTE: For DOD samples, a high biased CCV with non-detects in the samples is only acceptable to report if approval is granted by the client. Otherwise, samples associated with a high failing CCV need to be re-analyzed.

9.14 Any extra QC that is analyzed in a batch or sequence must be evaluated using the same criteria as the corresponding QC above.

10.0 Procedure

One-time procedural variations are allowed only if deemed necessary in the professional judgment of supervision to accommodate variation in sample matrix, radioactivity, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using an NCM. The NCM is approved by the supervisor and then automatically sent to the laboratory Project Manager by e-mail so that the client can be notified as appropriate. The QA group also receives NCMs by e-mail for tracking and trending purposes. The NCM process is described in more detail in SOP TA-QA-0610. The NCM shall be filed in the project file and addressed in the case narrative.

10.1.1 Note: It has been noted that some petroleum products, i.e. heavy oils such as #6 fuel oil or bunker crude may experience a concentration loss of between 10 and 20 percent when subjected to this cleanup technique. This loss appears to be primarily associated with the removal of petroleum compounds which contain sulfur. To account for this loss when analyzing samples that have subjected to the cleanup procedure in preparation for heavy fuel oil determination, the analyst must use standards that have undergone the cleanup technique to calibrate the GC.

10.2 Calibration

10.2.1 *Refer to Table 2 for on-instrument calibration levels.*

10.3 The gas chromatograph is set up as follows:

Injector: 300℃

Detector: 350℃

Oven ramping profile for 6890 GC systems with 15 meter column(s): Initial column temperature is set to ~~45~~*30*-60℃, and held for 0.5 minutes, ramped to 340℃ at 30℃/min and held for 2-3 minutes. Flow is set to constant flow at 1.5-3.5 mL/min. A post run is initialized at 340℃ at a flow rate of 5.0 mL/min, and held for 2-4 minutes to clean out the system of contaminants.

Oven ramping profile for 5890 GC systems with 15 meter column(s): The oven temperature program parameters for these systems are similar to that of the 6890 systems, however, the final holding time is increased to 4-6 minutes due to the instrument software not having a post run capability.

Note: the oven ramping profile will vary from instrument to instrument, as each does not perform exactly like one another. In addition, actual column lengths and types vary as well.

Note: each instrument's run method parameters are printed out and stored in each appropriate instrument maintenance logbook.

10.3.1 The FID is allowed to stabilize at manufacturers recommended makeup and carrier gas flows prior to analysis.

10.3.2 Standard and surrogate solutions are allowed to come to room temperature prior to use.

10.4 Sample Analysis

10.5 Prior to analysis of any samples or QC samples, the analyst must prepare and analyze a mid-range calibration check standard (CCV) to insure that the instrument is functioning correctly and that the calibration is still valid.

10.5.1 CCVs need to be followed by a blank (method blank or instrument blank). CCVs cannot be preceded by a blank, unless a blank is analyzed before each sample in the bracket.

10.5.2 Instrument response should be monitored daily by recording the absolute response of an individual peak. The surrogate o-Terphenyl is the peak chosen for these instruments. The absolute response for this peak in this standard needs to be documented in the maintenance log book on a daily basis.

10.6 The analyst shall use #2 diesel and motor oil as the default product for reporting purposes when no petroleum products were identified in any initial screening or when type(s) of petroleum products are unknown prior to analysis.

10.7 A portion of sample extract stored in an appropriately sized vial is transferred to 1.5 mL autosampler vials.

10.8 Extracts are analyzed by injection of 1 uL on the GC by an autosampler. **Note:** The use of GC/MS or GC/AED may be substituted for GC/FID as long as all other method parameters are met.

10.9 Samples which are expected to contain elevated levels of contamination may be followed by a solvent rinse blank to avoid possibility of carryover.

10.10 A mid-range calibration standard is analyzed every 12 hours of operation, or every 10 samples (whichever is more frequent), and at the end of the analytical sequence.

10.11 If NWTPH-HCID has not been previously performed on the samples and/or the type of petroleum present is unknown, the analyst may prescreen the samples to determine the petroleum product.

10.12 The observed petroleum product shall be determined by pattern matching with standard(s) analyzed the same day. Chromatograms used for this "fingerprinting" should be normalized to approximately 90% of full scale for the largest component of the particular petroleum product observed.

10.13 When reporting results, the analyst should adhere to the following:

10.13.1 If detection is due to a typical fuel pattern other than diesel or motor oil, the analyst must apply the "FUEL" qualifier to the appropriate range(s). The analyst must then follow-up with a "Pattern Recognition" NCM of the appropriate type, explaining the fuel pattern observed in each sample.

10.13.2 If detection is not due to a typical fuel pattern, such as a single peak, the analyst must apply the "NOFUEL" qualifier to the appropriate range(s). The analyst must then follow-up with an "Other – Observation" type NCM, explaining the particular detection.

10.14 For those surrogate compounds that elute within retention time ranges used for petroleum product integration, the analyst must subtract the area of the surrogate from the total area to yield a corrected area of the petroleum product.

10.15 At the discretion of the analyst, the range of components included in the integration may be adjusted in order to minimize the potential contribution of a co-eluting fractions arising from the presence of multiple petroleum products. Any change in the integration range must be reflected in the integration of the calibration standards.

10.16 For the default petroleum products, #2 diesel and motor oil, the calibration standard area of the components from decane (nC_{10}) and tetracosane (nC_{24}) (#2 diesel) and from tetracosane (nC_{24}) to hexatriacontane (nC_{36}) (motor oil) are integrated to the baseline as a group. The data system will automatically remove any surrogate areas that elute within the retention time windows. The samples are integrated in the same manner and the areas compared.

10.17 An example instrument analysis sequence is shown in Attachment 1.

10.18 Upon completion of the analytical sequence:

10.18.1 Review chromatograms via Chrom/Peak Review software and determine

whether manual data manipulations are necessary.

10.18.2 All manual integrations must be justified and documented. See Corporate SOP CA-Q-S-002 for requirements for manual integration.

10.18.3 Manual integrations, if necessary, are performed in the Chrom/Peak Review software module, utilizing the appropriate integration type and reason. Before and after chromatograms with appropriate user information are automatically generated in Chrom and is uploaded into LIMS with each sample.

10.18.4 Confirm that run logs have printed on them the instrument ID, the analyst and the method used. If this is not printed on the run logs, this must be entered by hand prior to completing the package.

10.19 Open the analysis batch in the TALS/LIMS Analyst Desktop II module, and allow the system to perform the sample calculations.

10.19.1 Perform a level 1 data review and document the review on the data review checklist (GC Data Review Checklist).

10.19.2 Submit the data folder containing the preparation batch data sheets, worklist information, and review checklist to the peer reviewer for the level 2 review. The data review process is explained in SOP TA-QA-0635.

10.19.3 Update the instrument sequence logbook.

10.20 GC Maintenance

10.20.1 Leak Checking. Leak checking after column installation is recommended. In order to avoid contamination when leak testing fittings and connections, direct a small jet of gas which can be detected by the detector, (for example methane for an FID) at the point to be tested, then use the detector at the maximum sensitivity to detect leakage of gas into the system. Response is rapid at points downstream of the column. Response time will be delayed by the elution time of the gas in the column. A quicker leak test can be performed by placing a drop of isopropanol on the point to be tested. If bubbles form, a leak is indicated. Alternatively, an electronic leak detector may be used.

10.20.2 Column Installation. Columns are replaced every six months or as needed. When a column will not hold its calibration for any length of time, replacement is needed. Poor peak shape and excessive baseline rise not attributed to sample contamination are other indication that the column may need replacement.

10.20.2.1 Remove the old column from the GC oven by loosening the injector and detector nuts with the appropriate wrench.

10.20.2.2 The *injector* end of the new column is installed first. Slide the column nut over the column end.

10.20.2.3 Install the appropriate ferrule onto the column. For the HP 6890*/7890* GCs, the tapered end is placed towards the end of the column.

10.20.2.4 Cut 1 to 2 cm from the end of the column.

10.20.2.5 Uncoil approximately 20 cm of column.

10.20.2.6 Move the column nut and ferrule within 12-15 cm of the end of the column.

10.20.2.7 Cut 1 to 2 cm. off of the end of the retention gap. Insert the column end

through the column nut, and then place a graphite ferrule onto the column and column nut. Using an old adaptable FID fitting, pre-crush the graphite ferrule to hold the column in place. For HP 6890/7890 GCs, measure *3* to *4* mm from the end of the column to the beginning of the ferrule.

10.20.2.8 Insert the retention gap into the injector while holding the column in place so it does not slide out of the ferrule. Tighten the column nut to finger tight. Make sure that the mark is visible and in the correct place for HP GCs. Tighten the column nut with a wrench approximately 1/4 turn or until the column cannot be pulled out of the injector.

10.20.2.9 For the detector end, insert the column end through the column nut, and slide a graphite ferrule over the column. Clip approximately 1 – 2 cm off the column end.

10.20.2.10 Partially insert the column into the lower end of the detector. For HP 6890/7890 GCs, the column is inserted 68 mm. CAUTION: The column can break or chip if it is forced into the detector!! Thread the column nut and ferrule until finger tight. For HP 6890/7890 GCs, pull the column back out of the detector approximately 1 mm. Tighten the ferrule and column nut with a wrench approximately 1/3 to 1/2 turn or until the column cannot be removed by pulling on it.

10.20.2.11 Install a ferrule onto the retention gap. For HP 6890/7890 GCs, the tapered end is placed towards the injector.

10.20.2.12 The gas flows are set to manufacturer or method recommended levels and are checked prior to each initial calibration:

Column flow: Approximately 1.5 -11 mL/min.
Make-up gas at the detector (Nitrogen): Column flow + X mL/min. = to 20 mL/min.
Hydrogen: 30 mL/min.
Air: 300 mL/min.
Total Flow: 360 mL/min.

10.20.2.13 Condition the column by heating the oven to 5-10 ℃ above its maximum operating temperature for approximately two hours, or until the baseline drops to its normal operating level. After the column is conditioned, the oven temperature is set at standby. At this point, the instrument is ready to be calibrated.

10.20.3 The injection port septa are replaced at least every 100-150 injections, or as needed under normal operating conditions.

10.20.4 The injection port be cleaned and the liner replaced monthly, or as needed. The frequency is determined by the number of samples analyzed and the amount of contamination introduced into the system. The loss of detector response, particularly in early eluting peaks is an indicator that the liner or retention gap needs replacement. To replace the injection port:

10.20.4.1 Cool the column and injection port to ambient temperature to avoid burns.

10.20.4.2 Unscrew the septum nut from the top of the injector. Remove the septum. Unscrew the nut below the septum plate.

10.20.4.3 Using tweezers or needle nose pliers, remove the liner and the viton O-ring. If the O-ring is not damaged, it may be used again. Insert a clean liner into the O-ring with the tapered end up. Insert the liner into the injection port. Tighten the lower nut onto the injection port.

10.20.4.4 Replace the septum with a new septum. Tighten the septum nut until finger tight. Puncture the septum with a syringe. This will also indicate if the septum nut is tight enough.

10.20.5 The oven is heated to maximum operating temperature for approximately one hour to remove any residue or contamination introduced into the system during maintenance.

10.21 FID Maintenance

10.21.1 Maintenance of the FID involves cleaning deposits from internal parts, including the flame tip, and ferrule replacement. These maintenance procedures are performed every six months, or more frequently if there is degradation in the FID performance. "Spiking" signals and carbon build-up are indications that the detector needs cleaning.

10.21.2 Refer to the GC Operator's Manual for proper disassembly and reassembly of the FID.

10.21.3 When removing the FID from the GC, inspect the O-ring at the base of the detector and replace as necessary.

10.21.4 Flame Tip and Internal Parts Cleaning.

10.21.4.1 Using Emery cloth, clean deposits from the bore of the collecting tube, the insulator, and the metal part of the flame tip.

10.21.4.2 If the flame tip is plugged, clear it by inserting a wire through the flame tip orifice.

10.21.4.3 Sonicate the detector parts in a methanol bath for ten to fifteen minutes.

10.21.4.4 Flush all components with methanol and dry in an oven at 100 ℃ for at least 15 minutes.

10.21.4.5 Reinstall the detector.

10.21.5 Ferrule Replacement.

10.21.5.1 If a leak develops around the base of the flame tip assembly, replace the ferrule.

10.21.5.2 Note: A leak is evident by detector noise, instability, and loss of sensitivity.

10.21.6 Autosampler Maintenance

10.21.6.1 Check the wash solvent levels daily. Fill if needed. Empty the waste bottles if necessary.

10.21.6.2 The syringe may need replacement. Follow the procedure outlined in the HP 7673 Automatic Sampler Manual (pp 3-30 through 3-32).

10.21.6.3 Periodically clean the surface of the tray arm, gripper, gripper jaws, and the tray quadrants.

10.22 Spare Parts

10.22.1 Gas Chromatograph.

10.22.1.1 Septa, Merlin Microseal septum and column nut set

10.22.1.2 Injection Port Liners: HP 5890/6890 GCs: 4 mm ID straight

10.22.1.3 Column nut

10.22.1.4 Ferrules: 1/4 in. graphite *0.4* mm ID graphite

10.22.2 Autosampler

10.22.2.1 Syringes: HP7673: HP 10 uL 7673 Std. Plunger, or equivalent

10.22.2.2 Solvent and waste vials and septa

10.22.3 FID

10.22.3.1 FID jet

10.22.3.2 Column insulator

10.22.3.3 Collector tube

All maintenance and repairs need to be documented in the instrument's maintenance logbook. The logbook must include the instrument name, serial number for each major component (e.g., GC, autosampler, column) and the date of start-up. When an instrument is not capable of analyzing samples, it needs to be tagged "Out of Service". Logbook entries must include a description of the problem and what actions were taken to address the problem. After an instrument has undergone maintenance or repairs, the system is evaluated using a CCV or ICAL. If the evaluation is successful, the analyst documents in the logbook that the "System returned to control as indicated by a passing CCV" (or ICAL, MB, etc as may be the case).

If a column was replaced during maintenance procedures the specific make, model and serial numbers of the column installed needs to be entered in the instrument's maintenance logbook.

11.0 Calculations / Data Reduction

11.1 Accuracy

$$\textbf{ICV / CCV, LCS \% Recovery} = \frac{\text{observed concentration}}{\text{known concentration}} \times 100$$

$$\textbf{MS \% Recovery} = \frac{\text{(spiked sample) - (unspiked sample)}}{\text{spiked concentration}} \times 100$$

11.2 Precision (RPD)

$$\textbf{Matrix Duplicate (MD)} = \frac{|\text{orig. sample value - dup. sample value}|}{[(\text{orig. sample value + dup. sample value})/2]} \times 100$$

11.3 Concentration

$$\text{sample conc., mg/L} = \frac{(\text{area count} * \text{response factor}^{1}) * \text{extract volume}}{(\text{volume inj., uL}) * \text{sample volume, mL})}$$

$$\text{sample conc., mg/kg} = \frac{(\text{area count} * \text{response factor}^{1}) * \text{extract volume}}{(\text{volume inj., uL}) * (\text{sample weight, g}) * (\%\text{solids})}$$

1 = ng injected/area count

NOTE: All dry weight corrections are made in LIMS at the time the final report is prepared.

12.0 Method Performance

12.1 Method Detection Limit Study (MDL)

The method detection limit (MDL) is the lowest concentration that can be detected for a given analytical method and sample matrix with 99% confidence that the analyte is present. The MDL is determined according to the laboratory's MDL procedure (see SOP TA-QA-0602). MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. The laboratory maintains MDL studies for analyses performed; these are verified at least annually unless method requirements require a greater frequency.

Instrumentation software must have each target limit set to the lowest MDL. CHROM (LOD)

12.2 Demonstration of Capabilities

Analyst initial and continuing Demonstrations of Capability (DOC) are performed before any client samples are analyzed and are updated annually. See SOP TA-QA-0617 for details.

12.3 Training Requirements

See SOP TA-QA-0608 for detailed training requirements.

13.0 Pollution Control

It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity needed, preparation of reagents based on anticipated usage and reagent stability). Employees must abide by the policies in Section 13 of the Corporate Environmental Health and Safety Manual (CW-E-M-001) for "Waste Management and Pollution Prevention".

14.0 Waste Management

Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes are disposed of in an accepted manner. Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to SOP TA-EHS-0036.

14.1 Waste Streams Produced by the Method

14.1.1 Acidic extracted sample and QC wastewater. After the extraction has been completed the spent water is neutralized and then collected into the organics extraction water conical reservoir. The collected wastewater is then purged with

air to remove any remaining methylene chloride. When the concentration levels are at or below local discharge limits, the wastewater can be discarded down the drain.

14.1.2 Solvent/Methylene Chloride waste. Any waste methylene chloride/solvent is collected in beakers and then poured into a 4-liter amber bottle labeled "Hazardous Waste" located in the hood. After the extraction has been completed, the $MeCl_2$ collected in the 4 L bottles is emptied into the $MeCl_2$ satellite waste barrel located next to the neutralization tank in lab hood #17. The funnel lid on the drum must be closed after each use. At or before the satellite waste reaches 55 gallons, the barrel is transferred to the waste disposal room from where it is sent out for recycling or fuel blending.

14.1.3 Vialed extract waste. Sample extracts that have been placed in vials for analysis are discarded into satellite waste buckets labeled "Hazardous Waste" located underneath the bench top. Once the buckets are full, the GC vials are bulked into the non-PCB GC vial waste barrel located in the waste room and sent out for incineration.

14.1.4 Extract waste. Unused sample extracts are held for at least 40 days, in case further testing is deemed necessary. After at least 40 days has passed, these extracts are transported to the waste room in racks of 100 were they are bulked into a flammable loose pack waste stream and sent out for incineration.

14.1.5 Expired primary and working standards. Expired standards are stored in a canister labeled "Hazardous Waste" at or near the point of generation. At or before the satellite waste reaches 55 gallons, it is removed to the waste warehouse where it is bulked into the non-PCB GC vial waste barrel and sent out for incineration.

15.0 References / Cross-References

15.1 Analytical Methods for Petroleum Hydrocarbons, WA DOE, Toxics Cleanup Program and the Ecology Environmental Laboratory, Publication No. ECY 97-602, June 1997.

15.2 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition, Methods 3510C, 3550B, 3540C, 3580A, 8000C, and 8015B.

16.0 Method Modifications:

Item	Method	Modification
1	NWTPH-Dx	For petroleum products eluting after #2 diesel, e.g. motor oils, hydraulic fluids, and heavy fuel oils, the reporting limit is approximately 50 mg/kg for soil as opposed to 100 mg/kg
2	NWTPH-Dx	Final sample extract volume is 5.0 mL instead of 10 mL for waters analysis.
3	NWTPH-Dx	Silica gel SPE tubes are used instead of silica gel 100/200 mesh.
4	NWTPH-Dx	A full liter of water or 100 mL of water is extracted instead of 400 mL.
5	NWTPH-Dx	Both #2 diesel and motor oil are used as default petroleum products when product is unknown or not identified.
6	NWTPH-Dx	Soil samples may be prepared using a validated modification of method 3550B.

17.0 Tables and Attachments

Table I: Aliphatic Hydrocarbon Standard
Table II: Calibration Levels
Table III: Special Hydrocarbon Ranges
Table IV: Spike Levels for Quality Control
Table V: Recommended GC Conditions

Attachment 1: Example Instrument Sequence
Attachment 2: n-Alkane Retention Time Standard Chromatogram

18.0 Revision History

- Revision 13, dated 16 May 2013
  - Updated preparation SOP's in section 1.1.2.
  - Removed Isopropanol reagent from table in section 5.2.
  - Added average response factor criteria for calibrations in section 7.9.1.
  - Updated average response factor %RSD criteria in sections 9.11.4 and 9.11.5.
  - Added section 10.2.1 to refer to Table 2 for on-instrument calibration levels.
  - Updated Table 2 to include new calibration levels to accommodate LVI analysis.

- Revision 12, dated 6 August 2012
  - Updated preparation of stock surrogate standard in section 7.7.
  - Updated GC model number types and re-arranged column installation procedures outlined in sections 10.20.2.3 through 10.20.2.10.
  - Updated detector gas type in section 10.20.2.12.
  - Updated waste streams, section 14.1

- Revision 11, dated 31 May 2011
  - Added references to applicable extraction procedures in section 1.1.2
  - Added RLs in section 1.1.3.
  - Updated carbon ranges for several fuels types discussed in section 3.
  - Incorporated ROMDs 00019 and 00026 in section 6.1
  - Added software descriptions in Section 6.2
  - Added more detail on the preparation of the sodium sulfate in section 7.3.
  - Revised surrogate composition (7.7), RT standard (7.10) and Diesel/Motor Oil Spike (7.11).
  - Incorporated ROMD 00025 in section 9.4.
  - Incorporated ROMD 00022 in section 9.11.8.
  - Incorporated ROMD 00024 in section 9.13
  - Incorporated ROMD 00020 in section 10.3.
  - Incorporated ROMD 00033 in section 10.5.2.
  - Added Item #6 to Method Mods in section 16.
  - Updated information in Tables II and V.

- Revision 10, dated 26 March 2010
  - Added documentation of reagent/standards and reagent/standard preparation Section 7.1.
  - Added removal of expired standards Section 7.13.
  - Added BP requirement for surrogates, Section 9.7.
  - Added criteria for additional QC, Section 9.13
  - Added daily balance check to Section 10.2
  - Added maintenance documentation requirements to the end of section 10.22

- Revision 9, dated 26 April 2008
    - Integration for TestAmerica and STL operations.
    - This SOP is the combination of SOPs 0339.9 and 0387.6.

Table I: Aliphatic Hydrocarbon Standard

Compound Boiling Points		
n-Alkane	**Name**	**B.P.$_{760}$ (℃)**
C_{10}	Decane	174
C_{24}	Tetracosane	391
C_{32}	Dotriacontane	468
C_{36}	Hexatriacontane	498

This Table can be used to get the estimated boiling point ranges of the hydrocarbons reported in a given sample.

Table II: Calibration Levels

Standard	***Level 1***	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**	**Level 7**	***Level 8***
DRO	*10****	20	50	100	500**	1000	5000	*10000*
Jet Fuels 4 and 8	20	50	100	500**	1000	5000	*n/a*	*n/a*
Motor Oil / RRO	*10**	20	50	100	500**	1000	5000	*10000*
o-Terphenyl (surrogate)	*0.4*	0.8	2.0	4.0	20**	40	200	*400*

***** This level is frequently excluded as a calibration point as the RL for Motor Oil/RRO is 50.
****** Level used for CCV.
**** Level is required in calibration for analyzing LVI samples.*
(All concentrations are in mg/L.)

Table III: Special Hydrocarbon Ranges

Type	**Carbon Ranges**
Gasoline Range	Start of N-C8 through end of N-C12
Kerosene Range	Start of N-C8 through end of N-C20
Mineral Spirits Range	Start of N-C8 through end of N-C12
Mineral (Transformer) Oil Range	Start of N-C12 through end of N-C24
Hydraulic Oil Range	Start of N-C19 through end of N-C36
Heavy Fuel Oil Range	Start of N-C12 through end of N-C38

Table IV: Spike Levels for Quality Control

Laboratory Control Samples (LCS) and Matrix Spike/ Spike Duplicate		
Analyte	**Spike Concentration**	
	Water (mg/L)	**Soil (mg/kg)**
Diesel Range Organics	5.0	500
Jet Fuel 8	5.0	500
Jet Fuel 4	5.0	500
Residual Range Organics (or Motor Oil)	5.0	500

Surrogate Control Samples		
Analyte	**Spike Concentration**	
	Water (mg/L)	**Low Soil (mg/kg)**
o-Terphenyl	0.2	20

Table V: Recommended GC Conditions

Hydrogen/Nitrogen Flow Rate	2.5 mL/min
Initial Column Temperature	45 ºC for 0.5 minutes
Temperature Ramp	30 ºC / minute
Final Column Temperature	330 ºC
Injector Temperature	300ºC
FID Temperature	350ºC

Attachment 1: Example Instrument Sequence

Page 1

Sequence Log

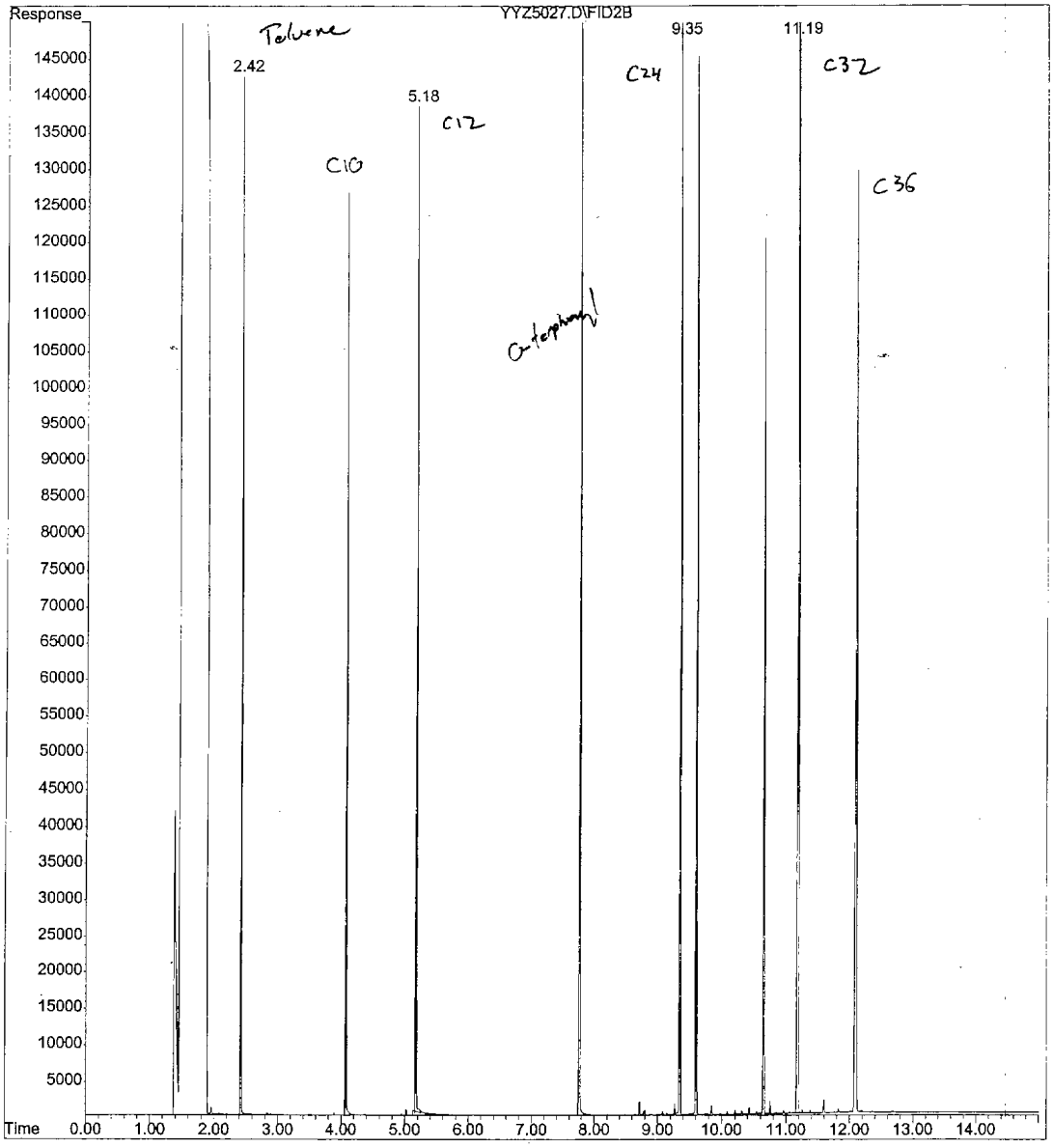
Directory : e:\Data\042508_a

#	Filename	Sample Name	Date/Time
1	fa34544.d	rinse	04/25/08 07:12
2	fa34545.d	RS 176241 8015/NWDX n-alkane	04/25/08 07:31
3	fa34546.d	ccv 254376 1000 NWDX	04/25/08 07:51
4	fa34547.d	MB 580-30606/1-A	04/25/08 09:14
5	fa34548.d	LCS 580-30606/2-A	04/25/08 09:33
6	fa34549.d	580-8586-A-3-C	04/25/08 09:59
7	fa34550.d	580-8586-A-4-C	04/25/08 10:24
8	fa34551.d	580-9702-A-1-F	04/25/08 10:50
9	fa34552.d	580-9702-A-2-B	04/25/08 11:15
10	fa34553.d	580-9702-A-2-C DU	04/25/08 11:40
11	fa34554.d	580-9702-A-3-B	04/25/08 12:06
12	fa34555.d	ccv 254376 1000 NWDX	04/25/08 12:31
13	fa34556.d	MB 580-30606/1-B	04/25/08 13:02
14	fa34557.d	LCS 580-30606/2-B	04/25/08 13:22
15	fa34558.d	580-8586-A-3-D	04/25/08 13:47
16	fa34559.d	580-8586-A-4-D	04/25/08 14:12
17	fa34560.d	ccv 254376 1000 NWDX	04/25/08 14:38

Sea 013

Attachment 2: n-Alkane Retention Time Standard Chromatogram

```
File        : F:\DATA\051208_A\YYZ5027.D
Operator    : TMR
Acquired    : 12 May 2008  10:51      using AcqMethod RACQ.M
Instrument  :   SEA014
Sample Name: 1166-95-4 n-alkane rt std
Misc Info   : BT=S014051208
Vial Number: 2
```



Title: ANALYSIS OF METALS BY INDUCTIVELY COUPLED PLASMA / MASS SPECTROMETRY [SW-846 6020A; EPA 200.8]

Approvals (Signature/Date):

Fernando Cruz — Date 1/18/12
Inorganics Department Manager

Michael Riedenhower — Date 1/18/12
Health & Safety Manager / Coordinator

Marti Ward — Date 1-18-12
Quality Assurance Manager

Elaine Wild — Date 1/18/12
Laboratory Director

This SOP was previously identified as SOP No. ST-MT-0001 Rev. 19

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the determination of metals by inductively coupled plasma mass spectrometry (ICP-MS) by EPA SW846 Method 6020A, EPA 200.8 and ASTM Method D5673-03.

1.2 This method is applicable to surface, and saline waters; soil and waste samples.

1.3 The aqueous sample digestion procedure is found in SOP: ST-IP-0013, Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy, and ICP/MS (Method 3010A, EPA 200.7 and EPA 200.8) and the soil sample digestion procedure is found in SOP: ST-IP-0002, Acid Digestion of Soils, SW846 Method 3050B for ICP, and ICP/MS.

1.3.1 The Technetium-99 soil procedure is found in SOP ST-RC-0125, Determination of Technetium-99 Using Eichrom® Teva Resin, taking the following deviations: Rhenium is used instead of Technetium-99 meta as the tracer, there is no need to let the tracer decay out and the tracer is analyzed on the ICPMS.

1.4 The laboratory target analytes supported by this method, the reporting limits, method detection limits and QC limits are maintained in the Information Management System (QuantIMS). A copy of the Structure and Analysis Code (SAC), which lists this information, is included in the appendix of this SOP.

1.4.1 Additional elements may be amendable to this method provided the laboratory has established a MDL and the elements meets the QC requirements as prescribed in the associated preparation and analysis SOP.

2.0 SUMMARY OF METHOD

2.1 Sample digestates are nebulized into a spray chamber where a stream of argon carries the sample aerosol through a quartz torch and injects it into a radio frequency plasma. There the sample is decomposed and desolvated. The ions produces are entrained in the plasma gas and by means of a water-cooled, differentially pumped interface, introduced into a high-vacuum chamber that houses a quadrupole or octoplole mass spectrometer. The ions are sorted according to their mass-to-charge ratio and measured with a channel electron multiplier.

3.0 DEFINITIONS

3.1 See the TestAmerica St. Louis Quality Assurance Manual (QAM) for a glossary of common laboratory terms and data reporting qualifiers.

3.2 EPA and SW methodology use different terminology. Our SOP references the SW 846 terminology:

3.2.1 The ICV satisfies the QCS requirements found in method 200.8 and D5673-03.

3.2.2 The LCS satisfies the requirements of the LFB found in method 200.8 and D5673-03.

3.2.3 The MS satisfies the requirements of the LFM found in method 200.8 and D5673-03.

3.2.4 The CCV satisfies the requirements of the IPC found in method 200.8.

3.2.5 The LLICV satisfies the requirements of the CRI.

3.3 Dissolved Metals: Those elements which pass through a 0.45 um membrane filter. (Sample is acidified after filtration)

3.4 Suspended Metals: Those elements retained by a 0.45 um filter.

3.5 Total Metals: The concentration determined on an unfiltered sample following vigorous digestion.

3.6 Total Recoverable Metals: The concentration determined on an unfiltered sample following treatment with hot, dilute mineral acid.

3.7 Dilution Test – the terminology “dilution test” found in later versions of 200.8 and 6020A is referred to as a Serial Dilution in this SOP.

4.0 INTERFERENCES

4.1 Isobaric elemental interferences: Isobaric elemental interferences associated with naturally occurring isotopes are automatically corrected by the instrument software.

4.2 Isobaric molecular interferences: Corrections for molecular interferences will be applied where appropriate based on known or suspected interferences.

4.3 Common molecular ion interferences are listed in Table 1 of this SOP.

4.4 Matrix interferences: Internal standards are used to correct for some matrix interferences.

4.4.1 Internal standards are added at a level to give approximately 100,000 - 10,000,000 counts of raw signal intensity. The mass of the internal standard used should ideally be within ±50 amu of the mass of the affected analyte.

4.4.2 Severe matrix effects will be monitored by comparing the internal standard intensity in the sample to the internal standard intensity of the initial calibration blank .

5.0 SAFETY

5.1 Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001), Radiation Safety Manual and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.2 SPECIFIC SAFETY CONCERNS OR REQUIREMENTS

5.2.1 The ICP plasma emits strong UV light, harmful to vision. Analysts must avoid looking directly at the plasma.

5.3 PRIMARY MATERIALS USED

5.3.1 The following is a list of the materials used in this method, which have a serious or significant hazard rating. NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Nitric Acid	Corrosive Oxidizer Poison	2 ppm (TWA) 4 ppm (STEL)	Nitric acid is extremely hazardous; it is corrosive, reactive, an oxidizer, and a poison. Inhalation of vapors can cause breathing difficulties and lead to pneumonia and pulmonary edema, which may be fatal. Other symptoms may include coughing, choking, and irritation of the nose, throat, and respiratory tract. Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and stain skin a yellow or yellow-brown color. Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Hydrochloric Acid	Corrosive Poison	5 ppm (Ceiling)	Inhalation of vapors can cause coughing, choking, inflammation of the nose, throat, and upper respiratory tract, and in severe cases, pulmonary edema, circulatory failure, and death. Can cause redness, pain, and severe skin burns. Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			
TWA – Time Weighted Average			
STEL – Short Term Exposure Limit			
Ceiling – At no time should this exposure limit be exceeded.			

6.0 EQUIPMENT AND SUPPLIES

6.1 Perkin Elmer/Sciex ELAN 6100 ICP-MS with Autosampler/ Agilent 7500/ Agilent 7700 (all with auto samplers)

6.2 Helium gas: 5.5 trace analytical grade

6.3 Hydrogen gas: ultra high purity grade

6.4 Argon gas: High-purity grade (99.99%)

6.5 Chiller (water cooling device)

6.6 Peristaltic Pump

6.7 Calibrated automatic pipettes or Class A glass volumetric pipettes

6.8 Teflon flasks

6.9 Instrument software: ELAN version 2.3.2 or Mass Hunter version B.01.01.

7.0 REAGENTS AND STANDARD

7.1 All standards and reagent preparation, documentation and labeling must follow the requirements of SOP ST-QA-0002, current revision.

7.2 Concentrated nitric acid (HNO3), trace metal grade

7.3 Concentrated hydrochloric acid (HCl), trace metal grade

7.4 DI water from the Millipore unit

7.4.1 Water must be free of the analytes of interest as demonstrated through the analysis of method blanks. Water must be shown to have a resistivity greater than or equal to 16.67 Mohm-cm.

7.5 Standards, NIST traceable

7.5.1 Purchased as custom multi-element mixes or as single-element solutions.

7.5.2 All standards must be stored in FEP fluorocarbon or unused polyethylene or polypropylene bottles.

7.5.3 Working calibration and calibration verification solutions may be used for up to 1 week and must be replaced sooner if verification from an independent source indicates a problem. Standards should be prepared in a matrix of 2% hydrochloric and 2% nitric acid.

7.5.4 Internal Standard Solution: Prepare internal standards (Au, Sc, Ge, In, Ho, Li6) when needed.

7.5.5 Tuning solution: Prepare tuning solution (Be, Ba, Ce, Co, In, Pb, Li) when needed.

8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1 TestAmerica St. Louis supplies sample containers and chemical preservatives in accordance with the method. TestAmerica St. Louis does not perform sample collection. Samplers should reference the methods referenced and other applicable sample collection documents for detailed collection procedures. Sample volumes and preservative information is given in ST-PM-0002.

8.2 Aqueous samples for total metals must be digested before analysis using an appropriate digestion procedure, ST-IP-0013.

8.3 Soil or waste samples are digested before analysis using an appropriate digestion procedure. Method 3050B of SW846 is the appropriate digestion procedure, ST-IP-0002.

8.4 Digestate holding time is 6 months from sample collection.

9.0 QUALITY CONTROL

9.1 **Batch**

9.1.1 A sample batch is a maximum of 20 environmental samples, which are prepared together using the same process and same lot(s) of reagents.

9.1.2 Instrument conditions must be the same for all standards, samples and QC samples.

9.1.3 For this analysis, batch QC consists of a method blank, a Laboratory Control Sample (LCS), and Matrix Spike (MS)/ Matrix Spike Duplicate (MSD). In the event that there is insufficient sample to analyze a MS/MSD an LCS Duplicate (LCSD) is prepared and analyzed.

9.2 **Method Blank (MB)**

9.2.1 A method blank is a blank matrix processed simultaneously with, and under the same conditions as, samples through all steps of the procedure.

9.2.2 A method blank must be prepared with every sample batch.

9.3 **Laboratory Control Sample (LCS)**

9.3.1 An LCS is a blank matrix spiked with a known amount of analyte(s), processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.3.2 An LCS must be prepared with every sample batch.

9.4 **Matrix Spike (MS) /Matrix Spike Duplicate (MSD)**

9.4.1 A Matrix Spike is an aliquot of a field sample to which a known amount of target analyte(s) is added, and is processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.5 **Serial Dilution**

9.5.1 A dilution test is performed to determine whether significant physical or chemical interferences exist due to the sample matrix.

9.5.2 The test is performed by running a sample at a 5x (1:4) dilution.

9.5.3 Samples identified as field blanks cannot be used for dilution tests.

9.5.4 The serial dilution results shall agree within +\- 10% of the undiluted sample results, if the undiluted sample results are greater than 10 times the reporting limit. There is no criteria for sample results less than 10 times the reporting limit.

9.6 **Post Digestion Spike** (PDS)

9.6.1 Post digestion spike are applicable to 6020A only.

9.6.1.1 A post digestion spike is a sample which has been fortified with target analytes of interest after the digestion process.

9.6.2 The laboratory requires the analysis of a serial dilution for all batches and thus does not perform the intermediate post digestion spike QC step.

9.6.3 The method stipulates that a PDS be performed on the sample chosen for MS/MSD and if the PDS fails to proceed to performing a serial dilution on the sample. If the PDS is acceptable, the laboratory is not required to perform a serial dilution. Since the laboratory has elected to perform the serial dilution routinely, the outcome of the PDS is not critical. There is no qualification made to the data based on the performance of the PDS.

9.6.4 For client project or programs requiring a PDS, the laboratory will include a PDS in the batch in addition to the serial dilution. This requirement is noted by the Project Manager in the client requirement sheet and/or client summary report.

9.6.4.1 If a PDS is performed, the acceptance criteria is 80%-120%, with a spike concentration between 10-100 times the MDL, UNLESS, the project/program criteria is given.

9.7 **Method of Standard Addition** (MSA)

9.7.1 This technique involves adding known amounts of standard to one or more aliquots of the processed sample solution. This technique compensates for a sample interferent that may enhance or depress the analyte signal, thus producing a different slope from that of the calibration standards. It will not correct for additive interferences which cause a baseline shift.

9.7.2 MSA are not required by the method.

9.7.3 MSAs are not considered normal batch QC and if required by the client, must appear on the client requirement sheet or client summary report.

9.8 **Procedural Variations/ Nonconformance and Corrective Action**

9.8.1 Any variation shall be completely documented using a Nonconformance Memo and approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

9.8.2 Any deviations from QC procedures must be documented as a nonconformance, with applicable cause and corrective action approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Follow the instrument start-up procedure outlined in the Perkin Elmer Elan 6100 Operator's Manual or the Agilent 7500/ 7700 operator's manual.

10.2 Cone Conditioning

10.2.1 Aspirating a 25% tap water solution for at least 1 hour can enhance instrument performance. This procedure 75% ICPMS rinse solution should be used daily after a thorough cleaning of the interface cones or the installation of new cones takes place.

10.3 Rinse Time Determination

10.3.1 Prior to calibration and between each sample/standard the system is rinsed with the calibration blank solution. The minimum rinse time between analytical samples is 60 seconds unless following the protocol outlined in this SOP it can be demonstrated that a shorter rinse time may be used.

10.3.1.1 To determine the appropriate rinse time, a linear range verification standard should be aspirated as a regular sample followed by the analysis of a series of rinse blanks. The length of time required to reduce the analyte signals to < RL will define the rinse time for the system. For some analytes it may be impractical to set the rinse time based on the linear range standard result (i.e., analyte not typically detected in environmental samples at that level and an excessive rinse time would be required at the linear range level). The concentration levels used to establish the rinse time must be taken into consideration when reviewing the data.

10.4 All calibration procedures described in the subsequent subsections of section 10 applies to both detector systems.

10.5 Instrument Tuning (For no gas He and H2 mode)
- 10.5.1 Frequency:
  - 10.5.1.1 Daily with each initial calibration
- 10.5.2 Aspirate a 10 ppb tuning solution containing all of the tuning elements. The typical tuning elements for the Perkin Elmer are He, Mg, Rh. Ce, Pb and Ba. For the Agilent the elements are Li, Y, TL, Co, In, Ce, and Tl.
- 10.5.3 Tune Criteria:
  - 10.5.3.1 Mass calibration and resolution checks must be documented and included as part of the raw data package.
    - 10.5.3.1.1 Resolution must be < 0.9 amu at 10% peak height for method 6020A or produce a peak width of approximately 0.75 amu at a peak height of 5% for method 200.8
    - 10.5.3.1.2 Mass calibration must be within ± 0.1 amu from the actual value for the tuning elements of interest or the mass calibration must be adjusted.
    - 10.5.3.1.3 Using the Tuning Solution, an Auto-lens calibration is performed to ensure that optimum voltages are being applied to the Auto-lens. The default calibration should range from 4-10 volts (Perkin Elmer Only).
    - 10.5.3.1.4 The tuning elements must have RSDs below 5%. Mg must be at or above 30,000 counts. Pb must be at or above 100,000 counts. Rh must be at or above 150,000 (Perkin Elmer Only). counts and the oxides/polyatomic ions must be below 3.0%. The background must be less than or equal to 30 counts (Perkin Elmer Only).
      - 10.5.3.1.4.1 If any of these conditions are not met repairs or optimization procedures must be performed until these specifications are met.

10.6 **Initial Calibration**
- 10.6.1 Multi-point Calibration:
  - 10.6.1.1 A calibration curve, consisting of 3 standards and a blank, must be analyzed daily.
  - 10.6.1.2 Calibration criteria:
    - 10.6.1.2.1 Correlation Coefficient of ≥ 0.998
    - 10.6.1.2.2 The low level standard in the curve must be at or below the laboratory's routine reporting limit. See structure and analysis code (SAC) information appended to this SOP.
      - 10.6.1.2.2.1 If a client requested reporting limit is below the laboratory's routine reporting limit and thus below the low level verification standard, the laboratory will discuss with the client, prior to sample analysis, how to proceed with this requirement.

10.7 **Initial Calibration Verification/Initial Calibration Blank** (ICV/ICB)
- 10.7.1 The initial calibration accuracy is verified by analyzing a second source standard (ICV).
- 10.7.2 ICV Frequency:
  - 10.7.2.1 Perform with each initial calibration
- 10.7.3 ICV Criteria:
  - 10.7.3.1 **Method 200.8 and D6573-03**, the ICV result must fall within 10% of the true value for that solution.
  - 10.7.3.2 **Method 6020A**, the ICV must fall within 10% of the true value for that solution.
  - 10.7.3.3 The internal standard intensity must be 70-140% the IS intensity in the instrument standardization solution.
- 10.7.4 LLICV (Low Level Initial Calibration Verification)
  - 10.7.4.1 Same source as calibration.
  - 10.7.4.2 Perform with each initial calibration.
  - 10.7.4.3 +/- 30% criteria

10.7.4.4 Internal standard should be 70-140%.

10.7.5 ICB Frequency:

10.7.5.1 An ICB is analyzed immediately following the ICV to monitor low level accuracy and system cleanliness.

10.7.6 ICB Criteria:

10.7.6.1 The ICB result must fall within +/- the RL from zero.

10.7.6.2 The internal standard intensity must be 70-140% the IS intensity in the instrument standardization solution.

10.7.7 If either the ICV or ICB fail to meet criteria, the analysis should be terminated, the problem corrected, the instrument recalibrated and the calibration reverified.

10.7.7.1 Not meeting this requirement may be indicative of serious system malfunction or inaccuracies in the standards used for the initial calibration curve or ICV standard. Corrective action must be taken (including reanalysis of the ICV, or analysis of a different ICV). Any decision to proceed with analysis of samples when the ICV is out-of-control must be taken with great care and in consultation with the QA department and the laboratory director. Any such action must be documented in an NCM.

10.8 **Continuing Calibration Verification/Continuing Calibration Blank (CCV/CCB)**

10.8.1 Calibration is monitored throughout the analytical run through the analysis of a known standard.

10.8.2 A CCV may be a second source or the same source as the calibration

10.8.3 CCV Frequency:

10.8.3.1 Analyte response factors must be verified at the beginning of each analytical run (by either an ICV or a CCV), after every 10 samples and at the end of the analysis run through the analysis of a mid-level calibration standard.

10.8.4 CCV Criteria:

10.8.4.1 For **200.8**: The CCV must fall within 15% of the true value for that solution.

10.8.4.2 For **6020A and D5673-03**: The CCV must fall within 10% of the true value for that solution.

10.8.4.2.1 If a CCV has failed and the analyst can document the reason for failure (e.g mis-injection, etc.) then a second CCV may be analyzed without any adjustments to the instrument. If this CCV meets criteria then sample analysis may continue; however the preceding 10 samples must be reanalyzed. If this second CCV does not meet criteria, the analysis run is terminated. Instrument maintenance is performed and the instrument may require re-calibration (ie initial calibration).

10.8.4.3 The internal standard intensity must be within 70-140% of the IS intensity in the instrument standardization solution.

10.8.4.3.1 If not, the analyst will review the data. If the sample internal standard recoveries are within control and the CCV is within 10% of its true value and the CCB is <RL, it is apparent that whatever interference affected the internal standard for the QC standards has not affected the element bracketed by that internal standard based upon the criteria being met. If these specific occurrences are met then an NCM will be generating stating why the data is acceptable.

10.8.5 CCB Frequency:

10.8.5.1 A CCB is analyzed immediately following each CCV.

10.8.6 CCB Criteria:

10.8.6.1 The CCB result must fall within +/- RL from zero.

10.8.6.2 The internal standard intensity must be 70-140% of the IS intensity in the instrument standardization solution.

10.8.6.2.1 If not, the analyst will review the data. If the sample internal standard recoveries are within control and the CCV is within 10% of its true value and the CCB is <RL, it is apparent that whatever interference affected the internal standard for the QC standards has

not affected the element bracketed by that internal standard based upon the criteria being met. If these specific occurrences are met then an NCM will be generating stating why the data is acceptable.

10.9 **Interference Check Standard** (ICSA/ICSAB)

10.9.1 Interference check standards are applicable to 6020A only.

10.9.2 The validity of the interelement correction factors is demonstrated through the successful analysis of interference check solutions.

10.9.3 **ICSA**:

10.9.3.1 The ICSA contains only interfering elements. Refer to Table II for the details of ICSA composition.

10.9.3.2 Custom multielement ICS solutions must be used.

10.9.3.3 Elements known to be interferents on a required analyte must be included in the ICPMS run when that analyte is determined. Aluminum, iron, calcium and magnesium must always be included in all ICPMS runs.

10.9.4 **ICSB**:

10.9.4.1 The ICSAB contains analytes and interferents.

10.9.4.2 Refer to Table II for the details of ICSAB composition.

10.9.4.3 Custom multielement ICS solutions must be used.

10.9.5 ICSA/ICSAB Frequency:

10.9.5.1 For **6020A**: The ICSA and ICSAB must run with each initial calibration or every 12 hours whichever is shorter.

10.9.6 ICSA/ICSAB Criteria:

10.9.6.1 The ICSAB results for interferents must fall within 80% – 120% of the true value.

10.9.6.2 ICSA results for the non-interfering elements with RLs < 10 µg/L must fall within ± 2x RL from zero. ICSA results for the non-interfering elements with RLs > 10 µg/L must fall within ± 1xRL from zero.

10.10 Liner Dynamic Range

10.10.1 Prior to running the instrument, the upper limit of quantition must be established for each analyte.

10.10.2 This upper limit is tested by running a standard containing high concentrations of the analytes against a calibration curve.

10.10.3 The LDR standard must recover within ten percent of its true value.

10.10.4 The concentration of the LDR standard is higher than the high calibration standard.

10.10.5 LDR study is performed daily.

10.11 Calibration Sequence

Tuning Standard
Initial Calibration (3 standards plus a blank)
ICV
ICB
LLC
ICSA*
ICSAB*
CCV
CCB
LDR (Client Specific)
CCV
CCB
10 samples (analysis runs)
CCV
CCB
10 samples (repeat every 10 analysis runs)

CCV
CCB
End

* If sequence time is longer than 12 hours, the ICSA and ICSAB standard must be re-analyzed.

11.0 PROCEDURE

11.1 The aqueous sample digestion procedure is found in SOP: ST-IP-0013, Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy, and ICP/MS (Method 3010A, EPA 200.7 and EPA 200.8)
11.1.4 For 200.8 analyses, dissolved samples must be digested.

11.2 The soil sample digestion procedure is found in SOP: ST-IP-0002, Acid Digestion of Soils, SW846 Method 3050B for ICP, and ICP/MS.

11.3 Instrument conditions, including rinse times, must be the same for all standards and samples.

11.4 Internal standards are introduced to the standards and sample digestates by the instrument.

11.5 Load autosampler with standards and digestates in accordance with the sequence given in section 10.

11.6 Analyze samples.

11.7 When analysis is completed, return unused digestate to proper storage area.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 Commonly used calculations (e.g. % recovery and RPD) and standard instrument software calculations are given in the TestAmerica St. Louis QAM.

12.2 All measurements must fall within the defined linear range where spectral interference correction factors are valid.
12.2.1 Dilute and reanalyze all samples for required analytes that exceed the linear range.
12.2.2 Acid strength must be maintained in the dilution of samples.

12.3 The mass ions used for determination of the element of interest is given in Table 1 of this SOP

12.4 Internal Standard recovery
12.4.1 Internal Standard Criteria:
12.4.1.1 For **6020A**: Recovery 70%-140% of the intensity of that internal standard in the initial calibration standard for all samples and QC standards.
12.4.1.2 For **200.8 and D5673-03**: Recovery 60-125% of the response in the calibration blank for all samples and QC standards.
12.4.2 If this criteria is not met, the sample should be diluted and re-analyzed until the IS recoveries are within specified limits.

12.5 Tracer Calculations
12.5.1 Tracer Recovery: The measured concentration and the actual concentration for the tracer is entered into spreadsheet SL-INORG-0128. This spreadsheet uses the following formula:

$$\frac{\text{Measured Tracer Concentration}}{\text{Actual Tracer Concentration}} = \text{Final Recovery}$$

12.5.1.1 Tracer Criteria: The tracer recovery must fall within 40-110%.

12.5.2 Final concentration (corrected for tracer): the Technetium-99 measured concentration and the tracer recovery is entered into spreadsheet SL-INORG-0128. This spreadsheet uses the following formula:

$$\frac{\text{Measured Sample Concentration}}{\text{Tracer Recovery}} = \text{Final SampleConcentration}$$

13.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA; CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

13.1 The data assessment and corrective action process is detailed through the Clouseau Nonconformance Memorandum (NCM) process. The NCM process is described in SOP: ST-QA-0036. Below is a subset of the data assessment and QC excursion types within Clouseau; the text in underline is the exact "type" line in Clouseau. For a complete and current listing, please access the software program.

13.2 Method Blank

13.2.1 Acceptance Criteria:

13.2.1.1 No target analytes may be present in the method blank above the reporting limit.

13.2.1.2 Project specific requirements if more stringent than our routine procedure (e.g. no target analytes present above ½ RL), will be noted on the client requirements sheet.

13.2.2 Corrective Action for Method Blanks not meeting acceptance criteria:

13.2.2.1 Method Blank Contamination – See Clouseau NCM for corrective action (e.g. re-prep/reanalysis, narration). Note certain analytes are common laboratory contaminants which require special narrative comment. These compounds are so designated in Clouseau.

13.3 Laboratory Control Sample (LCS)

13.3.1 Acceptance Criteria:

13.3.1.1 All control analytes should be within established control limits for accuracy (%Recovery) and precision (RPD).
Corrective Action for LCS not meeting acceptance criteria:

13.3.1.2 LCS Spike Recovery excursion (high) – See Clouseau NCM for corrective action (e.g. , reanalysis, narration).

13.3.1.3 LCS Spike Recovery excursion (low) – See Clouseau NCM for corrective action (e.g. , reanalysis, narration).

13.3.1.4 RPD Duplicate excursion – See Clouseau NCM for corrective action (e.g. , reanalysis, narration).

13.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

13.4.1 Analytes should be within control limits for accuracy (%Recovery) and precision (RPD).

13.4.2 Corrective Action for MS/MSD not meeting acceptance criteria:

13.4.2.1 MS/MSD Spike Rec. excursion may not necessarily warrant corrective action other than narration. See Clouseau NCM to determine if re-preparation re-analysis is required.

13.5 Sample result evaluation

13.5.1 Dilutions

13.5.1.1 If the response for any compound exceeds the calibration range of the analytical system, a dilution of the extract is prepared and analyzed. An appropriate dilution should be in the upper half of the calibration range.

13.5.1.2 Dilution: Sample– See Clouseau NCM for corrective action.

13.5.2 Insufficient Sample

13.5.2.1 For any prescribed re-preparation corrective action, if there is insufficient sample to repeat the analysis and narrative comment stating such is included in

the report narrative. The insufficient sample description is included in the the Clouseau NCM within the type defining the excursion.

14.0 METHOD PERFORMANCE

14.1 Method performance data, Reporting Limits, and QC acceptance limits, are given in the appendix of this SOP.

14.2 Demonstration of Capability
14.2.1 Initial and continuing demonstrations of capability requirements are established in the QAM.

14.3 Training Qualification
14.3.1 The manager/supervisor has the responsibility to ensure that this procedure is performed by an analyst who has been properly trained in its use and has the required experience.
14.3.2 The analyst must have successfully completed the initial demonstration capability requirements prior to working independently. See requirements in the QAM.

14.4 Annually, the analyst must successfully demonstrate proficiency to continue to perform this analysis. See requirements in the QAM.

15.0 VALIDATION

15.1 Laboratory SOPs are based on standard reference EPA Methods that have been validated by the EPA and the lab is not required to perform validation for these methods. The requirements for lab demonstration of capability are included in LQM. Lab validation data would be appropriate for performance based measurement systems or non-standard methods. TestAmerica St. Louis will include this information in the SOP when accreditation is sought for a performance based measurement system or non-standard method.

16.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

16.1 All waste will be disposed of in accordance with Federal, State and Local regulations. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in section 13 of the Corporate Safety Manual for "Waste Management and Pollution Prevention."

16.2 Waste Streams Produced by the Method
16.2.1 The following waste streams are produced when this method is carried out.
16.2.1.1 Acidic sample waste generated. All acidic waste will be accumulated in the appropriate waste accumulation container, labeled as Drum Type "A" or "B."
16.2.1.2 Contaminated disposable glass or plastic materials utilized in the analysis are disposed of in the sanitary trash. If the lab ware was used for the analysis of radioactive samples and contains radioactivity at a level of 100 cpm over background as determined by a GM meter, the lab ware will be collected in waste barrels designated for solid rad waste for disposal by the EH&S Coordinator.

17.0 REFERENCES

17.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Method 6020A

17.2 Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma/Mass Spectrometry Method 200.8

17.3 ASTM Method D 5673-03, "Standard Test Method for Elements in Water by Inductively Coupled

Plasma-Mass Spectrometry", 2003

17.4 Perkin Elmer ELAN 6000 Inductively Coupled Plasma Mass Spectrometer Hardware Guide

17.5 TestAmerica Quality Assurance Manual (QAM), current revision

17.6 TestAmerica Corporate Environmental Health and Safety Manual (CW-E-M-001) and St. Louis Facility Addendum (SOP ST-HS-0002), current revisions.

17.7 Associated SOPs, current revisions

- 17.7.1 ST-IP-0002, Acid Digestion of Soils, SW846 Method 3050B for ICP, and ICP/MS
- 17.7.2 ST-IP-0013, Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy, and ICP/MS (Method 3010A, EPA 200.7 and EPA 200.8)
- 17.7.3 ST-QA-0002, Standard and Reagent Preparation
- 17.7.4 ST-PM-0002, Sample Receipt and Chain of Custody
- 17.7.5 ST-QA-0014, Evaluation of Analytical Accuracy and Precision Through the Use of Control Charts
- 17.7.6 ST-QA-0016, IDL/MDL Determination
- 17.7.7 ST-QA-0036, Non-conformance Memorandum (NCM) Process

18.0 CLARIFICATIONS, MODIFICATIONS TO THE REFERENCE METHOD

18.1 The post spike is not performed per batch. Internal standards are used to monitor matrix interferences in all samples. Post spikes are done per specific QAPP or program requirements. Post-spikes using analytes other than the internal standards may be used if an analyst encounters a new or unusual matrix.

18.2 Method 6020A requires a single point plus a blank for initial calibration. Rather than assume linearity across the instrument range, TestAmerica St. Louis uses a multi-point calibration (3 standards plus a blank) to establish linearity.

18.3 (Lower limit of quantitation check) The LLQC sample is analyzed annually with the MDL study.

18.4 Method 6020 requires the analysis of a Lower Limit Quantitation Check Sample (LLQC) to establish and confirm the lowest quantitation limit. TestAmerica St. Louis fills this requirement with the running of a MDL verification standard which is taken through the entire sample preparation procedure. The method suggested recovery criteria of ± 30% is not applied.

18.5 Method 6020 suggests the analysis of a Low Level Continuing Calibration Verification (LLCCV) standard. This standard should be at the laboratory limit of quantitation and be run periodically throughout an analytical sequence. TestAmerica St. Louis runs this standard only at the beginning of each analytical run.

19.0 CHANGES TO PREVIOUS REVISION

19.1 Updated formatting and spelling errors throughout SOP.
19.2 Updated section 4.4 referring to the amount of an internal standard being used.
19.3 Added new instrument and gases used in section 6.0.
19.4 Added Lithium to section 7.0 as part of the new reagents and standards used.
19.5 Made reference to new instruments for calibration in section 10.0.
19.6 Add new list of tuning element for both instruments in section 10.5.
19.7 Updated the internal standard intensity throughout section 10.7 and section 10.8

19.8 Added new elements to table 2.
19.9 Rev. 18;
- 19.9.1 Added LLICV to definitions in section 3.2.
- 19.9.2 Removed Hydrogen Peroxide from Safety Section (included in prep SOP's.)
- 19.9.3 Added tuning solution to section 7.5.5.
- 19.9.4 Updated cone conditioning solution, make up and frequency of use.
- 19.9.5 Added clarification to tuning section 10.5.
- 19.9.6 Added Low Level initial calibration verification standards plus criteria to section 10.0.
- 19.9.7 Updated tables 1 and 2, added analytes, updated concentrations.
- 19.9.8 Added method 1311 MSA requirements information to section 18.0.
- 19.9.9 Spelling and grammatical corrections.

19.10 Rev. 19:
- 19.10.1 Updated Table III regarding QC Criteria limits.

19.11 Revision 20:
- 19.11.1 Updated section 1.3 adding reference to the Technetium-99 soil procedure.
- 19.11.2 Added formulas for determining the Tracer Recovery and the Final tracer Corrected Concentration to section 12.5.
- 19.11.3 Added instrument software and hardware to section 6.0.
- 19.11.4 Updated the PDS acceptance criteria in section 9.6.

Table 1
ANALYTICAL ISOTOPES

ELEMENT	Tune Step	7500	Tune Step	7700	6100
Li	3	7	3	7	7
Be	3	9	3	9	9
B	3	11	3	11	10
Na	2	23	2	23	23
Mg	2	24	2	24	24
Al	2	27	2	27	27
Si	3	28	1	28	28
P	2	31	3	31	31
S	3	34	3	34	34
K	2	39	2	39	39
Ca	3	44	1	44	44
Ti	3	47	3	47	47
V	2	51	2	51	51
Cr	2	52	2	52	52
Mn	2	55	2	55	55
Fe	2	57	2	57	57
Co	2	59	2	59	59
Ni	2	60	2	60	60
Cu	2	63	2	63	65
Zn	2	66	2	66	66
As	2	75	2	75	75
Se	2	78	2	78	82
Sr	3	88	3	88	86
Y	2	89	2	89	89
Zr	2	90	2	90	90
Nb	2	93	2	93	93
Mo	3	95	3	95	97
Ru	2	101	2	101	102
Rh	2	103	2	103	103
Pd	2	105	2	105	105
Ag	3	107	3	107	107
Cd	3	111	3	111	111
Sn	3	118	3	118	118
Sb	3	121	3	121	123
Te	2	125	2	125	130
Cs	2	133	2	133	133
Ba	3	137	3	137	135
La	2	139	2	139	N/A
Ce	2	140	2	140	140
Pr	2	141	2	141	N/A
Nd	2	146	2	146	N/A
Sm	3	147	3	147	147
Hf	2	178	2	178	180
Ta	2	181	2	181	181
W	2	182	2	182	182
Pt	2	195	2	195	194
Tl	3	205	3	205	205
Pb	3	208	3	208	208
Bi	2	209	2	209	209

Th	3	232	3	232	232
Tc					99
U	3	236	3	236	236
U	3	235	3	235	235
U	3	234	3	234	234
U	3	233	3	233	233
U	3	238	3	238	238

Tune Step 1; Hydrogen gas
Tune Step 2: Heluim
Tune Step 3: No Gas (argon only)

COMMON MOLECULAR ION INTERFERENCES IN ICP-MS

BACKGROUND MOLECULAR IONS

Molecular Ion	Mass	Element Interferences*
NH^+	15	
OH^+	17	
OH_2^+	18	
C_2^+	24	
CN^+	26	
CO^+	28	
N_2^+	28	
N_2H^+	29	
NO^+	30	
NOH^+	31	
O_2^+	32	
O_2H_+	33	
$^{36}ArH^+$	37	
$^{38}ArH^+$	39	
$^{40}ArH^+$	41	
CO_2^+	44	
CO_2H^+	45	Sc
ArC^+, ArO^+	52	Cr
ArN^+	54	Cr
$ArNH^+$	55	Mn
ArO^+	56	
$ArOH^+$	57	
$^{40}Ar^{36}Ar^+$	76	Se
$^{40}Ar^{38}Ar^+$	78	Se
$^{40}Ar_2^+$	80	Se

* Method elements or internal standards affected by the molecular ions.

MATRIX MOLECULAR IONS * No gas Mode Only

CHLORIDE

Molecular Ion	Mass	Element Interference
$^{35}Cl0^+$	51	V
$^{35}Cl0H^+$	52	Cr
$^{37}Cl0^+$	53	Cr
$^{37}Cl0H^+$	54	Cr
$Ar^{35}Cl^+$	75	As
$Ar^{37}Cl^+$	77	Se

SULFATE

Molecular Ion	Mass	Element Interference
$^{32}SO^+$	48	
$^{32}SOH^+$	49	
$^{34}SO^+$	50	V, Cr
$^{34}SOH^+$	51	V
SO_2^+, S_2^+	64	Zn
$Ar^{32}S^+$	72	
$Ar^{34}S^+$	74	

PHOSPHATE

Molecular Ion	Mass	Element Interference
PO^+	47	
POH^+	48	
PO_2^+	63	Cu
ArP^+	71	

GROUP I, II METALS

Molecular Ion	Mass	Element Interference
$ArNa^+$	63	Cu
ArK^+	79	
$ArCa^+$	80	

MATRIX OXIDES*

Molecular Ion	Mass	Element Interference
TiO	62-66	Ni, Cu, Zn
ZrO	106-112	Ag, Cd
MoO	108-116	Cd

* Oxide interferences will normally be very small and will only impact the method elements when present at relatively high concentrations. Some examples of matrix oxides are listed of which the analyst should be aware. It is recommended that Ti and Zr isotopes are monitored in solid waste samples, which are likely to contain high levels of these elements. Mo is monitored as a method analyte.

Table II Interference Check Sample Concentrations

Element	ICSA (ug/L)	ICSAB (ug/L)
Aluminum	50,000	50,000
Antimony	-	50
Arsenic	-	100
Barium	-	100
Beryllium	-	100
Bismuth	-	100
Boron	-	200
Cadmium	-	100
Calcium	50,000	50,000
Carbon	100,000	100,000
Chromium	-	100
Chlorine	500,000	500,000
Cobalt	-	100
Copper	-	100
Iron	50,000	50,000
Lead	-	100
Lithium	-	100
Magnesium	50,000	50,000
Manganese	-	100
Molybdenum	1,000	1,000
Nickel	-	100
Niobium	-	100
Palladium	-	25
Platinum	-	25
Phosphorus	50,000	50,000
Potassium	50,000	50,000
Samarium	-	100
Selenium	-	100
Silicon	-	500
Silver	-	20
Sodium	50,000	50,000
Strontium	-	100
Sulfur	50,000	50,000
Thallium	-	100
Thorium	-	100
Tin	-	100
Titanium	1,000	1,000
Tungsten	-	100
Uranium	-	100
Vanadium	-	100
Zinc	-	100
Zirconium	-	100
Hafnium	-	100
Cesium	-	100
Yttrium	-	100
Tantalum	-	100
Tellurium	-	100
Rhodium	-	100
Ruthenium	-	100
Cerium	-	100

Lanthanum	-	100
Praseodymium	-	100
Neodymium	-	100
Technetium	-	0.233
U233	-	0.958
U234	-	1.786
U235	-	3.761
U236	-	0.162
U238	-	0.436

* Clients may request higher concentrations (LANL, Pantex), See client requirements memo.

Table III, QC Criteria

Methods	**6020A**	**200.8**
Corr Coeff.	>0.998	
Tuning Res	<0.9amu	≈ 0.75amu
Int Std	>70%	60-125%
LCS	80-120%	85-115%
ICV	90-110%	90-110%
CCV	90-110%	85-115%
PDS	80-120%	N/A
MS	75-125%	70-130%
LLICV	70-130%	N/A

TAL Reference Data Summary

Structured Analysis Code: I-JX-QV-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, FILTERED 2% HCL, DISSOLVED
Method: ICP-Mass Spectrometry (200.8)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6226							Spike List 6227						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	4.47	ug/L	20100108	C	Y	10000	ug/L	85	115	20	C	Y	10000	ug/L	70	130	20
128	Antimony	5	ug/L	1.67	ug/L	20110110	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
140	Arsenic	10	ug/L	0.946	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
194	Barium	2	ug/L	0.196	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
222	Beryllium	0.5	ug/L	0.114	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
313	Boron	50	ug/L	10.0	ug/L	20110110	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
411	Cadmium	0.5	ug/L	0.055	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
413	Calcium	100	ug/L	48.7	ug/L	20100108	C	Y	10000	ug/L	85	115	20	C	Y	10000	ug/L	70	130	20
5935	Cesium 133	0.5	ug/L	0.00282	ug/L	20051128														
2952	Chromium	10	ug/L	3.26	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
637	Cobalt	2	ug/L	0.217	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
643	Copper	1	ug/L	0.097	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
1539	Iron	50	ug/L	20.35	ug/L	20100108	C	Y	10000	ug/L	85	115	20	C	Y	10000	ug/L	70	130	20
1605	Lead	3	ug/L	0.173	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
1616	Lithium	5	ug/L	0.674	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
1618	Magnesium	50	ug/L	5.20	ug/L	20110110	C	Y	10000	ug/L	85	115	20	C	Y	10000	ug/L	70	130	20
1659	Manganese	2	ug/L	0.234	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
1906	Molybdenum	5	ug/L	0.216	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
1956	Nickel	5	ug/L	0.231	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
3924	Niobium	25	ug/L	2.23	ug/L	20100115														
3925	Palladium	0.5	ug/L	0.054	ug/L	20100115														
2200	Phosphorus	20.0	ug/L	8.23	ug/L	20100108								C	Y	1000	ug/L	70	130	20
2209	Platinum	1	ug/L	0.060	ug/L	20100108														
2214	Potassium	100	ug/L	8.33	ug/L	20100108	C	Y	10000	ug/L	85	115	20	C	Y	10000	ug/L	70	130	20
3927	Rhenium	1	ug/L	0.578	ug/L	20060328														
5936	Ruthenium 101	0.5	ug/L	0.00155	ug/L	20051128														
2281	Selenium	5	ug/L	0.308	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
2283	Silicon	250	ug/L	17.8	ug/L	20090119	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
2285	Silver	2	ug/L	0.04	ug/L	20100108	C	Y	100	ug/L	85	115	20	C	Y	100	ug/L	70	130	20
2315	Sodium	50	ug/L	5.30	ug/L	20100108	C	Y	10000	ug/L	85	115	20	C	Y	10000	ug/L	70	130	20
2353	Strontium	5	ug/L	0.114	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
4113	Technetium 99	0.5	ug/L	0.00050	ug/L	20051118														
2477	Thallium	2	ug/L	0.55	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
3935	Thorium	2	ug/L	0.552	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
2479	Tin	2	ug/L	0.150	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
2482	Titanium	2	ug/L	0.573	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
2602	Tungsten	5	ug/L	0.839	ug/L	20100108								C	Y	1000	ug/L	70	130	20

Structured Analysis Code: I-JX-QV-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, FILTERED 2% HCL, DISSOLVED
Method: ICP-Mass Spectrometry (200.8)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6226							Spike List 6227						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
3827	Uranium	1	ug/L	0.14	ug/L	20110110	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20071227														
4129	Uranium 234	0.05	ug/L	0.00004(	ug/L	20071227														
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20071227														
5385	Uranium 236	0.05	ug/L	0.00012:	ug/L	20071227														
4133	Uranium 238	0.05	ug/L	0.0016	ug/L	20071227														
2607	Vanadium	10	ug/L	2.37	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
2649	Zinc	10	ug/L	3.74	ug/L	20100112	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20
2651	Zirconium	5	ug/L	0.248	ug/L	20100108	C	Y	1000	ug/L	85	115	20	C	Y	1000	ug/L	70	130	20

TAL Reference Data Summary

Structured Analysis Code: I-GJ-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, TOTAL - 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	12.9	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
128	Antimony	5	ug/L	1.67	ug/L	20110124	C	Y	500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
140	Arsenic	10	ug/L	0.946	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
194	Barium	2	ug/L	0.203	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
222	Beryllium	0.5	ug/L	0.350	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
307	Bismuth	20.0	ug/L	0.732	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
313	Boron	50	ug/L	10.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
411	Cadmium	0.5	ug/L	0.10	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
413	Calcium	100	ug/L	68.1	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3489	Cerium	10	ug/L	0.886	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3488	Cesium	0.10	ug/L	0.053	ug/L	20110124	C	Y	500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
2952	Chromium	10	ug/L	3.26	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
637	Cobalt	2	ug/L	0.217	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
643	Copper	1	ug/L	0.451	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3917	Hafnium	10	ug/L	1.13	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1539	Iron	50	ug/L	20.35	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3922	Lanthanum	2	ug/L	0.051	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1605	Lead	3	ug/L	0.173	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1616	Lithium	5	ug/L	0.694	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1618	Magnesium	50	ug/L	5.20	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
1659	Manganese	2	ug/L	0.245	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1906	Molybdenum	5	ug/L	1.00	ug/L	20110624	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3490	Neodymium	2	ug/L	0.104	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1956	Nickel	5	ug/L	0.40	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3924	Niobium	25	ug/L	2.23	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	250	ug/L	75	125	20
3925	Palladium	1	ug/L	0.059	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20
2200	Phosphorus	50	ug/L	8.53	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2209	Platinum	1	ug/L	0.079	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20
2214	Potassium	100	ug/L	41.6	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3926	Praseodymium	2	ug/L	0.042	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3927	Rhenium	1	ug/L	0.025	ug/L	20110906	C	Y	100	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
3928	Rhodium	10	ug/L	0.817	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3930	Ruthenium	10	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3931	Samarium	10	ug/L	0.326	ug/L	20110124														
2281	Selenium	5	ug/L	1.59	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2283	Silicon	250	ug/L	17.8	ug/L	20110124	C	Y	5000	ug/L	80	120	20	C	Y	5000	ug/L	75	125	20
2285	Silver	2	ug/L	0.04	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20

Structured Analysis Code: I-GJ-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, TOTAL - 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
2315	Sodium	50	ug/L	15.0	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
2353	Strontium	5	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2876	Sulfur	5000	ug/L	333	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3742	Tellurium	10.0	ug/L	0.536	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2477	Thallium	2	ug/L	0.55	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3935	Thorium	2	ug/L	0.552	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2479	Tin	2	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2482	Titanium	5	ug/L	2.1	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2602	Tungsten	5	ug/L	2.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3827	Uranium	1	ug/L	0.231	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20110124	C	Y	0.386	ug/L	80	120	20	C	Y	0.386	ug/L	75	125	20
4129	Uranium 234	0.05	ug/L	0.0021	ug/L	20110124	C	Y	0.175	ug/L	80	120	20	C	Y	0.175	ug/L	75	125	20
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20110124	C	Y	0.228	ug/L	80	120	20	C	Y	0.228	ug/L	75	125	20
5385	Uranium 236	0.05	ug/L	0.0015	ug/L	20110124	C	Y	1.75	ug/L	80	120	20	C	Y	1.75	ug/L	75	125	20
4133	Uranium 238	1.0	ug/L	0.0082	ug/L	20110124	C	Y	33.6	ug/L	80	120	20	C	Y	33.6	ug/L	75	125	20
2607	Vanadium	10	ug/L	2.37	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2726	Yttrium	5	ug/L	0.212	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2649	Zinc	10	ug/L	8.29	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2651	Zirconium	5	ug/L	0.248	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20

TAL Reference Data Summary

Structured Analysis Code: I-JX-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, FILTERED 2% HCL, DISSOLVED
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	12.9	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
128	Antimony	5	ug/L	1.67	ug/L	20110124	C	Y	500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
140	Arsenic	10	ug/L	0.946	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
194	Barium	2	ug/L	0.203	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
222	Beryllium	0.5	ug/L	0.350	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
313	Boron	50	ug/L	10.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
411	Cadmium	0.5	ug/L	0.10	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
413	Calcium	100	ug/L	68.1	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3489	Cerium	10	ug/L	0.886	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3488	Cesium	0.10	ug/L	0.053	ug/L	20110124	C	Y	500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
5935	Cesium 133	0.5	ug/L	0.00282	ug/L	20051128	C	Y	500	ug/L	80	120	20	C	Y	10.00	ug/L	75	125	20
2952	Chromium	10	ug/L	3.26	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
637	Cobalt	2	ug/L	0.217	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
643	Copper	1	ug/L	0.451	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1539	Iron	50	ug/L	20.35	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
1605	Lead	3	ug/L	0.173	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1616	Lithium	5	ug/L	0.694	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1618	Magnesium	50	ug/L	5.20	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
1659	Manganese	2	ug/L	0.245	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1906	Molybdenum	5	ug/L	1.00	ug/L	20110624	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1956	Nickel	5	ug/L	0.40	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3924	Niobium	25	ug/L	2.23	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	250	ug/L	75	125	20
3925	Palladium	0.5	ug/L	0.059	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20
2200	Phosphorus	50	ug/L	8.53	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2209	Platinum	1	ug/L	0.079	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20
2214	Potassium	100	ug/L	41.6	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
2281	Selenium	5	ug/L	1.59	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2283	Silicon	250	ug/L	17.8	ug/L	20110124	C	Y	5000	ug/L	80	120	20	C	Y	5000	ug/L	75	125	20
2285	Silver	2	ug/L	0.04	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20
2315	Sodium	50	ug/L	15.0	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
2353	Strontium	5	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
4113	Technetium 99	0.5	ug/L	0.00050	ug/L	20051118														
2477	Thallium	2	ug/L	0.55	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3935	Thorium	2	ug/L	0.552	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2479	Tin	2	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2482	Titanium	5	ug/L	2.1	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2602	Tungsten	5	ug/L	2.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20

Structured Analysis Code: I-JX-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, FILTERED 2% HCL, DISSOLVED
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
3827	Uranium	1	ug/L	0.231	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20110124	C	Y	0.386	ug/L	80	120	20	C	Y	0.386	ug/L	75	125	20
4129	Uranium 234	0.05	ug/L	0.0021	ug/L	20110124	C	Y	0.175	ug/L	80	120	20	C	Y	0.175	ug/L	75	125	20
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20110124	C	Y	0.228	ug/L	80	120	20	C	Y	0.228	ug/L	75	125	20
5385	Uranium 236	0.05	ug/L	0.0015	ug/L	20110124	C	Y	1.75	ug/L	80	120	20	C	Y	1.75	ug/L	75	125	20
4133	Uranium 238	0.05	ug/L	0.0082	ug/L	20110124	C	Y	33.6	ug/L	80	120	20	C	Y	33.6	ug/L	75	125	20
2607	Vanadium	10	ug/L	2.37	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2649	Zinc	10	ug/L	8.29	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2651	Zirconium	5	ug/L	0.248	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20

TAL Reference Data Summary

Structured Analysis Code: I-JV-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: SPLP-E -> LOW LEVEL, 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6038							Spike List 6223							
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	4.47	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
128	Antimony	5	ug/L	1.12	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
140	Arsenic	10	ug/L	0.946	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
194	Barium	2	ug/L	0.196	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
222	Beryllium	0.5	ug/L	0.114	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	50	ug/L	75	125	20
313	Boron	50	ug/L	7.47	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
411	Cadmium	0.5	ug/L	0.055	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	50	ug/L	75	125	20
413	Calcium	100	ug/L	48.7	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
5935	Cesium 133	0.5	ug/L	0.00282	ug/L	20051128														
2952	Chromium	10	ug/L	3.26	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	200	ug/L	75	125	20
637	Cobalt	2	ug/L	0.217	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
643	Copper	1	ug/L	0.097	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	250	ug/L	75	125	20
1539	Iron	50	ug/L	20.35	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1605	Lead	3	ug/L	0.173	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
1618	Magnesium	50	ug/L	1.73	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
1659	Manganese	2	ug/L	0.234	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
1906	Molybdenum	5	ug/L	0.216	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1956	Nickel	5	ug/L	0.231	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
3924	Niobium	25	ug/L	2.23	ug/L	20100115														
3925	Palladium	0.5	ug/L	0.054	ug/L	20100115	C	Y	250	ug/L	80	120	20	C	Y	250	ug/L	75	125	20
2200	Phosphorus	50	ug/L	8.23	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
2209	Platinum	1	ug/L	0.060	ug/L	20100108														
2214	Potassium	100	ug/L	8.33	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
2281	Selenium	5	ug/L	0.308	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2283	Silicon	250	ug/L	17.8	ug/L	20090119	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2285	Silver	2	ug/L	0.04	ug/L	20100108	C	Y	250	ug/L	80	120	20	C	Y	50	ug/L	75	125	20
2315	Sodium	50	ug/L	5.30	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
2353	Strontium	5	ug/L	0.114	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
4113	Technetium 99	0.5	ug/L	0.00050	ug/L	20051118														
2477	Thallium	2	ug/L	0.55	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
3935	Thorium	2	ug/L	0.552	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2479	Tin	2	ug/L	0.150	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2482	Titanium	2	ug/L	0.573	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2602	Tungsten	5	ug/L	0.839	ug/L	20100108														
3827	Uranium	1	ug/L	0.08	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20071227														
4129	Uranium 234	0.05	ug/L	0.00004(	ug/L	20071227														

Structured Analysis Code: I-JV-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: SPLP-E -> LOW LEVEL, 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6038							Spike List 6223							
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20071227														
5385	Uranium 236	0.05	ug/L	0.00012	ug/L	20071227														
4133	Uranium 238	0.05	ug/L	0.0016	ug/L	20071227														
2607	Vanadium	10	ug/L	2.37	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
2649	Zinc	10	ug/L	3.74	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
2651	Zirconium	5	ug/L	0.248	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20

TAL Reference Data Summary

Structured Analysis Code: **A-GK-MH-01-06**

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: METALS, TOTAL - 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6428							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	5.0	mg/kg	1.67	mg/kg	20110125	C	Y	9780	mg/kg	44	155	20	C	Y	1000	mg/kg	75	125	30
128	Antimony	0.5	mg/kg	0.164	mg/kg	20110125	C	Y	121	mg/kg	21	251	20	C	Y	50	mg/kg	75	125	30
140	Arsenic	1.0	mg/kg	0.203	mg/kg	20110125	C	Y	109	mg/kg	70	131	20	C	Y	100	mg/kg	75	125	30
194	Barium	2.0	mg/kg	0.057	mg/kg	20110125	C	Y	325	mg/kg	74	125	20	C	Y	100	mg/kg	75	125	30
222	Beryllium	0.1	mg/kg	0.017	mg/kg	20110125	C	Y	92	mg/kg	74	126	20	C	Y	100	mg/kg	75	125	30
307	Bismuth	2.0	mg/kg	0.151	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
313	Boron	10	mg/kg	3.34	mg/kg	20110125	C	Y	142	mg/kg	63	136	20	C	Y	100	mg/kg	75	125	30
411	Cadmium	0.05	mg/kg	0.016	mg/kg	20110125	C	Y	110	mg/kg	73	139	20	C	Y	100	mg/kg	75	125	30
413	Calcium	50	mg/kg	5.82	mg/kg	20110125	C	Y	6700	mg/kg	74	125	20	C	Y	1000	mg/kg	75	125	30
3489	Cerium	1.0	mg/kg	0.035	mg/kg	20110125	C	Y	100	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
3488	Cesium	0.01	mg/kg	0.005	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	50	mg/kg	75	125	30
2952	Chromium	1.0	mg/kg	0.45	mg/kg	20110125	C	Y	93.4	mg/kg	69	130	20	C	Y	100	mg/kg	75	125	30
637	Cobalt	0.2	mg/kg	0.043	mg/kg	20110125	C	Y	133	mg/kg	74	125	20	C	Y	100	mg/kg	75	125	30
643	Copper	1.0	mg/kg	0.064	mg/kg	20110125	C	Y	74.7	mg/kg	73	126	20	C	Y	100	mg/kg	75	125	30
1464	Gold	0.50	mg/kg	0.05	mg/kg	20111019								C	Y	100	mg/kg	75	125	30
3917	Hafnium	1.0	mg/kg	0.302	mg/kg	20110125	C	Y	100	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
1539	Iron	5.0	mg/kg	3.30	mg/kg	20110125	C	Y	13100	mg/kg	32	167	20	C	Y	1000	mg/kg	75	125	30
3922	Lanthanum	0.2	mg/kg	0.05	mg/kg	20110125	C	Y	100	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
1605	Lead	0.30	mg/kg	0.10	mg/kg	20110125	C	Y	152	mg/kg	73	126	20	C	Y	100	mg/kg	75	125	30
1616	Lithium	1	mg/kg	0.30	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1618	Magnesium	50	mg/kg	3.80	mg/kg	20110125	C	Y	2980	mg/kg	66	134	20	C	Y	1000	mg/kg	75	125	30
1659	Manganese	0.5	mg/kg	0.077	mg/kg	20110125	C	Y	443	mg/kg	77	124	20	C	Y	100	mg/kg	75	125	30
1906	Molybdenum	0.5	mg/kg	0.077	mg/kg	20110125	C	Y	82.5	mg/kg	69	138	20	C	Y	100	mg/kg	75	125	30
3490	Neodymium	0.2	mg/kg	0.03	mg/kg	20110125	C	Y	100	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
1956	Nickel	0.5	mg/kg	0.0822	mg/kg	20110125	C	Y	109	mg/kg	72	126	20	C	Y	100	mg/kg	75	125	30
3924	Niobium	2.5	mg/kg	0.38	mg/kg	20110125	C	Y	25	mg/kg	80	120	20	C	Y	25	mg/kg	75	125	30
3925	Palladium	0.1	mg/kg	0.011	mg/kg	20110125	C	Y	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2200	Phosphorus	50	mg/kg	1.36	mg/kg	20110125	C	Y	500	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
2209	Platinum	0.1	mg/kg	0.013	mg/kg	20110125	C	Y	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2214	Potassium	10	mg/kg	3.00	mg/kg	20110125	C	Y	2770	mg/kg	61	138	20	C	Y	1000	mg/kg	75	125	30
3926	Praseodymium	0.2	mg/kg	0.023	mg/kg	20110125	C	Y	100	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
3927	Rhenium	1.0	mg/kg	0.022	mg/kg	20110906	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
3928	Rhodium	1.0	mg/kg	0.037	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
3930	Ruthenium	1.0	mg/kg	0.043	mg/kg	20110125	C	Y	50.0	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
3931	Samarium	1.0	mg/kg	0.0700	mg/kg	20110125														
2281	Selenium	0.5	mg/kg	0.158	mg/kg	20110125	C	Y	207	mg/kg	69	131	20	C	Y	100	mg/kg	75	125	30
2283	Silicon	25	mg/kg	7.12	mg/kg	20110125	C	Y	754	mg/kg	80	120	20	C	Y	500	mg/kg	75	125	30

Structured Analysis Code: A-GK-MH-01-06

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: METALS, TOTAL - 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6428							Spike List 6225							
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
2285	Silver	20	mg/kg	6.67	mg/kg	20110624	C	Y	52	mg/kg	66	133	20	C	Y	10.0	mg/kg	75	125	30
2315	Sodium	20	mg/kg	6.67	mg/kg	20110624	C	Y	724	mg/kg	56	144	20	C	Y	1000	mg/kg	75	125	30
2353	Strontium	0.5	mg/kg	0.212	mg/kg	20110125	C	Y	111	mg/kg	70	128	20	C	Y	100	mg/kg	75	125	30
2876	Sulfur	500	mg/kg	55.9	mg/kg	20110125	C	Y	1000	mg/kg	80	120	20	C	Y	1000	mg/kg	75	125	30
3933	Tantalum	1.0	mg/kg	0.156	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
3742	Tellurium	1.0	mg/kg	0.109	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
2477	Thallium	0.2	mg/kg	0.10	mg/kg	20110125	C	Y	171	mg/kg	68	131	20	C	Y	100	mg/kg	75	125	30
3935	Thorium	0.2	mg/kg	0.078	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
2479	Tin	0.2	mg/kg	0.10	mg/kg	20110125	C	Y	135	mg/kg	59	140	20	C	Y	100	mg/kg	75	125	30
2482	Titanium	0.5	mg/kg	0.25	mg/kg	20110125	C	Y	2340	mg/kg	29	171	20	C	Y	100	mg/kg	75	125	30
2602	Tungsten	0.5	mg/kg	0.25	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
3827	Uranium	0.10	mg/kg	0.0199	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
5927	Uranium 233	0.005	mg/kg	0.0015	mg/kg	20110125	C	Y	3.86	mg/kg	80	120	20	C	Y	3.86	mg/kg	75	125	30
4129	Uranium 234	0.005	mg/kg	0.00067	mg/kg	20110125	C	Y	1.75	mg/kg	80	120	20	C	Y	1.75	mg/kg	75	125	30
4131	Uranium 235	0.005	mg/kg	0.00203	mg/kg	20110125	C	Y	2.28	mg/kg	80	120	20	C	Y	2.28	mg/kg	75	125	30
5385	Uranium 236	0.005	mg/kg	0.00078	mg/kg	20110125	C	Y	17.5	mg/kg	80	120	20	C	Y	17.5	mg/kg	75	125	30
4133	Uranium 238	0.1	mg/kg	0.00055	mg/kg	20110125	C	Y	336	mg/kg	80	120	20	C	Y	336	mg/kg	75	125	30
2607	Vanadium	1.0	mg/kg	0.735	mg/kg	20110125	C	Y	110	mg/kg	67	132	20	C	Y	100	mg/kg	75	125	30
2726	Yttrium	1.0	mg/kg	0.034	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
2649	Zinc	5.0	mg/kg	1.33	mg/kg	20110125	C	Y	299	mg/kg	71	128	20	C	Y	100	mg/kg	75	125	30
2651	Zirconium	1.0	mg/kg	0.104	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30

TAL Reference Data Summary

Structured Analysis Code: **A-JV-MH-01-06**

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: SPLP-E -> LOW LEVEL, 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6038							Spike List 6223						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	4.47	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
128	Antimony	5	ug/L	1.12	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
140	Arsenic	10	ug/L	0.946	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
194	Barium	2	ug/L	0.196	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
222	Beryllium	0.5	ug/L	0.114	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	50	ug/L	75	125	20
313	Boron	50	ug/L	7.47	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
411	Cadmium	0.5	ug/L	0.055	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	50	ug/L	75	125	20
413	Calcium	100	ug/L	48.7	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
5935	Cesium 133	0.5	ug/L	0.00282	ug/L	20051128														
2952	Chromium	10	ug/L	3.26	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	200	ug/L	75	125	20
637	Cobalt	2	ug/L	0.217	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
643	Copper	1	ug/L	0.097	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	250	ug/L	75	125	20
1539	Iron	50	ug/L	20.35	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1605	Lead	3	ug/L	0.173	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
1616	Lithium	5	ug/L	0.674	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
1618	Magnesium	50	ug/L	1.73	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
1659	Manganese	2	ug/L	0.234	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
1906	Molybdenum	5	ug/L	0.216	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1956	Nickel	5	ug/L	0.231	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
3924	Niobium	25	ug/L	2.23	ug/L	20100115														
3925	Palladium	0.5	ug/L	0.054	ug/L	20100115	C	N	250	ug/L	80	120	200	C	Y	250	ug/L	75	125	20
2200	Phosphorus	50	ug/L	8.23	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
2209	Platinum	1	ug/L	0.060	ug/L	20100108														
2214	Potassium	100	ug/L	8.33	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
2281	Selenium	5	ug/L	0.308	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2283	Silicon	250	ug/L	17.8	ug/L	20090119	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2285	Silver	2	ug/L	0.04	ug/L	20100108	C	Y	250	ug/L	80	120	20	C	Y	50	ug/L	75	125	20
2315	Sodium	50	ug/L	5.30	ug/L	20100108	C	Y	25000	ug/L	80	120	20	C	Y	50000	ug/L	75	125	20
2353	Strontium	5	ug/L	0.114	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
4113	Technetium 99	0.5	ug/L	0.00050	ug/L	20051118														
2477	Thallium	2	ug/L	0.55	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
3935	Thorium	2	ug/L	0.552	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2479	Tin	2	ug/L	0.150	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2482	Titanium	2	ug/L	0.573	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20
2602	Tungsten	5	ug/L	0.839	ug/L	20100108	C	Y	2500	ug/L	80	120	20							
3827	Uranium	1	ug/L	0.08	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	N	2000	ug/L	75	125	20
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20071227														

Structured Analysis Code: A-JV-MH-01-06

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: SPLP-E -> LOW LEVEL, 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6038							Spike List 6223						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
4129	Uranium 234	0.05	ug/L	0.00004(	ug/L	20071227														
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20071227														
5385	Uranium 236	0.05	ug/L	0.00012:	ug/L	20071227														
4133	Uranium 238	0.05	ug/L	0.0016	ug/L	20071227														
2607	Vanadium	10	ug/L	2.37	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
2649	Zinc	10	ug/L	3.74	ug/L	20100112	C	Y	2500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
2651	Zirconium	5	ug/L	0.248	ug/L	20100108	C	Y	2500	ug/L	80	120	20	C	Y	2000	ug/L	75	125	20

TAL Reference Data Summary

Structured Analysis Code: **A-MV-MH-01-06**

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: Soil Scoop Preparation/TCLP lab; 2% HCl
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6428							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	5.0	mg/kg	1.67	mg/kg	20110125	C	Y	9780	mg/kg	44	155	20	C	Y	1000	mg/kg	75	125	30
128	Antimony	0.5	mg/kg	0.164	mg/kg	20110125	C	Y	121	mg/kg	21	251	20	C	Y	50	mg/kg	75	125	30
140	Arsenic	1.0	mg/kg	0.203	mg/kg	20110125	C	Y	109	mg/kg	70	131	20	C	Y	100	mg/kg	75	125	30
194	Barium	2.0	mg/kg	0.057	mg/kg	20110125	C	Y	325	mg/kg	74	125	20	C	Y	100	mg/kg	75	125	30
222	Beryllium	0.1	mg/kg	0.017	mg/kg	20110125	C	Y	92	mg/kg	74	126	20	C	Y	100	mg/kg	75	125	30
307	Bismuth	2.0	mg/kg	0.151	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
313	Boron	10	mg/kg	3.34	mg/kg	20110125	C	Y	142	mg/kg	63	136	20	C	Y	100	mg/kg	75	125	30
411	Cadmium	0.05	mg/kg	0.016	mg/kg	20110125	C	Y	110	mg/kg	73	139	20	C	Y	100	mg/kg	75	125	30
413	Calcium	50	mg/kg	5.82	mg/kg	20110125	C	Y	6700	mg/kg	74	125	20	C	Y	1000	mg/kg	75	125	30
3488	Cesium	0.01	mg/kg	0.005	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	50	mg/kg	75	125	30
2952	Chromium	1.0	mg/kg	0.45	mg/kg	20110125	C	Y	93.4	mg/kg	69	130	20	C	Y	100	mg/kg	75	125	30
637	Cobalt	0.2	mg/kg	0.043	mg/kg	20110125	C	Y	133	mg/kg	74	125	20	C	Y	100	mg/kg	75	125	30
643	Copper	1.0	mg/kg	0.064	mg/kg	20110125	C	Y	74.7	mg/kg	73	126	20	C	Y	100	mg/kg	75	125	30
3917	Hafnium	1.0	mg/kg	0.302	mg/kg	20110125	C	Y	100	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
1539	Iron	5.0	mg/kg	3.30	mg/kg	20110125	C	Y	13100	mg/kg	32	167	20	C	Y	1000	mg/kg	75	125	30
1605	Lead	0.30	mg/kg	0.10	mg/kg	20110125	C	Y	152	mg/kg	73	126	20	C	Y	100	mg/kg	75	125	30
1616	Lithium	1	mg/kg	0.30	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1618	Magnesium	50	mg/kg	3.80	mg/kg	20110125	C	Y	2980	mg/kg	66	134	20	C	Y	1000	mg/kg	75	125	30
1659	Manganese	0.5	mg/kg	0.074	mg/kg	20110125	C	Y	443	mg/kg	77	124	20	C	Y	100	mg/kg	75	125	30
1906	Molybdenum	0.5	mg/kg	0.077	mg/kg	20110125	C	Y	82.5	mg/kg	69	138	20	C	Y	100	mg/kg	75	125	30
1956	Nickel	0.5	mg/kg	0.0822	mg/kg	20110125	C	Y	109	mg/kg	72	126	20	C	Y	100	mg/kg	75	125	30
3924	Niobium	2.5	mg/kg	0.38	mg/kg	20110125	C	Y	25	mg/kg	80	120	20	C	Y	25	mg/kg	75	125	30
3925	Palladium	0.1	mg/kg	0.011	mg/kg	20110125	C	Y	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2200	Phosphorus	50	mg/kg	1.36	mg/kg	20110125	C	Y	500	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
2209	Platinum	0.1	mg/kg	0.013	mg/kg	20110125	C	Y	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2214	Potassium	10	mg/kg	3.00	mg/kg	20110125	C	Y	2770	mg/kg	61	138	20	C	Y	1000	mg/kg	75	125	30
3928	Rhodium	1.0	mg/kg	0.037	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
2281	Selenium	0.5	mg/kg	0.158	mg/kg	20110125	C	Y	207	mg/kg	69	131	20	C	Y	100	mg/kg	75	125	30
2283	Silicon	25	mg/kg	7.12	mg/kg	20110125	C	Y	754	mg/kg	80	120	20	C	Y	500	mg/kg	75	125	30
2285	Silver	0.2	mg/kg	0.0139	mg/kg	20110125	C	Y	52	mg/kg	66	133	20	C	Y	10.0	mg/kg	75	125	30
2315	Sodium	20	mg/kg	6.67	mg/kg	20110624	C	Y	724	mg/kg	56	144	20	C	Y	1000	mg/kg	75	125	30
2353	Strontium	0.5	mg/kg	0.212	mg/kg	20110125	C	Y	111	mg/kg	70	128	20	C	Y	100	mg/kg	75	125	30
2876	Sulfur	500	mg/kg	55.9	mg/kg	20110125	C	Y	1000	mg/kg	80	120	20	C	Y	1000	mg/kg	75	125	30
3933	Tantalum	1.0	mg/kg	0.156	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
3742	Tellurium	1.0	mg/kg	0.109	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
2477	Thallium	0.2	mg/kg	0.10	mg/kg	20110125	C	Y	171	mg/kg	68	131	20	C	Y	100	mg/kg	75	125	30
3935	Thorium	0.2	mg/kg	0.078	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30

Structured Analysis Code: A-MV-MH-01-06

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: Soil Scoop Preparation/TCLP lab; 2% HCl
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6428							Spike List 6225							
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
2479	Tin	0.2	mg/kg	0.10	mg/kg	20110125	C	Y	135	mg/kg	59	140	20	C	Y	100	mg/kg	75	125	30
2482	Titanium	0.5	mg/kg	0.25	mg/kg	20110125	C	Y	2340	mg/kg	29	171	20	C	Y	100	mg/kg	75	125	30
2602	Tungsten	0.5	mg/kg	0.25	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
3827	Uranium	0.10	mg/kg	0.0199	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
5927	Uranium 233	0.005	mg/kg	0.0015	mg/kg	20110125	C	Y	3.86	mg/kg	80	120	20	C	Y	3.86	mg/kg	75	125	30
4129	Uranium 234	0.005	mg/kg	0.00067	mg/kg	20110125	C	Y	1.75	mg/kg	80	120	20	C	Y	1.75	mg/kg	75	125	30
4131	Uranium 235	0.005	mg/kg	0.00203	mg/kg	20110125	C	Y	2.28	mg/kg	80	120	20	C	Y	2.28	mg/kg	75	125	30
5385	Uranium 236	0.005	mg/kg	0.00078	mg/kg	20110125	C	Y	17.5	mg/kg	80	120	20	C	Y	17.5	mg/kg	75	125	30
4133	Uranium 238	0.1	mg/kg	0.00055	mg/kg	20110125	C	Y	336	mg/kg	80	120	20	C	Y	336	mg/kg	75	125	30
2607	Vanadium	1.0	mg/kg	0.735	mg/kg	20110125	C	Y	110	mg/kg	67	132	20	C	Y	100	mg/kg	75	125	30
2726	Yttrium	1.0	mg/kg	0.034	mg/kg	20110125	C	Y	50	mg/kg	75	125	30	C	Y	100	mg/kg	75	125	30
2649	Zinc	5.0	mg/kg	1.33	mg/kg	20110125	C	Y	299	mg/kg	71	128	20	C	Y	100	mg/kg	75	125	30
2651	Zirconium	1.0	mg/kg	0.104	mg/kg	20110125	C	Y	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30

TAL Reference Data Summary

Structured Analysis Code: **A-MY-MH-01-06**

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: LEACHATE, DI (ASTM D3987-85) - 18 hour; 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	4.47	ug/L	20100108	C	N	6320	mg/kg	58	142	20	C	Y	1000	mg/kg	75	125	30
128	Antimony	5	ug/L	1.12	ug/L	20100112	C	N	81.5	mg/kg	10	150	20	C	Y	50	mg/kg	75	125	30
140	Arsenic	10	ug/L	0.946	ug/L	20100108	C	N	161	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
194	Barium	2	ug/L	0.196	ug/L	20100108	C	N	252	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
222	Beryllium	0.5	ug/L	0.114	ug/L	20100108	C	N	94.4	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
313	Boron	50	ug/L	7.47	ug/L	20100108	C	N	136	mg/kg	56	144	20	C	Y	100	mg/kg	75	125	30
411	Cadmium	0.5	ug/L	0.055	ug/L	20100112	C	N	128	mg/kg	81	119	20	C	Y	100	mg/kg	75	125	30
413	Calcium	100	ug/L	48.7	ug/L	20100108	C	N	3320	mg/kg	79	121	20	C	Y	1000	mg/kg	75	125	30
5935	Cesium 133	0.5	ug/L	0.00282	ug/L	20051128														
2952	Chromium	10	ug/L	3.26	ug/L	20100108	C	N	69.5	mg/kg	78	121	20	C	Y	100	mg/kg	75	125	30
637	Cobalt	2	ug/L	0.217	ug/L	20100112	C	N	35.2	mg/kg	73	127	20	C	Y	100	mg/kg	75	125	30
643	Copper	1	ug/L	0.097	ug/L	20100112	C	N	148	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
1539	Iron	50	ug/L	20.35	ug/L	20100108	C	N	11200	mg/kg	57	143	20	C	Y	1000	mg/kg	75	125	30
1605	Lead	3	ug/L	0.173	ug/L	20100108	C	N	142	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1618	Magnesium	50	ug/L	1.73	ug/L	20100108	C	N	2040	mg/kg	77	123	20	C	Y	1000	mg/kg	75	125	30
1659	Manganese	2	ug/L	0.234	ug/L	20100108	C	N	408	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1906	Molybdenum	5	ug/L	0.216	ug/L	20100112	C	N	84.1	mg/kg	79	120	20	C	Y	100	mg/kg	75	125	30
1956	Nickel	5	ug/L	0.231	ug/L	20100112	C	N	147	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
3924	Niobium	25	ug/L	2.23	ug/L	20100115	C	N	25	mg/kg	80	120	20	C	Y	25	mg/kg	75	125	30
3925	Palladium	0.5	ug/L	0.054	ug/L	20100115	C	N	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2200	Phosphorus	50	ug/L	8.23	ug/L	20100108	C	Y	500	mg/kg	85	115	30	C	Y	100	mg/kg	75	125	30
2209	Platinum	1	ug/L	0.060	ug/L	20100108	C	N	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2214	Potassium	100	ug/L	8.33	ug/L	20100108	C	N	1250	mg/kg	71	129	20	C	Y	1000	mg/kg	75	125	30
2281	Selenium	5	ug/L	0.308	ug/L	20100112	C	N	64.2	mg/kg	76	124	20	C	Y	100	mg/kg	75	125	30
2283	Silicon	250	ug/L	17.8	ug/L	20090119	C	N	754	mg/kg	10	150	20	C	Y	500	mg/kg	75	125	30
2285	Silver	2	ug/L	0.04	ug/L	20100108	C	N	130	mg/kg	53	147	20	C	Y	10.0	mg/kg	75	125	30
2315	Sodium	50	ug/L	5.30	ug/L	20100108	C	N	1250	mg/kg	56	144	20	C	Y	1000	mg/kg	75	125	30
2353	Strontium	5	ug/L	0.114	ug/L	20100112	C	N	84.0	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
4113	Technetium 99	0.5	ug/L	0.00050	ug/L	20051118														
2477	Thallium	2	ug/L	0.55	ug/L	20100108	C	N	84	mg/kg	76	125	20	C	Y	100	mg/kg	75	125	30
3935	Thorium	2	ug/L	0.552	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
2479	Tin	2	ug/L	0.150	ug/L	20100108	C	N	61.0	mg/kg	58	142	20	C	Y	100	mg/kg	75	125	30
2482	Titanium	2	ug/L	0.573	ug/L	20100108	C	N	310	mg/kg	40	150	20	C	Y	100	mg/kg	75	125	30
2602	Tungsten	5	ug/L	0.839	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
3827	Uranium	1	ug/L	0.08	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20071227	C	Y	3.86	mg/kg	80	120	20	C	Y	3.86	mg/kg	75	125	30
4129	Uranium 234	0.05	ug/L	0.00004(	ug/L	20071227	C	Y	1.75	mg/kg	80	120	20	C	Y	1.75	mg/kg	75	125	30

Structured Analysis Code: A-MY-MH-01-06

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: LEACHATE, DI (ASTM D3987-85) - 18 hour; 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225							
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20071227	C	N	2.28	mg/kg	80	120	20	C	Y	2.28	mg/kg	75	125	30
5385	Uranium 236	0.05	ug/L	0.00012	ug/L	20071227	C	Y	17.5	mg/kg	80	120	20	C	Y	17.5	mg/kg	75	125	30
4133	Uranium 238	1.0	ug/L	0.0016	ug/L	20071227	C	Y	336	mg/kg	80	120	20	C	Y	336	mg/kg	75	125	30
2607	Vanadium	10	ug/L	2.37	ug/L	20100108	C	N	97.3	mg/kg	75	125	20	C	Y	100	mg/kg	75	125	30
2649	Zinc	10	ug/L	3.74	ug/L	20100112	C	N	165	mg/kg	79	120	20	C	Y	100	mg/kg	75	125	30
2651	Zirconium	5	ug/L	0.248	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30

TAL Reference Data Summary

Structured Analysis Code: **A-M6-MH-01-06**

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: KD leach/2% HCl 3010
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225					
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	4.47	ug/L	20100108	C	N	6320	mg/kg	58	142	20	C	Y	1000	mg/kg	75	125	30
128	Antimony	5	ug/L	1.12	ug/L	20100112	C	N	81.5	mg/kg	10	150	20	C	Y	50	mg/kg	75	125	30
140	Arsenic	10	ug/L	0.946	ug/L	20100108	C	N	161	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
194	Barium	2	ug/L	0.196	ug/L	20100108	C	N	252	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
222	Beryllium	0.5	ug/L	0.114	ug/L	20100108	C	N	94.4	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
313	Boron	50	ug/L	7.47	ug/L	20100108	C	N	136	mg/kg	56	144	20	C	Y	100	mg/kg	75	125	30
411	Cadmium	0.5	ug/L	0.055	ug/L	20100112	C	N	128	mg/kg	81	119	20	C	Y	100	mg/kg	75	125	30
413	Calcium	100	ug/L	48.7	ug/L	20100108	C	N	3320	mg/kg	79	121	20	C	Y	1000	mg/kg	75	125	30
5935	Cesium 133	0.5	ug/L	0.00282	ug/L	20051128														
2952	Chromium	10	ug/L	3.26	ug/L	20100108	C	N	69.5	mg/kg	78	121	20	C	Y	100	mg/kg	75	125	30
637	Cobalt	2	ug/L	0.217	ug/L	20100112	C	N	35.2	mg/kg	73	127	20	C	Y	100	mg/kg	75	125	30
643	Copper	1	ug/L	0.097	ug/L	20100112	C	N	148	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
1539	Iron	50	ug/L	20.35	ug/L	20100108	C	N	11200	mg/kg	57	143	20	C	Y	1000	mg/kg	75	125	30
1605	Lead	3	ug/L	0.173	ug/L	20100108	C	N	142	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1618	Magnesium	50	ug/L	1.73	ug/L	20100108	C	N	2040	mg/kg	77	123	20	C	Y	1000	mg/kg	75	125	30
1659	Manganese	2	ug/L	0.234	ug/L	20100108	C	N	408	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1906	Molybdenum	5	ug/L	0.216	ug/L	20100112	C	N	84.1	mg/kg	79	120	20	C	Y	100	mg/kg	75	125	30
1956	Nickel	5	ug/L	0.231	ug/L	20100112	C	N	147	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
3924	Niobium	25	ug/L	2.23	ug/L	20100115	C	N	25	mg/kg	80	120	20	C	Y	25	mg/kg	75	125	30
3925	Palladium	0.5	ug/L	0.054	ug/L	20100115	C	N	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2209	Platinum	1	ug/L	0.060	ug/L	20100108	C	N	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2214	Potassium	100	ug/L	8.33	ug/L	20100108	C	N	1250	mg/kg	71	129	20	C	Y	1000	mg/kg	75	125	30
2281	Selenium	5	ug/L	0.308	ug/L	20100112	C	N	64.2	mg/kg	76	124	20	C	Y	100	mg/kg	75	125	30
2283	Silicon	250	ug/L	17.8	ug/L	20090119	C	N	754	mg/kg	10	150	20	C	Y	500	mg/kg	75	125	30
2285	Silver	2	ug/L	0.04	ug/L	20100108	C	N	130	mg/kg	53	147	20	C	Y	10.0	mg/kg	75	125	30
2315	Sodium	50	ug/L	5.30	ug/L	20100108	C	N	1250	mg/kg	56	144	20	C	Y	1000	mg/kg	75	125	30
2353	Strontium	5	ug/L	0.114	ug/L	20100112	C	N	84.0	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
4113	Technetium 99	0.5	ug/L	0.00050	ug/L	20051118														
2477	Thallium	2	ug/L	0.55	ug/L	20100108	C	N	84	mg/kg	76	125	20	C	Y	100	mg/kg	75	125	30
3935	Thorium	2	ug/L	0.552	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
2479	Tin	2	ug/L	0.150	ug/L	20100108	C	N	61.0	mg/kg	58	142	20	C	Y	100	mg/kg	75	125	30
2482	Titanium	2	ug/L	0.573	ug/L	20100108	C	N	310	mg/kg	40	150	20	C	Y	100	mg/kg	75	125	30
2602	Tungsten	5	ug/L	0.839	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
3827	Uranium	1	ug/L	0.08	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20071227	C	Y	3.86	mg/kg	80	120	20	C	Y	3.86	mg/kg	75	125	30
4129	Uranium 234	0.05	ug/L	0.00004(	ug/L	20071227	C	Y	1.75	mg/kg	80	120	20	C	Y	1.75	mg/kg	75	125	30
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20071227	C	N	2.28	mg/kg	80	120	20	C	Y	2.28	mg/kg	75	125	30

Structured Analysis Code: A-M6-MH-01-06

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: KD leach/2% HCl 3010
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
5385	Uranium 236	0.05	ug/L	0.00012	ug/L	20071227	C	Y	17.5	mg/kg	80	120	20	C	Y	17.5	mg/kg	75	125	30
4133	Uranium 238	1.0	ug/L	0.0016	ug/L	20071227	C	Y	336	mg/kg	80	120	20	C	Y	336	mg/kg	75	125	30
2607	Vanadium	10	ug/L	2.37	ug/L	20100108	C	N	97.3	mg/kg	75	125	20	C	Y	100	mg/kg	75	125	30
2649	Zinc	5	ug/L	3.74	ug/L	20100112	C	N	165	mg/kg	79	120	20	C	Y	100	mg/kg	75	125	30

TAL Reference Data Summary

Structured Analysis Code: A-3E-MH-01-06

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: LEACHATE, DI (ASTM D3987-85)-18 hour > Digestion/Inor
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	4.47	ug/L	20100108	C	N	6320	mg/kg	58	142	20	C	Y	1000	mg/kg	75	125	30
128	Antimony	5	ug/L	1.12	ug/L	20100112	C	N	81.5	mg/kg	10	150	20	C	Y	50	mg/kg	75	125	30
140	Arsenic	10	ug/L	0.946	ug/L	20100108	C	N	161	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
194	Barium	2	ug/L	0.196	ug/L	20100108	C	N	252	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
222	Beryllium	0.5	ug/L	0.114	ug/L	20100108	C	N	94.4	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
313	Boron	50	ug/L	7.47	ug/L	20100108	C	N	136	mg/kg	56	144	20	C	Y	100	mg/kg	75	125	30
411	Cadmium	0.5	ug/L	0.055	ug/L	20100112	C	N	128	mg/kg	81	119	20	C	Y	100	mg/kg	75	125	30
413	Calcium	100	ug/L	48.7	ug/L	20100108	C	N	3320	mg/kg	79	121	20	C	Y	1000	mg/kg	75	125	30
5935	Cesium 133	0.5	ug/L	0.00282	ug/L	20051128														
2952	Chromium	10	ug/L	3.26	ug/L	20100108	C	N	69.5	mg/kg	78	121	20	C	Y	100	mg/kg	75	125	30
637	Cobalt	2	ug/L	0.217	ug/L	20100112	C	N	35.2	mg/kg	73	127	20	C	Y	100	mg/kg	75	125	30
643	Copper	1	ug/L	0.097	ug/L	20100112	C	N	148	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
1539	Iron	50	ug/L	20.35	ug/L	20100108	C	N	11200	mg/kg	57	143	20	C	Y	1000	mg/kg	75	125	30
1605	Lead	3	ug/L	0.173	ug/L	20100108	C	N	142	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1618	Magnesium	50	ug/L	1.73	ug/L	20100108	C	N	2040	mg/kg	77	123	20	C	Y	1000	mg/kg	75	125	30
1659	Manganese	2	ug/L	0.234	ug/L	20100108	C	N	408	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
1906	Molybdenum	5	ug/L	0.216	ug/L	20100112	C	N	84.1	mg/kg	79	120	20	C	Y	100	mg/kg	75	125	30
1956	Nickel	5	ug/L	0.231	ug/L	20100112	C	N	147	mg/kg	82	118	20	C	Y	100	mg/kg	75	125	30
3924	Niobium	25	ug/L	2.23	ug/L	20100115	C	N	25	mg/kg	80	120	20	C	Y	25	mg/kg	75	125	30
3925	Palladium	0.5	ug/L	0.054	ug/L	20100115	C	N	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2200	Phosphorus	50	ug/L	8.23	ug/L	20100108	C	Y	500	mg/kg	85	115	30	C	Y	100	mg/kg	75	125	30
2209	Platinum	1	ug/L	0.060	ug/L	20100108	C	N	10	mg/kg	80	120	20	C	Y	10	mg/kg	75	125	30
2214	Potassium	100	ug/L	8.33	ug/L	20100108	C	N	1250	mg/kg	71	129	20	C	Y	1000	mg/kg	75	125	30
2281	Selenium	5	ug/L	0.308	ug/L	20100112	C	N	64.2	mg/kg	76	124	20	C	Y	100	mg/kg	75	125	30
2283	Silicon	250	ug/L	17.8	ug/L	20090119	C	N	754	mg/kg	10	150	20	C	Y	500	mg/kg	75	125	30
2285	Silver	2	ug/L	0.04	ug/L	20100108	C	N	130	mg/kg	53	147	20	C	Y	10.0	mg/kg	75	125	30
2315	Sodium	50	ug/L	5.30	ug/L	20100108	C	N	1250	mg/kg	56	144	20	C	Y	1000	mg/kg	75	125	30
2353	Strontium	5	ug/L	0.114	ug/L	20100112	C	N	84.0	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
4113	Technetium 99	0.5	ug/L	0.00050	ug/L	20051118														
2477	Thallium	2	ug/L	0.55	ug/L	20100108	C	N	84	mg/kg	76	125	20	C	Y	100	mg/kg	75	125	30
3935	Thorium	2	ug/L	0.552	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
2479	Tin	2	ug/L	0.150	ug/L	20100108	C	N	61.0	mg/kg	58	142	20	C	Y	100	mg/kg	75	125	30
2482	Titanium	2	ug/L	0.573	ug/L	20100108	C	N	310	mg/kg	40	150	20	C	Y	100	mg/kg	75	125	30
2602	Tungsten	5	ug/L	0.821	ug/L	20100222	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
3827	Uranium	1	ug/L	0.08	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20071227	C	Y	3.86	mg/kg	80	120	20	C	Y	3.86	mg/kg	75	125	30
4129	Uranium 234	0.05	ug/L	0.00004	ug/L	20071227	C	Y	1.75	mg/kg	80	120	20	C	Y	1.75	mg/kg	75	125	30

Structured Analysis Code: A-3E-MH-01-06

Target Analyte List: All Analytes

Matrix: SOLID
Extraction: LEACHATE, DI (ASTM D3987-85)-18 hour > Digestion/Inorg
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20071227	C	N	2.28	mg/kg	80	120	20	C	Y	2.28	mg/kg	75	125	30
5385	Uranium 236	0.05	ug/L	0.00012	ug/L	20071227	C	Y	17.5	mg/kg	80	120	20	C	Y	17.5	mg/kg	75	125	30
4133	Uranium 238	1.0	ug/L	0.0016	ug/L	20071227	C	Y	336	mg/kg	80	120	20	C	Y	336	mg/kg	75	125	30
2607	Vanadium	10	ug/L	2.37	ug/L	20100108	C	N	97.3	mg/kg	75	125	20	C	Y	100	mg/kg	75	125	30
2649	Zinc	10	ug/L	3.74	ug/L	20100112	C	N	165	mg/kg	79	120	20	C	Y	100	mg/kg	75	125	30
2651	Zirconium	5	ug/L	0.248	ug/L	20100108	C	N	100	mg/kg	80	120	20	C	Y	100	mg/kg	75	125	30

TAL Reference Data Summary

Structured Analysis Code: I-GJ-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, TOTAL - 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
88	Aluminum	30	ug/L	12.9	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
128	Antimony	5	ug/L	1.67	ug/L	20110124	C	Y	500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
140	Arsenic	10	ug/L	0.946	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
194	Barium	2	ug/L	0.203	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
222	Beryllium	0.5	ug/L	0.350	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
307	Bismuth	20.0	ug/L	0.732	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
313	Boron	50	ug/L	10.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
411	Cadmium	0.5	ug/L	0.10	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
413	Calcium	100	ug/L	68.1	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3489	Cerium	10	ug/L	0.886	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3488	Cesium	0.10	ug/L	0.053	ug/L	20110124	C	Y	500	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
2952	Chromium	10	ug/L	3.26	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
637	Cobalt	2	ug/L	0.217	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
643	Copper	1	ug/L	0.451	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3917	Hafnium	10	ug/L	1.13	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1539	Iron	50	ug/L	20.35	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3922	Lanthanum	2	ug/L	0.051	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1605	Lead	3	ug/L	0.173	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1616	Lithium	5	ug/L	0.694	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1618	Magnesium	50	ug/L	5.20	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
1659	Manganese	2	ug/L	0.245	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1906	Molybdenum	5	ug/L	1.00	ug/L	20110624	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3490	Neodymium	2	ug/L	0.104	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
1956	Nickel	5	ug/L	0.40	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3924	Niobium	25	ug/L	2.23	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	250	ug/L	75	125	20
3925	Palladium	1	ug/L	0.059	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20
2200	Phosphorus	50	ug/L	8.53	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2209	Platinum	1	ug/L	0.079	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20
2214	Potassium	100	ug/L	41.6	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3926	Praseodymium	2	ug/L	0.042	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3927	Rhenium	1	ug/L	0.025	ug/L	20110906	C	Y	100	ug/L	80	120	20	C	Y	500	ug/L	75	125	20
3928	Rhodium	10	ug/L	0.817	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3930	Ruthenium	10	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3931	Samarium	10	ug/L	0.326	ug/L	20110124														
2281	Selenium	5	ug/L	1.59	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2283	Silicon	250	ug/L	17.8	ug/L	20110124	C	Y	5000	ug/L	80	120	20	C	Y	5000	ug/L	75	125	20
2285	Silver	2	ug/L	0.04	ug/L	20110124	C	Y	100	ug/L	80	120	20	C	Y	100	ug/L	75	125	20

Structured Analysis Code: I-GJ-MH-01-06

Target Analyte List: All Analytes

Matrix: WATER
Extraction: METALS, TOTAL - 2% HCL
Method: Inductively Coupled Plasma Mass Spectrometry(6020)
QC Program: STANDARD TEST SET
Location: TestAmerica St. Louis

Analyte List		Detection Limits					Check List 6224							Spike List 6225						
Syn	Compound	RL	Units	MDL	Units	Run Date	T	A	Amt	Units	LCL	UCL	RPD	T	A	Amt	Units	LCL	UCL	RPD
2315	Sodium	50	ug/L	15.0	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
2353	Strontium	5	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2876	Sulfur	5000	ug/L	333	ug/L	20110124	C	Y	10000	ug/L	80	120	20	C	Y	10000	ug/L	75	125	20
3742	Tellurium	10.0	ug/L	0.536	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2477	Thallium	2	ug/L	0.55	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3935	Thorium	2	ug/L	0.552	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2479	Tin	2	ug/L	1.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2482	Titanium	5	ug/L	2.1	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2602	Tungsten	5	ug/L	2.0	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
3827	Uranium	1	ug/L	0.231	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
5927	Uranium 233	0.05	ug/L	0.0066	ug/L	20110124	C	Y	0.386	ug/L	80	120	20	C	Y	0.386	ug/L	75	125	20
4129	Uranium 234	0.05	ug/L	0.0021	ug/L	20110124	C	Y	0.175	ug/L	80	120	20	C	Y	0.175	ug/L	75	125	20
4131	Uranium 235	0.05	ug/L	0.0034	ug/L	20110124	C	Y	0.228	ug/L	80	120	20	C	Y	0.228	ug/L	75	125	20
5385	Uranium 236	0.05	ug/L	0.0015	ug/L	20110124	C	Y	1.75	ug/L	80	120	20	C	Y	1.75	ug/L	75	125	20
4133	Uranium 238	1.0	ug/L	0.0082	ug/L	20110124	C	Y	33.6	ug/L	80	120	20	C	Y	33.6	ug/L	75	125	20
2607	Vanadium	10	ug/L	2.37	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2726	Yttrium	5	ug/L	0.212	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2649	Zinc	10	ug/L	8.29	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20
2651	Zirconium	5	ug/L	0.248	ug/L	20110124	C	Y	1000	ug/L	80	120	20	C	Y	1000	ug/L	75	125	20

Title: PREPARATION AND ANALYSIS OF MERCURY IN SOLID SAMPLES BY COLD VAPOR ATOMIC ABSORPTION SPECTROSCOPY [SW-846 7471B]

Approvals (Signature/Date):

Kristen Ely 6/17/13
Kristen Ely Date
Metals Supervisor

Michael Riddenhower 6/17/13
Michael Riddenhower Date
Health & Safety Manager / Coordinator

Marti Ward 6-17-13
Marti Ward Date
Quality Assurance Manager

Elaine Wild 6/17/13
Elaine Wild Date
Laboratory Director

This SOP was previously identified as SOP No. ST-MT-0007 Rev. 12

Facility Distribution No.: 0 **Distributed To:** See Electronic Distribution Sheet

1.0 SCOPE AND APPLICATION

1.1 This procedure describes the preparation and analysis of mercury by Cold Vapor Atomic Absorption (CVAA) Spectroscopy using SW-846 Method 7471B.

1.2 CVAA analysis provides for the determination of total mercury (organic and inorganic). The combination of the oxidants, potassium permanganate, has been found to give 100% recovery with both types of compounds. Detection limits, sensitivity and optimum concentration ranges for mercury analysis will vary with the matrices, instrumentation and volume of sample used.

1.3 Method 7471B is applicable to the preparation and analysis of mercury in soils, sediments, bottom deposits and sludge-type materials. All matrices require sample preparation prior to analysis.

1.4 The laboratory target analytes supported by this method, the reporting limits, method detection limits and QC limits are maintained in the Laboratory Information Management System (LIMS).

2.0 SUMMARY OF METHOD

2.1 This SOP describes a technique for the determination of mercury in solution. The procedure is a physical method based on the absorption of radiation at 253.7 nm by mercury vapor. A representative portion of the sample is digested in hydrochloric and nitric acids. Organic mercury compounds are oxidized with potassium permanganate and the mercury reduced to its elemental state with stannous chloride and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance is measured as a function of mercury concentration. Concentration of the analyte in the sample is determined by comparison of the sample absorbance to the calibration curve (absorbance vs. concentration).

3.0 DEFINITIONS

3.1 See the TestAmerica St. Louis Quality Assurance Manual (ST-QAM) for a glossary of common laboratory terms and data reporting qualifiers.

4.0 INTERFERENCES

4.1 Potassium permanganate, which is used to breakdown organic mercury compounds, also eliminates possible interferences from sulfide. Concentrations as high as 20 mg/L of sulfide as sodium sulfide do not interfere with the recovery of inorganic mercury from reagent water.

4.2 Copper has also been reported to interfere with recovery of mercury; however, copper concentrations as high as 10 mg/L had no effect on the recovery of mercury from spiked samples.

4.3 Interference from certain volatile organic materials that absorb at this wavelength may also occur. If suspected, a preliminary run without stannous chloride can determine if this type of interference is present. While the possibility of absorption from certain organic substances present in the sample does exist, this problem is not routinely encountered. This is mentioned only to caution the analyst of the possibility. If this condition is found to exist, the mercury concentration in the sample can be determined by subtracting the result of the sample run without the reducing reagent (stannous chloride) from that obtained with the reducing reagent.

4.4 Samples containing high concentrations of oxidizable organic materials, as evidenced by high COD levels, may not be completely oxidized by this procedure. When this occurs the recovery of mercury will be low. The problem can be eliminated by reducing the volume of original sample used.

5.0 SAFETY

5.1 Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001), Radiation Safety Manual and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.2 SPECIFIC SAFETY CONCERNS OR REQUIREMENTS

5.2.1 Samples that contain high concentrations of carbonates or organic material or samples that are at elevated pH can react violently when acids are added.

5.3 PRIMARY MATERIALS USED

5.3.1 The following is a list of the materials used in this method, which have a serious or significant hazard rating. NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material[(1)]	Hazards	Exposure Limit[(2)]	Signs and symptoms of exposure
Mercury (1,000 ppm in Reagent)	Oxidizer Corrosive Poison	0.1 mg/m^3 for Hg Compounds (Ceiling)	Extremely toxic. Causes irritation to the respiratory tract. Causes irritation. Symptoms include redness and pain. May cause burns. May cause sensitization. Can be absorbed through the skin with symptoms to parallel ingestion. May affect the central nervous system. Causes irritation and burns to eyes. Symptoms include redness, pain, and blurred vision; may cause serious and permanent eye damage.
Nitric Acid	Corrosive Oxidizer Poison	2 ppm (TWA) 4 ppm (STEL)	Nitric acid is extremely hazardous; it is corrosive, reactive, an oxidizer, and a poison. Inhalation of vapors can cause breathing difficulties and lead to pneumonia and pulmonary edema, which may be fatal. Other symptoms may include coughing, choking, and irritation of the nose, throat, and respiratory tract. Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and stain skin a yellow or yellow-brown color. Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.
Hydrochloric Acid	Corrosive Poison	5 ppm (Ceiling)	Inhalation of vapors can cause coughing, choking, inflammation of the nose, throat, and upper respiratory tract, and in severe cases, pulmonary edema, circulatory failure, and death. Can cause redness, pain, and severe skin burns. Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.
Potassium Permanganate	Oxidizer	5 mg/m^3 for Mn Compounds (Ceiling)	Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath. Dry crystals and concentrated solutions are caustic causing redness, pain, severe burns, brown stains in the contact area and possible hardening of outer skin layer. Diluted solutions are only mildly irritating to the skin. Eye contact with crystals (dusts) and concentrated solutions causes severe irritation, redness, and blurred vision

Material[1]	Hazards	Exposure Limit[2]	Signs and symptoms of exposure
			and can cause severe damage, possibly permanent.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			
TWA – Time weighted average			
STEL – Short term exposure limit			
Ceiling – At no time should this exposure limit be exceeded			

6.0 EQUIPMENT AND SUPPLIES

6.1 Temperature controlled hot block (capable of maintaining a temperature of 95 ± 3 °C).

6.2 Leeman Labs Mercury Analyzer.

6.3 Hydra II AA software: Envoy version 2.8

6.4 Hydra AA software: WinHg version 1.4

6.5 150 mL plastic containers or equivalent

6.6 Argon gas supply, welding grade or equivalent.

6.7 Pipettes

6.8 Volumetric flasks, class A

6.9 Top-loading balance, capable of reading ± 0.001 g

6.10 Thermometer (capable of reading 95 ± 3 °C)

6.11 Disposable cups or tubes.

7.0 REAGENTS AND STANDARDS

7.1 All standards and reagent preparation, documentation and labeling must follow the requirements of SOP ST-QA-0002, current revision.

7.2 DI Water (Type II or better), obtained from the Milli-Q unit

7.3 Nitric acid (HNO_3), concentrated, trace grade

7.4 Hydrochloric Acid (HCl), concentrated, trace grade

7.5 Aqua Regia: Prepare immediately before use by carefully adding three volumes of concentrated HCl to one volume of concentrated HNO_3.

7.6 Stannous chloride - Dissolve 100 g of stannous chloride into 1000 mL of 10% HCl.

7.7 Hydroxylamine sulfate/12% sodium hydroxide solution, a certified stock standard is purchased
NOTE: Hydroxylamine hydrochloride (12%) may be used in place of hydroxylamine sulfate. (120 g →1000 mL)

7.8 Potassium permanganate, 5% solution (w/v) -certified stock reagent is purchased.
7.8.1 Alternately, dissolve 5 g of potassium permanganate for every 100 mL of DI water.

7.9 Mercury standard – (100 ppm)

7.9.1 Intermediate mercury standard (0.1 ppm): Add 2 mL of concentrated HNO_3 to a 100 mL volumetric flask. Add 0.1 mL of the stock ICV mercury standard and dilute to a 100 mL final volume in DI water.

7.9.1.1 The intermediate standard must be made daily.

7.9.1.2 Mercury calibration standards must be prepared fresh daily from the intermediate standard by transferring 0.0, 0.2, 0.5, 1.0, 5.0 and 10.0 mL aliquots of the intermediate mercury standard into sample prep bottles and proceeding as specified in Section 11.1

7.10 Mercury standard – ICV Stock (100 ppm) in 5% HNO_3

7.10.1 The initial calibration verification (ICV) standard must be made from a different stock solution than that of the calibration standards.

7.10.2 ICV Intermediate mercury standard (0.1 ppm) – Add 2 mL of concentrated HNO_3 to a 100 mL volumetric flask. Add 0.1 mL of the stock mercury standard and dilute to a 100 mL final volume in DI water.

7.10.2.1 The ICV intermediate standard must be made daily.

7.10.2.1.1 ICV mercury standard must be prepared fresh daily from the intermediate standard by transferring 2.5 mL aliquots of the ICV intermediate mercury standard into sample prep bottles and proceeding as specified in Section 11.1

7.10.3 All standards must be processed through the entire analytical procedure including sample preparation.

8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1 TestAmerica St. Louis supplies sample containers and chemical preservatives in accordance with the method. TestAmerica St. Louis does not perform sample collection. Samplers should reference the methods referenced and other applicable sample collection documents for detailed collection procedures. Sample volumes and preservative information is given in ST-PM-0002.

8.2 The sample holding time for mercury is 28 days from time of collection to the time of analysis.

8.3 Soil samples do not require chemical preservation but must be stored at 4 °C ± 2 °C until the time of analysis.

9.0 QUALITY CONTROL

9.1 **Batch**

9.1.1 A sample batch is a maximum of 20 environmental samples, which are prepared together using the same process and same lot(s) of reagents. Where no preparation method exists (e.g. water sample volatile organics, water sample anion analysis) the batch is comprised of a maximum of 20 environmental samples which are analyzed together with the same process, lots of reagents and personnel.

9.1.2 Instrument conditions must be the same for all standards, samples and QC samples.

9.1.3 For this analysis, batch QC consists of a method blank, an Laboratory Control Sample (LCS), and Matrix Spike (MS) and Matrix Spike Duplicate (MSD) In the event that there is insufficient sample to analyze a MS/MSD, an LCS Duplicate (LCSD) is prepared and analyzed.

9.1.3.1 At the instrument, a Serial dilution is performed with every batch.

9.1.4 Samples having different QC codes, due to non-standard client specific QC requirements, must be batched separately in the LIMS. A method blank and LCS may be shared across QC codes provided the actual "sample batch" does not exceed 20 environmental samples. Duplicates (and MS/MSD if applicable) must be performed for each separate QC code.

9.2 **Method Blank**

9.2.1 A method blank is a blank matrix processed simultaneously with, and under the same conditions as, samples through all steps of the procedure.

9.2.2 A method blank must be prepared with every sample batch.

9.2.3 For Soil analyses, the method blank is comprised of glass beads.

9.2.4 See section 13 for acceptance criteria

9.3 **Laboratory Control Sample**

9.3.1 An LCS is a blank matrix spiked with a known amount of analyte(s), processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.3.2 An LCS must be prepared with every sample batch.

9.3.3 For Soil analyses, the LCS is a commercially prepared purchased solid reference material containing mercury.

9.3.3.1 Alternately, the LCS may be comprised of glass beads fortified with mercury, if client requirements request or QC criteria dictate such.

9.3.4 See section 13 for acceptance criteria

9.4 **Matrix Spike (MS) /Matrix Spike Duplicate (MSD)**

9.4.1 A Matrix Spike is an aliquot of a field sample to which a known amount of target analyte(s) is added, and is processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

9.4.2 MS/MSD samples do not count towards the 20 environmental samples in a sample batch.

9.4.3 MS/MSD samples must be performed with every sample batch and every LIMS batch.

9.4.3.1 If there is insufficient sample to perform a MS and/or MSD, a duplicate LCS is analyzed. A NCM is written to document the insufficient volume and the utilization of a LCSD to demonstrate precision.

9.4.4 See section 13 for acceptance criteria

9.5 **Sample Duplicate (SD)**

9.5.1 A Sample Duplicate is an additional aliquot of a field sample taken through the entire analytical process to demonstrate precision.

9.5.1.1 Certain client project requirements may request a sample duplicate in lieu of a MSD. Please check client requirements or comments in LIMS.

9.6 **Serial Dilution**

9.6.1 A sample digestate is diluted 1:5 and reanalyzed to assess the present of a matrix interference.

9.6.2 A serial dilution is performed with every analytical batch.

9.6.3 Agreement within 10% between the concentration for the undiluted sample and five times the concentration for the diluted sample indicates the absence of interferences.

9.7 **Post Digestion Spikes (PDS)**

9.7.1 A known amount of mercury is added to the sample chosen for MS/MSD to bring the concentration of mercury to 2 to 5 times the original concentration. If the sample's mercury concentration is below the detection limit, spike at a concentration between the low and mid-level standard.

9.7.2 At client's request, a post digestion spike is performed when MS/MSD fails.

9.7.3 See section 13 for acceptance criteria

9.8 **Method of Standard Addition (MSA)**

9.8.1 This technique involves adding known amounts of standard to one or more aliquots of the processed sample solution. This technique compensates for a sample interferent that may enhance or depress the analyte signal, thus producing a different slope from that of the

calibration standards. It will not correct for additive interferences which cause a baseline shift.

9.8.2 MSAs are not considered normal batch QC and if required by the client, must appear on the Client Requirement Memo or in comments in LIMS.

9.9 **Procedural Variations/ Nonconformance and Corrective Action**

9.9.1 Any variation shall be completely documented using a Nonconformance Memo and approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

9.9.2 Any deviations from QC procedures must be documented as a nonconformance, with applicable cause and corrective action approved by the Supervisor and QA Manager. See SOP ST-QA-0036 for details regarding the NCM process.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Initial Calibration

10.1.1 Calibration standards must be processed through the preparation procedure, section 11.

10.1.1.1 Due to the differences in preparation protocols, separate calibration and calibration verification standards must be prepared for aqueous and solid matrices.

10.1.1.2 Record the prep of the calibration standard on the digestion record.

10.1.2 Calibration must be performed daily (every 24 hours) and each time the instrument is set up.

10.1.3 Set up the instrument with the operating parameters recommended by the manufacturer.

10.1.4 Allow the instrument to become thermally stable before beginning calibration.

10.1.5 Calibrate the instrument according to instrument manufacturer's instructions, using a minimum of five standards and a blank.

10.1.5.1 One standard must be at the reporting limit. . The other standards define the working range of the detector, with the highest level standard establishing the linear range of the instrument.

10.1.5.2 Analyze standards in ascending order beginning with the blank.

10.1.6 Calibration criteria:

10.1.6.1 A correlation coefficient must be ≥ 0.995

10.1.6.2 If the calibration curve does not meet method requirements, perform maintenance and perform another calibration curve.

10.2 Initial Calibration Verification (ICV)

10.2.1 An ICV is a second source verification of the calibration.

10.2.2 An ICV must be performed with every calibration.

10.2.3 ICV criteria:

10.2.3.1 ICV recovery must be ± 10% of the known true value.

10.2.3.1.1 If the ICV fails to meet criteria (± 10%), the analysis is terminated, the problem corrected, the instrument recalibrated and the calibration re-verified.

10.2.3.1.2 If it is suspected that the failure was attributed to a poor sample introduction to the instrument, the ICV may be rerun once, provided no samples have been analyzed after the failing ICV. If the second ICV is acceptable, analysis may continue.

10.3 Initial Calibration Blank (ICB)

10.3.1 Analyze the initial continuing calibration blank (ICB) immediately following the ICV.

10.3.2 ICB criteria:

10.3.2.1 The absolute value of the ICB result must be less than or equal to the reporting limit (RL).

10.3.2.1.1 If the result is not within the control level, terminate the analysis, correct the problem, and recalibrate the instrument if necessary

10.3.2.1.2 Certain client programs may require more stringent ICB criteria, please see Client Requirement Memo or comments in LIMS.

10.4 Low Level Check (LLC) aka CRA (when requested by client)

10.4.1 Can be the same source as the calibration

10.4.2 An LLC is analyzed at the beginning of each analytical run.

10.4.3 LLC must be spiked at RL.

10.4.4 LLC Criteria

10.4.4.1 Must fall within 30% of the known value

10.4.4.2 If the result is not within the control level, terminate the analysis, correct the problem and recalibrate.

10.4.4.3 If it is suspected that the failure was attributed to a poor sample introduction to the instrument, the LLC may be rerun once, provided any samples analyzed after the failing LLC are also re-analyzed. If the second LLC is acceptable, analysis may continue.

10.5 Continuing Calibration Verification (CCV)

10.5.1 A CCV is analyzed after every 10 samples and at the end of the analytical sequence run.

10.5.2 CCV criteria:

10.5.2.1 The CCV must fall within 20% of the known true value.

10.5.2.1.1 If the CCV does not meet QC criteria, the analysis must be terminated, the problem corrected, the instrument recalibrated, and the preceding 10 samples reanalyzed.

10.5.2.1.2 If it is suspected that the failure was attributed to a poor sample introduction to the instrument, the CCV may be rerun once, provided any samples bracketing the failing CCV are also re-analyzed. If the second CCV is acceptable, analysis may continue.

10.6 Continuing Calibration Blank (CCB)

10.6.1 Analyze a continuing calibration blank (CCB) immediately following the CCV.

10.6.2 CCB criteria:

10.6.2.1 The absolute value of the CCB result must be less than or equal to the reporting limit (RL).

10.6.2.1.1 If the result is not within the control level, terminate the analysis, correct the problem, and recalibrate the instrument if necessary

10.6.2.1.2 Certain client programs may require more stringent CCB criteria. (see Client Requirement Memos or in comments in LIMS).

11.0 PROCEDURE

11.1 Sample Preparation:

11.1.1 Pipette 0.0, 0.2, 0.5, 1.0, 5.0 and 10.0 mL aliquots of the curve intermediate standard into a series of sample digestion bottles. Bring up all to 10 mL final volume with DI water.

11.2 To Prepare a ICV,

11.2.1 Pipette 2.5 mL of QC intermediate into a sample digestion bottle and bring up to a 10 mL final volume with DI water

11.3 To Prepare a LLC,

11.3.1 Pipette 0.2 mL calibration into a digestion bottle and bring up to a final volume of 10 mL.

11.4 To prepare a CCV,

11.4.1 To prepare the CCV, pipette 5.0 mL of QC intermediate into a sample digestion bottle and bring up all to a 10 mL final volume with DI water.

11.4.2 Transfer 0.6 – 0.7 g of well-mixed sample to a clean sample digestion bottle.

11.4.2.1 Reduced sample size can be used as long as a representative sample can be obtained and the reagent levels are adjusted to maintain the sample to reagent ratio.

11.4.3 Hot Block protocol:

11.4.3.1 Spike MS/MSD with 1 mL of the QC intermediate.
11.4.3.2 To each **standard** bottle: Add 5 mL of aqua regia.
11.4.3.3 To each **sample** bottle: Add 5 mL of reagent water and 5 mL of aqua regia.
11.4.3.4 Heat for 2 minutes in a hot block at 95 ± 3 °C
11.4.3.5 Cool.
11.4.3.6 Add 50 mL of DI water.
11.4.3.7 Add 15 mL of potassium permanganate solution, mix thoroughly
11.4.3.8 Let stand until purple color persists for 15 minutes, adding additional portions of permanganate solution if needed. If additional portions of permanganate solution are needed, an equivalent portion must also be added to all QC and client samples being prepped. Amount must be equal to that of the highest amount added to any sample.
11.4.3.9 Heat for 30 minutes in the hot block at 95 ± 3 °C
11.4.3.10 Cool.
11.4.3.11 Add 6 mL of sodium chloride-hydroxylamine sulfate solution to reduce the excess permanganate.
11.4.3.12 Bring sample to a final volume of 100 mL with DI water.

11.5 Sample Analysis:

11.5.1 The samples must be allowed to cool to room temperature prior to analysis or a decrease in the response signal can occur.
11.5.2 Follow instructions provided by instrument manufacturer.
11.5.3 Baseline correction is acceptable as long as it is performed after every sample or after the CCV and CCB; resloping is acceptable as long as it is immediately preceded and followed by a compliant CCV and CCB.
11.5.4 Analytical sequence:

Instrument Initial Calibration (5 standard plus a blank)
ICV
ICB
LLC (only if required by client)
CCV
CCB
Maximum 10 samples
CCV
CCB
Repeat sequence of 10 samples between CCV/CCB pairs as required to complete run.
CCV
CCB

NOTE: Samples include the method blank, LCS, LCS dup, MS, MSD, duplicate, field samples and sample dilutions.

NOTE: Analytical sequence must close with a CCV/CCB pair.

NOTE: If the instrument stops during the sequence, the instrument may be restarted. When restarting the instrument, the run must begin with an acceptable CCV/CCB only if the run has been stopped for more than 2 hours.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 Commonly used calculations (e.g. % recovery and RPD) and standard instrument software calculations are given in the TestAmerica St. Louis ST-QAM.

12.2 Sample results are reported to three significant figures in accordance with the significant figure policy.

12.3 All measurements must fall within the defined calibration range to be valid. Dilute and reanalyze all samples for analytes that exceed the highest calibration standard.

13.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA; CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

13.1 The data assessment and corrective action process is detailed through the LIMS Nonconformance Memorandum (NCM) process. The NCM process is described in SOP: ST-QA-0036.

13.2 Method Blank (MB)

13.2.1 Acceptance Criteria: No target analytes may be present in the method blank above the reporting limit.

13.2.2 Project specific requirements if more stringent than our routine procedure (e.g. no target analytes present above ½ RL), will be noted on the client requirements memo or in comments in LIMS.

13.2.3 Corrective Action for Method Blanks not meeting acceptance criteria:

13.2.3.1 Method Blank Contamination – If the Method Blank concentration exceeds the applicable criteria, the batch must be re-prepped unless the concentration of all associated samples is less than the RL or greater than ten times the concentration found in the blank.

13.3 Laboratory Control Sample (LCS)

13.3.1 Acceptance Criteria:

13.3.1.1 All control analytes should be within established control limits for accuracy (%Recovery) and precision (RPD).

13.3.1.2 Limits can be found in LIMS.

13.3.2 Corrective Action for LCS not meeting acceptance criteria:

13.3.2.1 LCS Spike Recovery excursion (high) – Samples with results less than the RL may be reported with an NCM (unless prohibited by client requirements). Samples with detects for the analyte with a high bias in the LCS are re-prepped and re-analyzed.

13.3.2.2 LCS Spike Recovery excursion (low) – the batch is re-prepped and re-analyzed for the affected analytes.

13.4 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

13.4.1 Analytes should be within control limits for accuracy (%Recovery) and precision (RPD).

13.4.2 MS/MSD Recovery criteria: 80% – 120%

13.4.3 Corrective Action for MS/MSD not meeting acceptance criteria:

13.4.3.1 MS/MSD Spike Recovery excursion: may not necessarily warrant corrective action other than narration

13.4.3.2 If the affected analyte concentration in the original sample is greater than four times the amount spiked, recovery information is ineffective and the data is reported with an NCM.

13.4.3.3 If the excursion is due to a physically evident matrix interference, the data is reported with an NCM.

13.4.3.4 In cases where the MS and/or MSD don't meet criteria, but the RPD is in control, data may be reported with and NCM.

13.4.3.5 When the MS/MSD recoveries and the %RPD are outside criteria, the batch is re-prepped and re-analyzed for the affected analytes.

13.5 Post Digestion Spike (PDS)

13.5.1 A PDS is only done when requested by the client.

13.5.2 The method stipulates that a PDS be performed on the sample chosen for MS/MSD.

13.5.2.1 The acceptance criteria is 80% – 120%, with a spike concentration between 10–100 times the RL UNLESS, other project/program criteria is given.

13.6 Serial Dilution (SD)

13.6.1 The serial dilution results shall agree within ± 10% of the undiluted sample results, if the undiluted sample results are greater than 10 times the reporting limit. There is no criteria for sample results less than 10 times the reporting limit.

13.6.2 Corrective Action: Serial dilution failure is documented in an NCM and the reported data is flagged. If multiple analytes fail the serial dilution test, the analyst may re-prep and re-analyze the samples.

13.7 Sample result evaluation

13.7.1 Analyses must fall within the calibration range.

13.7.2 Dilutions

13.7.2.1 If the response for any compound exceeds the working range of the analytical system, a dilution of the extract is prepared and analyzed. An appropriate dilution should be in the upper half of the calibration range.

13.7.2.1.1 An NCM will be written for any samples that are diluted.

13.7.3 Carryover

13.7.3.1 When a sample has a high response for a compound, there is a real possibility that some of the sample may carry over into the sample analyzed immediately afterward.

13.7.3.2 If a sample analyzed after a sample with high concentrations has negative results, carryover did not occur.

13.7.3.3 If a sample analyzed after a sample with high concentrations has positive results for the same analytes, the results are questionable. This sample must be reanalyzed under conditions in which carryover can be confirmed to not have occurred.

13.8 Insufficient Sample

13.8.1 For each prescribed re-preparation corrective action, if there is insufficient sample to repeat the analysis a narrative comment stating such is included in the report narrative. The insufficient sample description is included in the Clouseau NCM within the type defining the excursion.

14.0 METHOD PERFORMANCE AND DEMONSTRATIONS OF CAPABILITY

14.1 Method performance data, Reporting Limits, and QC acceptance limits, are given in the appendix of this SOP.

14.2 Demonstration of Capability

14.2.1 Initial and continuing demonstrations of capability requirements are established in the ST-QAM.

14.3 Training Qualification

14.3.1 The manager/supervisor has the responsibility to ensure that this procedure is performed by an analyst who has been properly trained in its use and has the required experience.

14.3.2 The analyst must have successfully completed the initial demonstration capability requirements prior to working independently. See requirements in the ST-QAM.

14.4 Annually, the analyst must successfully demonstrate proficiency to continue to perform this analysis. See requirements in the ST-QAM.

15.0 VALIDATION

15.1 Laboratory SOPs are based on published methods (EPA, DOE, ASTM, Eichrom, Standard Methods) and do not require validation by the laboratory. The requirements for laboratory demonstration of capability are included in the ST-QAM. Laboratory validation data would be appropriate for performance based measurement systems, non-standard methods and significant modifications to published methods. Data from said validations is held in the QA department.

16.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

16.1 All waste will be disposed of in accordance with Federal, State and Local regulations. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in section 13 of the Corporate Safety Manual for "Waste Management and Pollution Prevention."

16.2 Waste Streams Produced by this Method

16.2.1 Acidic sample waste

16.2.1.1 All acidic waste will be accumulated in the appropriate waste accumulation container, labeled as Drum Type "A" or "B."

16.2.1.2 Contaminated disposable glass or plastic materials utilized in this analysis are disposed of in the sanitary trash. If the lab ware was used for the analysis of radioactive samples and contains radioactivity at a level of 100 cpm over background as determined by a GM meter, the lab ware will be collected in waste barrels designated for solid rad waste and disposed of by the EH&S Coordinator.

17.0 REFERENCES

17.1 Test Methods for Evaluating Solid Waste , Physical/Chemical Methods, SW-846, 3rd Edition, Revision 2, January 1998, Method 7471B (Mercury).

17.2 TestAmerica St. Louis Quality Assurance Manual (ST-QAM), current revision.

17.3 TestAmerica Corporate Environmental Health and Safety Manual (CW-E-M-001) and St. Louis Facility Addendum (ST-HS-0002), current revisions.

17.4 Associated SOPs, current revisions:

17.4.1 ST-QA-0002, Standard and Reagent Preparation

17.4.2 ST-QA-0005, Calibration and Verification Procedure for Thermometers, Balances, Weights and Pipettes

17.4.3 ST-QA-0016, IDL/MDL Determination

17.4.4 ST-QA-0014, Evaluation of Analytical Accuracy and Precision Through the Use of Control Charts

17.4.5 ST-QA-0036, Non-conformance Memorandum (NCM) Process

17.4.6 ST-PM-0002, Sample Receipt and Chain of Custody

17.4.7 ST-IP-0004, Labware Preparation for Inorganic and Trace Metals Analysis

18.0 CLARIFICATIONS, MODIFICATIONS AND ADDITIONS TO REFERENCE METHOD

18.1 Stannous chloride is used in place of Stannous sulfate.

18.2 TestAmerica St.Louis uses less DI water in steps 11.1.5.12 and 11.1.5.13 than the method suggests. The laboratory considers the volume of 15 mL not to be significant enough to render compensation/adjustment when diluting sample to final volume. The lab has adjusted the final volume of the standards and samples by 15 mL.

18.3 TestAmerica uses an ERA solid reference material for the LCS. Control limits supplied by ERA are used to determine acceptability of the LCS recovery.

18.4 Method SW-846 1311 requires that the Method Standard Addition (MSA) be used when matrix spike recovery is less than 50% and the measured sample results is within the range of 80-120% of the Toxicity Characteristics Limit.

19.0 CHANGES TO PREVIOUS REVISION

19.1 Removed sulfuric acid from section 5.0. It is no longer used in this method.

19.2 Updated section 10.0 by adding Low Level Check (LLC)

19.3 Added instructions on how to prepare an ICV, LLC and CCV in section 11.0

19.4 Added LLC, CCV and CCB to the list of analytical sequences in section 11.2.

19.5 Rev. 10;

- 19.5.1 Updated post digestion spike section 9.7; removed serial dilution requirements.
- 19.5.2 Updated MSA section 9.8; removed suggested criteria for MSA analysis.
- 19.5.3 Added Method 1311 MSA requirements, section 18.4.

19.6 Rev. 11:

- 19.6.1 Added instrument hardware and software to section 6.0.
- 19.6.2 Added requirement to document preparation of calibration standard to section 10.1.
- 19.6.3 Clarified instructions on addition of permanganate solution in section 11.4.

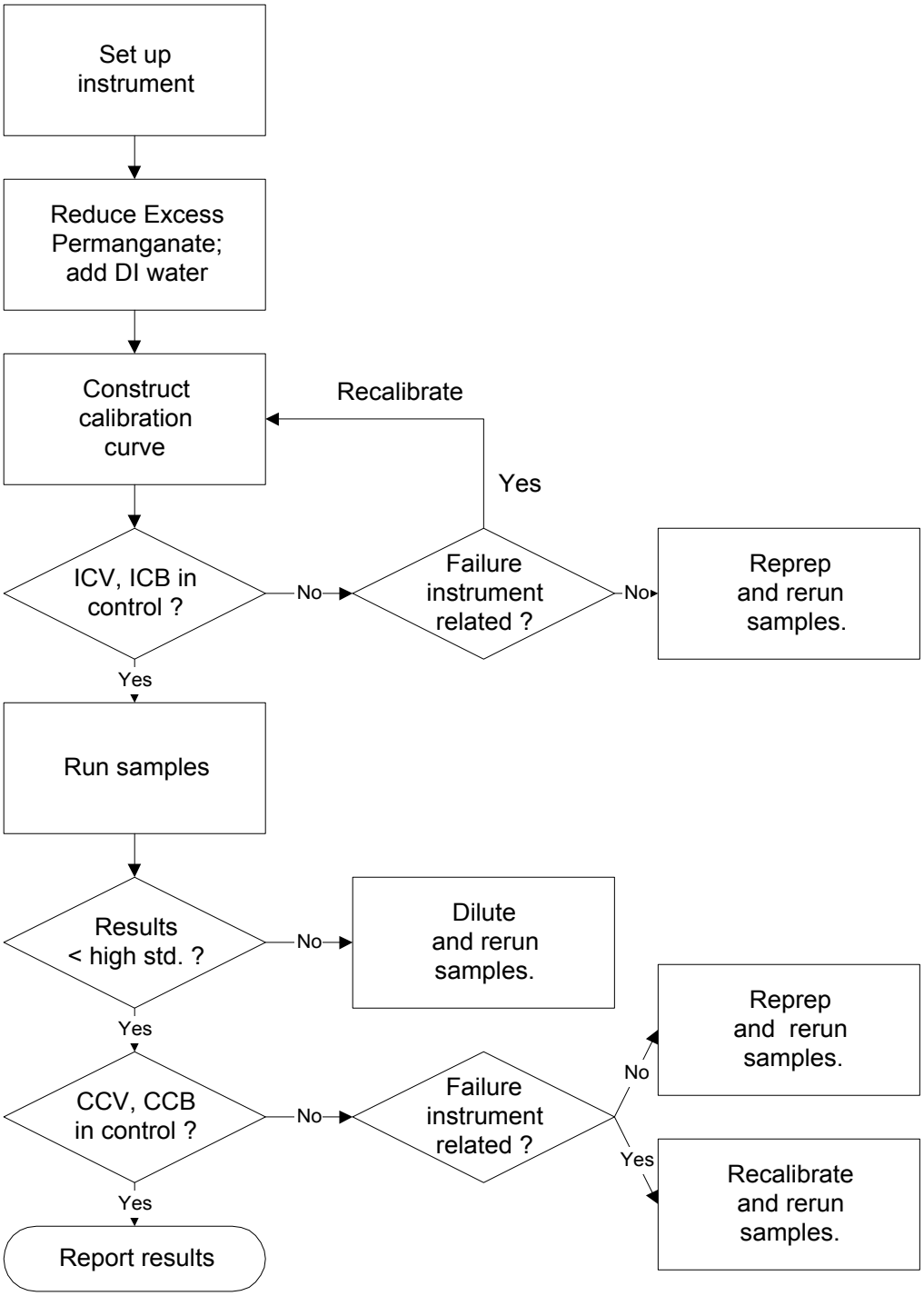
19.7 Rev. 12:

- 19.7.1 Updated requirement for prepping all client and QC samples in section 11.4.3.8.

19.8 Rev. 13:

- 19.8.1 Removed references to QuantIMS and Clouseau
- 19.8.2 Section 6, updated top-loading balance and DI water requirements
- 19.8.3 Section 9, recovery criteria and updated post digestion spike recovery criteria
- 19.8.4 Section 10, updated Low Level Check and Continuing Calibration Blank
- 19.8.5 Section 11, added sample amount for CCV preparation
- 19.8.6 Section 13 updated
- 19.8.7 Section 15 updated

CVAA Mercury Analysis



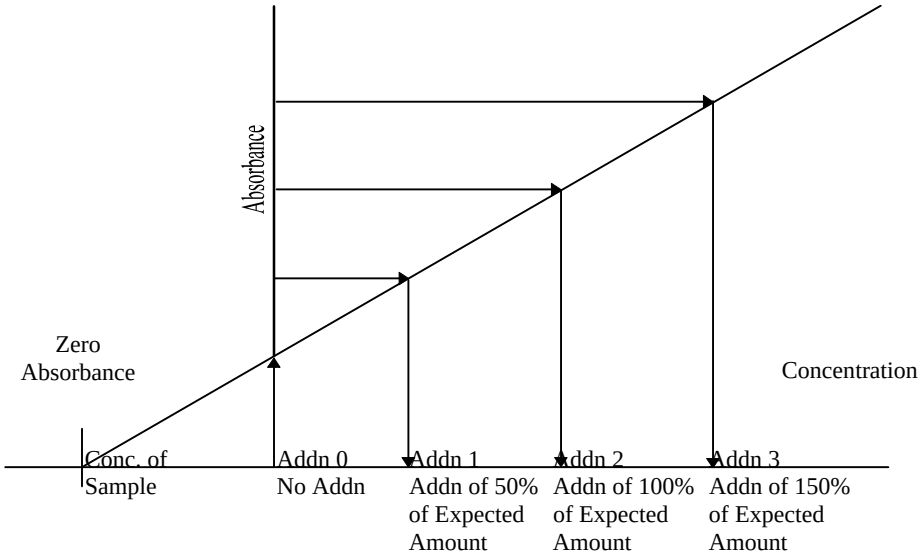
MSA GUIDANCE

Method of Standard Addition

Four equal volume aliquots of sample are measured and known amounts of standards are added to three aliquots. The fourth aliquot is the unknown and no standard is added to it. The concentration of standard added to the first aliquot should be 50% of the expected concentration. The concentration of standard added to the second aliquot should be 100% of the expected concentration and the concentration of standard added to the third aliquot should be 150% of the expected concentration. The volume of the unspiked and spiked aliquots should be the same (i.e., the volume of the spike added should be negligible in relation to the volume of sample).

To determine the concentration of analyte in the sample, the absorbance (or response) of each solution is determined and a linear regression performed. On the vertical axis the absorbance (or response) is plotted versus the concentrations of the standards on the horizontal axis using 0 as the concentration of the unspiked aliquot. An example plot is shown in Figure 1. When the resulting line is extrapolated back to zero absorbance, the point of interception of the horizontal axis is the concentration of the unknown. Calculate the correlation coefficient (r) and the x-intercept (where y=0) of the curve. The concentration in the digestate is equal to the negative x-intercept.

Figure



- For the method of standard additions to be correctly applied, the following limitations must be taken into consideration.
- The plot of the sample and standards must be linear over the concentration range of concern. For best results, the slope of the curve should be similar to that of a plot of the aqueous standard curve.
- The effect of the interference should not vary as the ratio of the standard added to the sample matrix changes.

Title: Determination of Hexavalent Chromium By Manual Colorimetric Method [Method SW-846/7196A]

Approvals (Signature/Date):

Elizabeth Nguyen — Date: 5/25/12
Technical Manager

Joe Schairer — Date: 5/27/12
Health & Safety Manager / Coordinator

Douglas Weir — Date: 06/01/12
Quality Assurance Manager

Karla Buechler — Date: 6/4/12
Laboratory Director

1. SCOPE AND APPLICATION

1.1. This procedure is used for the determination of dissolved hexavalent chromium by EPA method 7196A.

1.2. This method is applicable to waters, soils, sediments, solid waste samples, TCLP and STLC extracts.

1.3. The reporting limit is 0.01 mg/L for water samples and 0.05 mg/kg for soil and waste samples. The linear range of the calibration curve is 0.005 mg/L – 0.1 mg/L.

1.4. When undertaking projects for Department of Defense (DoD) the relevant criteria in QA Policy WS-PQA-021 "DoD QSM and AFCEE QAPP Implementation" must be checked and incorporated.

2. SUMMARY OF METHOD

2.1. Hexavalent chromium, in the absence of interfering amounts of substances such as molybdenum, vanadium, and mercury, may be determined colorimetrically from the reaction with diphenylcarbazide in acidic solution. The addition of an excess of diphenylcarbazide yields the red-violet product of unknown composition, and its absorbance is measured photometrically at 540 nm.

3. DEFINITIONS

3.1. Definitions of terms used in this SOP may be found in the glossary of the Quality Assurance Manual (QAM).

3.2. Data qualifiers are defined on each data report. Commonly used data qualifiers are defined in the QAM.

4. INTERFERENCES

4.1. Hexavalent molybdenum and mercury salts react with diphenylcarbazide, but the intensity of the colors produced is much lower and concentrations up to 200 mg/L can be tolerated.

4.2. Vanadium interferes strongly at concentrations greater than 10 times the concentration of hexavalent chromium.

4.3. Iron at concentrations greater than 1 mg/L may produce a yellow color but should not interfere at the wavelength used in this analysis.

4.4. Turbidity and color in the samples may cause erroneously high absorbance readings. In such cases, filtration and or centrifugation may be required.

4.5. Reducing agents such as sulfite and organic compounds interfere by reducing hexavalent chromium to trivalent chromium.

5. SAFETY

Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001), the West Sacramento Addendum to the Corporate EH&S Manual (WS-PEHS-002) and this document. This procedure may involve hazardous material, operations and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toes, nonabsorbent shoes are a minimum.

5.1. Specific Safety Concerns or Requirements

5.1.1. Samples that contain high concentrations of carbonates or organic material or samples that are at elevated pH can react violently when acids are added.

5.1.2. Eye protection that satisfies ANSI Z87.1, laboratory coat, and chemically resistant gloves must be worn while samples, standards, solvents, and reagents are being handled. Latex, vinyl and nitrile gloves all provide satisfactory protection.

5.1.3. Exposure to chemicals must be maintained as low as reasonably achievable; therefore all samples must be opened, transferred and prepared in a fume hood. Solvent and waste containers will be kept closed unless transfers are being made.

5.1.4. Laboratory procedures such as repetitive use of pipettes, repetitive transferring of extracts and manipulation of filled separatory funnels and other glassware represent a significant potential for repetitive motion or other ergonomic injuries. Laboratory associates performing these procedures are in the best position to realize when they are at risk for these types of injuries. Whenever a situation is found in which an employee is performing the same repetitive motion, the employee shall immediately bring this to the attention of their supervisor, manager, or the EH&S staff. The task will be analyzed to determine a better means of accomplishing it.

5.2. Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. **NOTE: This list does not include all materials used in**

the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
1,5-Diphenylcarbazide	Irritant		Causes irritation to skin, eyes, mucous membranes, upper respiratory tract
Acetone	Flammable	1000 ppm-TWA	Inhalation of vapors irritates the respiratory tract. May cause coughing, dizziness, dullness, and headache.
ChromaVer 3 (Cr(VI)+ Reagent)	Irritant	None established	Causes eye burns. May cause respiratory tract irritation.
Potassium Permanganate	Oxidizer	5 mg/m^3 for Mn Compounds	Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath. Dry crystals and concentrated solutions are caustic causing redness, pain, severe burns, brown stains in the contact area and possible hardening of outer skin layer. Diluted solutions are only mildly irritating to the skin. Eye contact with crystals (dusts) and concentrated solutions causes severe irritation, redness, and blurred vision and can cause severe damage, possibly permanent.
Sulfuric Acid (1)	Corrosive Oxidizer Dehydrator Poison Carcinogen	1 Mg/M3-TWA	Inhalation produces damaging effects on the mucous membranes and upper respiratory tract. Symptoms may include irritation of the nose and throat, and labored breathing. Symptoms of redness, pain, and severe burn can occur. Contact can cause blurred vision, redness, pain and severe tissue burns. Can cause blindness.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			

6. EQUIPMENT AND SUPPLIES

6.1. A ThermoSpectronic Genesys 20 spectrophotometer for use at 540 nm, providing a light path of 1 cm.

6.2. 1- cm disposable absorbance cell cuvettes.

6.3. 100 uL, 1 mL, 10 mL adjustable air displacement pipettes.

6.4. 13 mL capacity test tubes.

6.5. Narrow range pH test strips.

6.6. Miscellaneous laboratory glassware.

7. REAGENTS AND STANDARDS

7.1. Use reagent grade chemicals in all tests. "Certificates of Analysis" should be supplied with all chemicals purchased. If not supplied, contact the vendor. When received, label the certificate and the reagent container with the receipt date. Reagent containers also need to be labeled with the opened and expiration dates when opened.

7.2. Reagent water is produced by a Millipore nanopure system. Reagent water must be free of the analytes of interest as demonstrated through the analysis of method blanks.

7.3. HACH ChromaVer 3 hexavalent chromium reagent.

7.4. Diphenylcarbazide(DPC) solution: Weigh and transfer 250 mg of 1,5 diphenylcarbazide into a 50 ml volumetric flack containing 25 ml of acetone. Dissolve and dilute to the mark with acetone. Store in a brown bottle. Do not use when solution becomes discolored.

7.5. Cr(VI) certified stock calibration standard, 1 mg/L: Obtain commercially. The expiration date for this standard is the earlier of the date printed on the container or one year.

7.6. Cr(VI) certified stock second source standard, 10 mg/L: Obtain commercially and from a different manufacturer or with a different lot ID from the calibration stock solution (Section 7.5). The expiration date for this standard is the earlier of the date printed on the container or one year.

7.7. 0.04 mg/L hexavalent chromium ICV/LCS standard: add 0.04 ml of 10 mg/L stock standard (Section 7.6) to a test tube and dilute to 10 mL with reagent water.

7.8. Reagent Grade 50% H_2SO_4.

7.9. Reagent Grade Acetone.

7.10. 1,5 Diphenylcarbazide powder.

7.11. Reagent grade potassium Permanganate ($KMnO_4$)

7.11.1. Potassium Permanganate Stock Solution: Dissolve 0.16g of Potassium Permanganate into a 100mL volumetric flask containing reagent water and fill to volume mark.

7.11.2. Potassium Permanganate, 0.10mM: Pipet 1.0mL of Potassium Permanganate Stock Solution into a 100mL volumetric flask. Dilute to volume with reagent

water.

8. SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1. The holding time for aqueous samples is 24 hours from collection.

8.2. For solids, the holding time to preparation (deionized water leaching in accordance with SOP WS-WC-0049) is 30 days, and the holding time to analysis is 24 hours from the beginning of the leaching procedure.

8.3. The holding time for leachates prepared in accordance with SOP WS-IP-0004 (e.g., TCLP, STLC, etc) is 24 hours from the end of the leaching procedure.

8.4. To retard the chemical activity of hexavalent chromium, aqueous and solid samples along with extracts must be stored at 4°C ± 2°C until analyzed.

9. QUALITY CONTROL

9.1. The wavelength accuracy of non-scanning (manually advanced) monochromators in VIS/UV-VIS spectrophotometers must be checked annually. The checks must be documented and available for inspection. Any repairs or problems are documented in the maintenance logbook for the spectrophotometer.

9.2. Batch - A quality control batch is a set of no more than 20 field samples that consist of the same matrix and are processed using the same procedures, reagents and standards. A batch must be analyzed within the same time frame. A method blank (MB), laboratory control sample (LCS), or duplicate control sample (DCS) are analyzed as a part of every batch. Each batch must also be processed with a matrix spike/matrix spike duplicate (MS/SD). An analysis batch must include all QC samples, however they do not contribute to the maximum of 20 samples. Refer to the QC Program document (WS-PQA-0003) for more details.

9.3. One method blank must be reported for every 20 samples. The Initial Calibration Blank (ICB) is reported as the method blank for the first 20 aqueous samples. If more than 20 samples are analyzed, the continuing calibration blank (CCB) immediately preceding analysis of the second batch is reported as the method blank for all samples associated with the batch. Corrective action for aqueous method blanks is the same as for the corresponding instrument blank (Sections 9.6, 9.7). For solid samples, a leachate blank is used as the method blank. If a method blank exceeds ± the reporting limit than the samples must be re-extracted. For DOD projects, the method blank must be less than ½ the reporting limit. The exception is samples that are less than the reporting limit and those that exceed 10X the concentration of the analyte in the method blank. In such cases, the data can be reported and all corrective actions documented on a Non-Conformance memo. Refer to the QC Program document (WS-PQA-0003) for more details.

9.4. A laboratory control sample (LCS) must be reported for every 20 samples analyzed. The ICV is reported as the LCS for the first 20 aqueous samples. If more than 20 samples are analyzed, the CCV immediately preceding analysis of the second batch of samples is reported as the LCS for the associated samples. If a DCS (LCS-DUP) is required, a second LCS is analyzed and reported; alternatively the first two CCV's are reported as the LCS and DCS/LCS-DUP. Corrective action for an aqueous LCS is the same as for the corresponding instrument QC (Sections 9.7, 9.8). The leachate MB is spiked and reported as the LCS for solid samples. The LCS acceptance criterion is 90-110% recovery.

9.5. A matrix spike/matrix spike duplicate (MS/SD) pair must be analyzed with every batch. If the batch is greater than 10 samples, a second MS/SD pair is required. MS/SD pairs are aliquots of a selected field sample spiked with analyte of known identity and concentration. Spiked samples with percent recoveries or precision (RPD) outside of designated control limits for an analyte must be associated with an LCS that demonstrates that the system is in control. Carefully evaluate and review any out-of-control event. Re-analysis of an MS/SD pair may be required if there is any question that anomalous results may be due to instrument problems and not the matrix of the sample.

Note: Samples identified as field blanks, equipment blanks, or trip blanks should not be used for MS/SD analysis.

9.5.1. Recovery trends of less than 85% should be assessed to determine if the low spike recovery is due to the presence of residual reducing agent. This assessment is performed by first taking an aliquot of the sample and adjusting the pH to 8.0-8.5 using 1 N sodium hydroxide, then respiking and analyzing.

9.5.2. If the MS/SD is out of control, the sample may be diluted and reanalyzed.

9.6. A duplicate control sample (LCS/LCSD) may be substituted when insufficient volume is provided to process a sample/sample duplicate or MS/SD pair or as required by client or regulatory requirements. The LCS and LCSD are evaluated independently for acceptance. Refer to the QC Program document (WS-PQA-0003) for more details.

9.7. Initial Calibration Verification (ICV/ICB) – Calibration accuracy is verified by analyzing a second source standard immediately following instrument calibration. This standard must be at a concentration different from the CCV standard. The ICV must fall within ± 10% of the true value of the standard solution. An ICB prepared the same as the calibration blank must be analyzed immediately following the ICV to monitor low level accuracy and system cleanliness. The ICB result must fall within ± the reporting limit from zero. If either the ICV or ICB fail to meet acceptance criteria, the analysis must be terminated, the problem corrected, and the instrument re-calibrated.

9.8. Continuing Calibration Verification (CCV/CCB) – Calibration accuracy is evaluated throughout the analytical run by analyzing a continuing calibration verification standard (CCV) of a known concentration every 10 samples. In this case, a sample is any analysis that registers a result, whether the result is reported or not. The CCV must be a mid-range standard at a concentration other than that of the ICV. In most cases, the CCV is one of the middle standards used during calibration. The CCV must fall within ± 10% of the true value. A continuing calibration blank (CCB) prepared the same as the calibration blank must be analyzed following every CCV. The CCB must fall within ± RL from zero. Each CCV and CCB analyzed must reflect the conditions of the analysis of the associated samples. If a CCV or CCB fails, the analysis must be terminated, the problem corrected, the instrument re-calibrated, the calibration verified and the affected samples reanalyzed.

10. CALIBRATION

10.1. Annual Spectrophotometer Wavelength Check – The wavelength accuracy of non-scanning (manually advanced) monochromators in VIS/UV-VIS spectrophotometers is checked annually. The wavelengths of two peak maxima of a dilute solution of Potassium Permanganate (0.1mM $KMnO_4$) are determined on the VIS/UV-VVIS spectrophotometer and these determined wavelengths are compared to the true values.

10.1.1. Allow the spectrophotometer to warm up for at least ½ hour before using.

10.1.2. Set the monochromator to wavelength of 516mm and zero the instrument with reagent water. Fill a test tube with 0.10mM $KMnO_4$ solution, insert into the instrument and record the absorbance.

10.1.3. Advance the monochromator by a wavelength increment of 5mm, zero the instrument with reagent water and record the absorbance of the 0.10mM $KMnO_4$ solution. Continue advancing the monochromator in 5mm increments to 556mm, zeroing, and recording the absorbance of the 0.10mM $KMnO_4$ solution at each wavelength.

10.1.4. Find and record the instrument's wavelengths of maximum absorbance from the tabulation of absorbance values. One maximum absorbance should occur at 526mm and a second at either 541mm or 546mm. If these criteria are not met, the instrument should be serviced by qualified personnel.

10.2. Linear Dynamic Range Verification (LDR) – The linear dynamic range must be verified every six months for each analyte wavelength used on each instrument. The linear dynamic range is the concentration above which results cannot be reported without dilution of the sample. The standards used to define the linear dynamic range limit must be analyzed during a routine analytical run. For the initial determination and semi-annual verification of the upper limit of the LDR for each wavelength, determine the signal responses from a minimum of three different concentration

standards across the estimated range. One standard should be at or near the upper limit of the estimated range. The concentration measured at the upper limit of the LDR should be no more than 10% less than the expected level extrapolated from lower standards If the instrument is adjusted in any way that may affect the LDR's, new dynamic ranges must be determined. The LDR data must be documented and kept on file..

10.3. For details of the calculations used to generate the regression equations, and how to use the factors generated by these equations, refer to SOP CA-Q-S-005 "Calibration Curves (General)".

10.4. Prepare the calibration curve every 24 hours of operation.

10.5. One standard must be analyzed at the reporting limit. Analyze standards in ascending order beginning with the calibration blank.

10.5.1. Prepare the working hexavalent chromium calibration standards by diluting the 1.0 mg/L Cr(VI) stock calibration standard with reagent water as follows:

Standard	Aliquot (mL)	Final Volume (mL)	Final Concentration (mg/L)
1	0.05	10	0.005
2	0.1	10	0.01
3	0.25	10	0.025
4	0.5	10	0.05
5	1.0	10	0.1

10.5.2. The 0.005 mg/L Cr(VI) is analyzed as the first standard to meet client-specific requirements.

10.5.3. An ICV/LCS of 0.04 mg/L Cr(VI) is made by diluting 0.04 mL of the 10.0 mg/L Cr(VI) second source standard to 10 mL using reagent water in a 13 mL test tube.

10.5.4. The 0.05 mg/L Cr(VI) standard is also used as the CCV.

10.6. The calibration curve must have a correlation coefficient (r) $\geq$ 0.995.

11. PROCEDURE

11.1. Procedural Variations

Procedural variations are allowed only if deemed necessary in the professional judgment of the supervisor to accommodate variation in sample matrix, radioactivity, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using a Nonconformance memo and approved by a supervisor

and QA/QC manager. If contractually required, the client will be notified. The Nonconformance memo will be filed in the project file.

Any deviations from this procedure identified after the work has been completed must be documented as a nonconformance, with a cause and corrective action described. A Nonconformance memo shall be used for this documentation.

11.2. Any unauthorized deviations from this procedure must also be documented as a nonconformance, with a cause and corrective action described (see WS-QA-0023, Nonconformance and Corrective Action System).

11.3. This analytical method is restricted to use by, or under the supervision of, an analyst experienced in the operation of a manual spectrophotometer and the interpretation of its results.

11.4. Allow the spectrophotometer to warm up for at least 1/2 hour before using.

11.5. Sample and Standard Analysis

11.5.1. Prepare MS/MSDs for aqueous samples by spiking 10 mL of sample with 0.05 mL of the 10.0 mg/L Cr(VI) second source calibration standard. The resulting spiking level is 0.05 mg/L Cr(VI).

11.5.2. Extract solid samples at 10.0 g solids to 50 g reagent water as directed in SOP WS-WC-0049.

11.5.2.1. Prepare LCSs for leachates by spiking the leached method blank with 0.04 mL of the 10 mg/L Cr(VI) stock calibration standard and diluting to a final volume of 10 mL with method blank solution. The final concentration of the LCS is 0.2 mg/kg.

11.5.2.2. Prepare MS/MSDs for leachates by spiking 10mL of a leached sample with 0.05 mL of the 10.0 mg/L Cr(VI) second source calibration standard. If a sample requires dilution due to matrix or high analyte levels, the appropriate volume of sample is spiked with 0.05 mL of the 10.0 mg/L Cr(VI) second source calibration standard. and diluted to a final volume of 10 mL with reagent water. The final concentration of the leachate is 0.25 mg/kg.

11.5.3. Make the calibration curve, ICV, and CCVs according to Section 10.

11.5.4. Pipet 10 mL of each sample into two test tubes, one to be measured for any background absorbance (color blank), the other to be measured for color development (sample Cr(VI) absorbance).

11.5.5. If the samples are turbid, filter or centrifuge prior to the addition of reagents.

11.5.6. For calibration standards, ICVs, CCVs, and all blanks, making a color blank for background absorbance is not necessary.

11.5.7. Add the contents of one ChromaVer 3 hexavalent chromium reagent pillow or 0.2 ml of DPC solution to each of the sample and standard tubes. If using DPC solution, also add one drop of 50% H_2SO_4. Do not add the DPC reagent to the background absorbance tubes.

11.5.8. Add one drop of 50% H_2SO_4 to each color blank.

11.5.9. Cover and mix well. Allow 15 minutes for complete color development.

11.5.10. Check the pH of each color sample to assure the pH is 2 ± 0.5. Samples with high buffering capacity may interfere with obtaining the desired pH using the ChromaVer 3 reagent alone. If this occurs, add 50% H_2SO_4 to reach the desired pH.

11.5.11. Use reagent water to zero the instrument at 540 nm.

11.5.12. Pour an aliquot into a disposable absorbance cuvette and insert into the spectrometer, assuring the clear windows are directed towards the pathlength.

11.5.13. Read the absorbance of the calibration curve, including a calibration blank treated the same as all of the treated samples and standards.

11.5.14. Read the background absorbance for samples followed by the reading of the treated samples.

11.5.15. Enter the results in “real time” into the hexavalent chromium linear regression computer program.

12. CALCULATIONS/DATA REDUCTION

12.1. Data is calculated using linear regression.

12.2. Correct the absorbance reading for all samples using the following calculation:

12.2.1. (Color Sample Absorbance – Background Absorbance) = True Absorbance

12.2.2. Calculate the sample concentration by plotting the true absorbance reading against the standard curve.

12.3. Samples falling outside the linear range must be diluted and reanalyzed. The Dilution Factor (DF) is used to calculate the final concentration of the diluted sample.

12.4. For soil leachates, calculate the final concentration in by multiplying the prep factor (PF) by the final concentration found in the leachate in mg/L. Final units are mg/kg.

13. METHOD PERFORMANCE

13.1. The group/team leader has the responsibility to ensure that this procedure is performed by an associate who has been properly trained in its use and has the required expertise.

13.2. Method Detection Limit

The laboratory must generate a valid method detection limit for each analyte of interest. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in SOP WS-QA-0006. MDLs are available in the Quality Assurance Department.

13.3. Initial Demonstration

The laboratory must make an initial demonstration of capability for each individual method. Demonstration of capability for both soil and water matrices is required. This requires analysis of QC check samples containing all of the standard analytes for the method. For some tests it may be necessary to use more than one QC check mix to cover all analytes of interest.

13.3.1. Four aliquots of the QC check sample are analyzed using the same procedures used to analyze samples, including sample preparation. The concentration of the QC check sample should be less than or equivalent to the LCS samples.

13.3.2. Calculate the average recovery and standard deviation of the recovery for each analyte of interest. Compare these to the laboratory generated QC Limits.

13.4. If any analyte does not meet the acceptance criteria the test must be repeated. Only those analytes that did not meet criteria in the first test need to be evaluated. Repeated failure for any analyte indicates the need for the laboratory to evaluate the analytical procedure and take corrective action.

14. POLLUTION CONTROL

It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity needed, preparation of reagents based on anticipated usage and reagent stability). Employees must abide by the policies in Section 13 of the Corporate Environmental Health and Safety Manual (CW-E-M-001) for "Waste Management and Pollution Prevention."

15. WASTE MANAGEMENT

Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes are disposed of in an accepted manner.

Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to SOP WS-EHS-0001. The following waste streams are produced when this method is carried out.

15.1. Acidic liquid waste generated by the analysis is collected in a 1L polymer jar. When the polymer jar is full, or after no more than one year, move the carboy to the waste collection area where it will be consolidated into a plastic LLE drum for shipment.

15.2. Contaminated disposable glass test tubes and cuvettes. Collect the liquid waste as described above, then drop the glass into a contaminated glass box. When the box is full or after no more than 75 days, move it to the waste collection area for shipment.

16. REFERENCES/CROSS REFERENCES

16.1. Method 7196A, "Chromium, Hexavalent (Colorimetric)", Test Methods For Evaluating Solid Waste, Physical/Chemical Methods, 3rd Edition, Final Update II; EPA July 1992.

16.2. HACH, Method 8023

16.3. Handbook for Analytical Quality Control in Water and Wastewater laboratories, EPA-600/4, 79-019, U.S. EPA Office of Research and Development, Cincinnati March 1979.

16.4. Environmental Laboratory Approval Program Certification Manual; New York DOH, Albany, NY.

17. METHOD MODIFICATIONS

17.1. Reduced volume versions of the method source applied to this SOP are acceptable as long as the same volume-ratio of samples and reagents are used and they meet the quality control performance requirements stated in the method.

17.2. Section 7.3.4 of the reference Method is not included in this SOP. This facility does not perform methods 7195 or 7197.

17.3. HACH *ChromaVer 3* hexavalent chromium reagent can be used as a replacement for diphenylcarbazide and H_2SO_4.

17.4. pH strips are used instead of a pH meter to measure and adjust sample pH.

17.5. Sections 7.5 and 8.6 of the reference method (method of standard addition for delisting petitions) are not included in this SOP. This procedure is not appropriate for delisting petition.

18. ATTACHMENTS

18.1. None.

19. REVISION HISTORY

19.1. WS-WC-0020, Revision 7.4, Effective 6/08/2012

19.1.1. Updated annual spectrophotometer wavelength check procedures in Sections7 and 10.

19.1.2. Added Potassium Permanganate to Section 7.

19.1.3. Editorial revision.

19.2. WS-WC-0020, Revision 7.3, Effective 2/13/2011

19.2.1. Modified Section 6.1 to read: “A ThermoSpectronic Genesys 20 spectrophotometer for use at 540 nm, providing a light path of 1 cm.”

19.2.2. Editorial Revisions

19.2.3. Switched order of Sections 9.4.1 and 9.4.2.

19.3. WS-WC-0020, Revision 7.2, Effective 9/4/2009

19.3.1. Changed SOP header from [Method SW-946/7196A] to [Method SW-846/7196A].

19.4. WS-WC-0020, Revision 7.1, Effective 9/4/2009

19.4.1. Added Section 1.4, “When undertaking projects for Department of Defense (DoD) the relevant criteria in QA Policy WS-PQA-021 “DoD QSM and AFCEE QAPP Implementation” must be checked and incorporated.”

19.4.2. Inserted Section 10.1, “For details of the calculations used to generate the regression equations, and how to use the factors generated by these equations, refer to SOP CA-Q-S-005 “Calibration Curves (General)”.”

19.5. WS-WC-0020, Revision 7, Effective 8/29/2008

19.5.1. Updated to TestAmerica format.

APPENDIX B

EXAMPLE OF CHAIN-OF-CUSTODY RECORD, SAMPLE LABEL, AND CUSTODY SEAL (on CD only)

This page intentionally left blank.

TETRA TECH
1230 Columbia Street, Suite 500
San Diego, CA 92101 (619) 234-8696

NUMBER 21700

CHAIN-OF-CUSTODY RECORD

PROJECT NAME	PURCHASE ORDER NO.	ANALYSES REQUIRED	LABORATORY NAME	Project Information Section Do not submit to Laboratory
PROJECT LOCATION	PROJECT NO.			
SAMPLER NAME	AIRBILL NUMBER		LABORATORY ID (FOR LABORATORY)	
PROJECT CONTACT	PROJECT CONTACT PHONE NUMBER			

SAMPLE ID	DATE COLLECTED	TIME COLLECTED	NO. OF CONTAINER	LEVEL 3	LEVEL 4	TYPE	TAT	COMMENTS	LOCATION	DEPTH START	DEPTH END	QC

RELINQUISHED BY (Signature)	DATE	RECEIVED BY (Signature)	LABORATORY INSTRUCTIONS/COMMENTS	SAMPLING COMMENT:
COMPANY	TIME	COMPANY		
RELINQUISHED BY (Signature)	DATE	RECEIVED BY (Signature)	COMPOSITE DESCRIPTION	
COMPANY	TIME	COMPANY		
RELINQUISHED BY (Signature)	DATE	RECEIVED BY (Signature)	SAMPLE CONDITION UPON RECEIPT (FOR LABORATORY)	
COMPANY	TIME	COMPANY	TEMPERATURE: _____ SAMPLE CONDITION: ☐ INTACT ☐ BROKEN COOLER SEAL: ☐ INTACT ☐ BROKEN	

White - Laboratory; Pink - Laboratory; Canary - Project File; Manila - Data Management

SAMPLE LABEL (EXAMPLE)

SAMPLE NO.:_____
PROJECT:_____
DATE:_____/_____/_____ **TIME:**_____**HRS**_____
MEDIUM: WATER_____ **SOIL**_____ **SEDIMENT**_____
OTHER_____**(Specify)**
TYPE: GRAB_____ **COMPOSITE**_____ **OTHER**_____
PRESERVATION:_____
ANALYSIS:_____
SAMPLED BY:_____
REMARKS:_____
_____

CUSTODY SEAL (EXAMPLE)

CUSTODY SEAL

Person Collecting Sample**:**_____ Sample No**.:**_____
(Signature)
Date Collected:_____ Time_____
_____

ATTACHMENT 2

PROJECT CONTRACTOR QUALITY CONTROL PLAN

This page intentionally left blank.

U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

ATTACHMENT 2

FINAL

PROJECT CONTRACTOR QUALITY CONTROL PLAN
July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION
AT FORMER NAVAL STATION PUGET SOUND
SEATTLE, WASHINGTON

TETRA TECH EC, INC.

1230 Columbia Street, Suite 750
San Diego, California 92101-8530

Greg Joyce
QC Program Manager

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

TABLES

FIGURES

APPENDICES

This page intentionally left blank.

ABBREVIATIONS AND ACRONYMS

AHA	Activity Hazard Analysis
APP	Accident Prevention Plan
BRAC	Base Realignment and Closure
CQC	contractor quality control
CTO	Contract Task Order
DCN	Design Change Notice
DFW	definable feature of work
DN	deficiency notice
DoD	Department of Defense
EBS	Environmental Baseline Survey
EHS	environmental health and safety
EM	Engineer Manual
FCR	Field Change Request
NAS	Naval Air Station
NAVSTA PS	Naval Station Puget Sound
NCR	Nonconformance Report
NTR	Navy Technical Representative
PCQC	project contractor quality control
PESM	Project Environmental Safety Manager
PjM	Project Manager
PQCM	Project Quality Control Manager
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
QCPM	Quality Control Program Manager
RPM	Remedial Project Manager
SSHO	Site Safety and Health Officer

ABBREVIATIONS AND ACRONYMS
(Continued)

SSHP	Site Safety and Health Plan
TCRA	time-critical removal action
TtEC	Tetra Tech EC, Inc.
UFGS	Unified Facilities Guide Specification

1.0 INTRODUCTION

This Project Contractor Quality Control (PCQC) Plan establishes the procedures and methods to be implemented in association with a radiological materials time-critical removal action (TCRA) at the former Naval Station Puget Sound (NAVSTA PS) in Seattle, Washington. This PCQC Plan will address remediation of radiologically contaminated building components, soil, and drain systems. Tetra Tech EC, Inc. (TtEC) has been contracted by the Department of the Navy (Navy) to perform this work at former NAVSTA PS for the Base Realignment and Closure (BRAC) Program Management Office West under Naval Facilities Engineering Command Southwest Contract No. N62473-10-D-0809, Contract Task Order (CTO) 0011. This PCQC Plan fulfills the TtEC quality control (QC) system requirements.

1.1 SITE LOCATION AND BACKGROUND

Former NAVSTA PS is located northeast of downtown Seattle on the western shore of Lake Washington. Former NAVSTA PS was initially named Naval Air Station (NAS) Seattle. Portions of the facility were built in 1925 on land donated by King County. Many of the major buildings were built in the late 1930s prior to World War II, including Building 27 (1937) and Building 2 (1929). Further building construction and remodeling took place in later years, including the addition of the South Shed to Building 27 in 1944 and the expansion of the instrument shop in Building 2 in 1943 (1943 Instrument Shop).

During World War II, NAS Seattle supported air transport and ship outfitting personnel for the Alaskan and Western Pacific theaters of operation. After World War II, NAS Seattle was designated a Naval Reserve Air Station. From 1945 to 1970, the station maintained naval reserve squadrons for supplementing active duty forces, both in the continental United States and abroad. Aviation activities officially ceased June 30, 1970, and NAS Seattle was decommissioned. On July 1, 1970, NAS Seattle was redesignated Naval Support Activity, Seattle. From 1970 until April 1, 1982, the base provided logistic services such as supply, billeting, and administration to the 13th Naval District, Department of Defense (DoD) activities and other federal agencies. In April 1982, Naval Support Activity, Seattle was designated Naval Station, Seattle. In October 1986, Naval Station Seattle was designated NAVSTA PS as a result of the station's decreasing support role in the Pacific fleet activities.

In June 1991, the BRAC Commission of the DoD announced the closure of former NAVSTA PS. In accordance with recommendations of the 1991 BRAC Commission, the Navy closed former NAVSTA PS in September 1995.

Subsequent to closure, the Navy conducted environmental investigations and cleanup of portions of the facility. The condition of the property was described in the Environmental Baseline Survey (EBS) report (URS 1996). The EBS described the significant operations and existing

conditions at specific buildings and areas at former NAVSTA PS that were addressed in past environmental investigations. The EBS identified areas of potential environmental concern where storage or release of hazardous substances had occurred. No radiological contamination was identified in the EBS report. The EBS report was used by the Navy to generate the Finding of Suitability to Transfer for the property. After completion of these actions as well as the appropriate National Environmental Policy Act actions, the Navy initiated transfer of the former NAVSTA PS property to several government agencies in accordance with the BRAC closure plan.

The Navy transferred portions of the facility to the city of Seattle for recreational development. Because of the facility's long history of use by the Navy, and because the environmental investigations conducted may not have identified all environmental hazards that pose a threat to human health and the environment, the transfer deed between the Navy and the city included an environmental covenant that allowed the city to seek action by the Navy to address contamination that was not identified in the EBS (URS 1996).

The city of Seattle leased several of the original buildings to public and private organizations to support recreational redevelopment. In association with recent proposed renovations of Building 27, the city's review of as-built drawings identified areas where radioactive materials may have been used or stored (i.e., a Radium Room in Building 27 and Instruments Room in Building 2). As a result, the city conducted a radiation screening survey that identified areas in Building 27 where the radiation dose appeared to exceed background. The city also conducted surveys in Building 2 and a pump house connected to the storm/sanitary sewer system. Results of the screening level survey of Building 2 and the pump house were not conclusive. The city contacted the Navy regarding the potential need for action to address radiological contamination on the site.

Subsequently, the Navy conducted a remedial investigation, which focused on Buildings 2 and 27, the surrounding ground surfaces, and associated drain systems. The investigation, which is documented in a Radiological Remedial Investigation Report prepared by Shaw Environmental & Infrastructure, Inc. (Shaw 2011), confirmed that a removal action was warranted to address radiological contamination in Building 2 and the Building 27 South Shed structures, soil surrounding Buildings 2, 12, and 27, and associated drain systems.

1.2 PURPOSE

This PCQC Plan establishes procedures and methods for field inspections and provides an effective system to ensure the quality of work performed by TtEC and its subcontractors during execution of the TCRA, which will focus on the following:

- Removal of radiologically contaminated soil surrounding Buildings 2, 12, and 27 and associated radiological surveys, restoration, and waste management

- Removal of radiologically contaminated drain systems and associated radiological surveys, restoration, and waste management
- Removal of radiologically contaminated Building 2 components and associated radiological surveys, restoration, and waste management
- Removal of radiologically contaminated Building 27 components and associated radiological surveys and waste management, and subsequent demolition of the Building 27 South Shed and restoration of the south face of the original Building 27 hangar structure

This plan is applicable to all definable features of work (DFWs) listed in Section 3.0 and will be available at the project field office.

This page intentionally left blank.

2.0 PROJECT ORGANIZATION, RESPONSIBILITY, AND POINTS OF CONTACT

This section describes the organization and the responsibilities and authorities of project personnel. The organizational structure, functional responsibilities, levels of authority, and lines of communication within the organization have been established to ensure high-quality work. The project organization chart showing the reporting lines for key personnel is provided on Figure 2-1. The responsibilities of key personnel are described in the following subsections. A list of the points of contact for the project is provided in Section 2.11.

2.1 REMEDIAL PROJECT MANAGER

The Remedial Project Manager (RPM) has primary responsibility with the Navy for day-to-day management of the project activities performed under this plan and for its successful completion. The RPM is responsible for the following:

- Perform project management for the Navy.
- Ensure the requirements of the project scope of work are fulfilled.
- Oversee the project cost and schedule.
- Provide formal technical direction to the TtEC project team, as needed.
- Coordinate with other RPMs for other projects being performed to ensure that proper controls are in place.
- Act as lead in interacting with regulatory agencies.

2.2 NAVY TECHNICAL REPRESENTATIVE

The Navy Technical Representative (NTR) has the primary responsibility for providing on-site QA and safety oversight of contractors. The NTR is responsible for the following:

- Verify that all work has been completed per contract and technical specifications prior to final government acceptance.
- Perform field verification for QA of contractor's implementation of the QC Program.
- Notify the contractor of any noncomplying work.
- Notify the contractor of any work being performed in an unsafe manner.
- Interact with the contractor's Project Quality Control Manager (PQCM) on quality-related issues.
- Review and sign waste manifests as the generator's representative.
- Review daily Contract Quality Control (CQC) Reports for completeness and accuracy.

- Attend preparatory phase, initial phase, prefinal, and final acceptance inspections.
- Attend weekly QC meetings.

2.3 PROJECT MANAGER

The Project Manager (PjM) is the TtEC representative responsible for the directing, executing, and successfully completing project tasks to achieve overall project goals. The PjM has responsibility for and the authority to direct all segments of the project including technical, construction, and administrative activities. The PjM is responsible for the following:

- Coordinate work activities of subcontractors and TtEC personnel and ensure that all personnel adhere to the administrative and technical requirements of the project.
- Monitor the status and progress of work and ensure that project deliverables are completed on time and within the project budget.
- Monitor the budget and schedule, and notify the client and the Program Manager of any changes that may require administrative actions.
- Ensure adherence to the quality requirements of the contract, project scope of work, and the QC plans.
- Ensure that all work meets the requirements of the project plans, procedures, and technical specifications and complies with applicable codes and regulations.
- Ensure that all work activities are conducted in a safe manner in accordance with the Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) – Safety and Health Requirements (Engineer Manual [EM] 385-1-1) (USACE 2008), and all applicable Occupational Safety and Health Administration regulations.
- Ensure that change conditions are properly identified and documented with the appropriate approvals.
- Serve as the primary contact with the Navy and TtEC for actions and information related to the work while ensuring that the appropriate TtEC lead and experts are involved in decision-making.
- Coordinate satisfactory resolution and completion of evaluation and acceptance for Nonconformance Reports (NCRs).
- Attend required meetings, including the preconstruction conference, weekly QC meetings, pre- and postconstruction site inspections, and other scheduled and unscheduled meetings.

2.4 PROJECT ENVIRONMENTAL SAFETY MANAGER

The Project Environmental Safety Manager (PESM) is the TtEC representative responsible for implementing and overseeing the Contract Health and Safety Program and for developing, implementing, and approving all APP/SSHP documents. Any changes to the established Contract Health and Safety Program or APP/SSHP must be at the direction and approval of the

PESM, with concurrence of the Navy Administrative Contracting Officer. The PESM or designee will not necessarily be on-site during all removal and survey activities but will be readily available for consultation when required.

The PESM or designee is a Certified Industrial Hygienist who is certified by the American Board of Industrial Hygiene. The PESM supervises and directs the activities of the Site Safety and Health Officer (SSHO). The PESM has the authority to stop unsafe operations, remove unqualified personnel from the work area, and approve changes to the APP/SSHP. The PESM is responsible for the following:

- Oversee all aspects of the APP/SSHP from development to implementation.
- Advise the SSHO on all matters relating to health and safety.
- Review site-specific plans for completeness and compliance.
- Review other site documents as they affect health and safety (e.g., Activity Hazard Analyses [AHAs] and sampling plans).
- Review and evaluate all monitoring results.
- Establish and monitor all related health and safety procedures through site safety inspections and audits.
- Ensure that TtEC employees receive required Environmental Health and Safety (EHS) regulatory training.
- Fulfill specific responsibilities for project EHS personnel that are identified within each EHS procedure.
- Function as a technical resource for all environmental compliance, safety, loss control, and industrial hygiene issues.

2.5 QUALITY CONTROL PROGRAM MANAGER

The Quality Control Program Manager (QCPM) is the TtEC representative responsible for the oversight of program QC, including field activities and data acquisition. The QCPM is responsible for the following:

- Coordinate and resolve quality concerns.
- Provide quality-related direction and ensure the training of the PQCM and others performing quality-related functions.
- Suspend project activities if quality standards are not maintained.
- Interact with the Navy on quality-related issues.
- Review audit and surveillance reports.
- Implement the Navy technical directives related to quality.

2.6 PROJECT SUPERINTENDENT

The Project Superintendent is a TtEC representative who reports to the PjM and is responsible for coordinating, directing, implementing, and supervising site construction activities. The Project Superintendent or designated representative will be on-site at all times during field activities. The Project Superintendent is responsible for the following:

- Implement field activities in accordance with the approved plans.
- Direct support personnel and subcontractors.
- Administer site access and communication.
- Maintain the work site, facilities, vehicles, and equipment.
- Coordinate work activities and ensure all personnel adhere to the administrative and technical requirements of the project.
- Prepare status reports and estimate future scheduling needs.
- Prepare daily Contractor Production Reports.
- Monitor the status and progress of field activities and ensure that project deliverables are completed on time and within the project budget.
- Ensure work activities in the field are conducted in a safe manner in accordance with the APP/SSHP.
- Investigate with the SSHO all incidents, accidents, injuries, illnesses, and near misses.

2.7 PROJECT QUALITY CONTROL MANAGER

The PQCM is the TtEC representative responsible for overall management of project QC and reports to the QCPM. The PQCM has the authority to stop work on site-related issues affecting the quality of the work performed and for directing the correction of all nonconforming work. The PQCM or designated alternate (Appendix A) will be on-site at all times during field activities. The PQCM is responsible for the following:

- Provide and maintain an effective QC system for all site activities.
- Perform ongoing field inspection to verify that all work complies with contract and technical specifications.
- Monitor QC activities to ensure conformance with authorized policies, procedures, contract specifications, required standards, and methods of quality construction.
- Prepare the daily CQC Reports.
- Coordinate and perform the three phases of inspection (preparatory, initial, and follow-up) for all DFWs.
- Issue, maintain, and enforce NCRs and other quality actions.

- Ensure that on-site and off-site inspections, testing, and sampling are performed in accordance with the plans, procedures, specifications, and applicable codes.
- Ensure that all required tests and inspections are performed and documented.
- Conduct required QC meetings, including the coordination and mutual understanding meeting, site survey visits, and other scheduled meetings.
- Coordinate and maintain submittal register, photograph log sheet, request for information, and NCR log and other required logs or registers.
- Review and maintain records of approved submittals, Design Change Notices (DCNs), and Field Change Requests (FCRs) for construction activities.
- Inspect material delivery handling and storage in accordance with technical specifications.
- Review and approve submittals and shop drawings and/or forward submittals as information only or for approval.
- Review project plans and procedures for quality issues.
- Confirm the removal or rework of material, equipment, or work activity that does not comply with plans and specifications.
- Perform daily QC safety inspections and document in the QC logs (EM 385-1-1 01.A.12.b) (USACE 2008).

2.8 SITE SAFETY AND HEALTH OFFICER

The SSHO is the TtEC representative who reports directly to the PESM and ensures all elements of the APP/SSHP are implemented and enforced on-site. The SSHO has full authority to issue stop work orders or evacuation orders when work operations or noncompliance(s) may threaten the health and safety of site workers or the public. The SSHO is responsible for the following:

- Ensure that all personnel understand the requirements of the TtEC EHS program and procedures through training and communication.
- Investigate with the Project Superintendent all incidents, accidents, injuries, illnesses, and near misses.
- Ensure project personnel are trained in the hazards of substances used on the project, maintain Material Safety Data Sheets and make them accessible to project personnel, and perform inspections and oversight to ensure the Waste Management Plan is being followed.
- Ensure tailgate safety meetings are conducted daily prior to start of work and are documented.
- Ensure project safety equipment is inspected and in good working order as required by the EHS program.
- Coordinate site health and safety requirements with the Project Superintendent and PjM.

- Ensure that all health and safety monitoring equipment and personal protective equipment are maintained and direct site-monitoring activities.
- Coordinate daily field activities with the Project Superintendent.
- Coordinate site safety and emergency response duties and verify site communications system with site personnel.
- Report incidents to the NTR as required by EM 385-1-1 (USACE 2008).
- Report immediately to the PjM, RPM, and NTR any fatal injury, persons admitted to a hospital, or damage to government property.
- Ensure all personnel have the required training and medical clearance prior to entering the exclusion zone at the site; inform the Project Superintendent of any site personnel with medical restrictions.
- Determine and post routes to medical facilities and telephone numbers for emergency transportation to medical facilities.
- Serve as the Project Hazard Communication Coordinator.
- Maintain training records and medical certifications for all on-site personnel, including subcontractors.
- Initiate revisions or changes to the APP/SSHP to support changing site conditions.
- Maintain site control procedures.
- Maintain current records of certification for first aid and cardiopulmonary resuscitation training for field personnel.
- Attend meetings, including the preconstruction conference, weekly QC meetings, pre- and postconstruction site inspections, and other project meetings.

2.9 PROGRAM CHEMIST

The Program Chemist is the TtEC representative who oversees sample collection, handling, analysis, and analytical data reporting. The Program Chemist is responsible for the following:

- Develop the Sampling and Analysis Plan.
- Evaluate and select qualified subcontract laboratories.
- Implement data QC procedures and perform audits of field performance.
- Review off-site laboratory data prior to use.
- Ensure that a proper review of on-site laboratory data is performed.
- Coordinate data validation of off-site laboratory data.
- Review data validation reports.
- Prepare analytical reports and supporting project reports.

2.10 SUBCONTRACTORS AND VENDORS

Qualified subcontractors may be selected to provide various construction services for this project. The subcontractor is required to provide labor, material, and equipment necessary to conduct construction activities as directed by the PjM. Subcontractors and vendors will comply with TtEC's quality requirements, including all approved procedures, technical specifications, and contract provisions.

The subcontractor is responsible for field inspection of their construction and operating activities. TtEC personnel will monitor, oversee, and make on-site, in-progress observations and inspections of work to determine whether the subcontractor's work is proceeding in accordance with TtEC's quality requirements.

Subcontractor personnel are responsible for maintaining a daily log of the project activities they perform and providing information needed to complete the daily CQC Report. All inspection records, including inspection reports, deficiency reports, and reinspections of corrective actions, will be documented.

The following subcontractors and their services are anticipated to be used in support of the TCRA:

- Radiological Survey & Remedial Services, LLC – Health physics support, data evaluation, and radiological instruments
- Wm. Dickson Co. – Asbestos materials removal and demolition

2.11 POINTS OF CONTACT

The following is a list of the key project, Navy, and regulatory points of contact:

Entity	Project Title	Contact Information
NAVFAC NW 1101 Tautog Circle, Suite 203 Silverdale, WA 98315-1101	RPM	Chris Generous (360) 396-0935 christopher.generous@navy.mil
BRAC PMO West 1455 Frazee Road, Ste. 900 San Diego, CA 92108-4310	Contract Specialist	Karen Barba (619) 532-0786 karen.barba@navy.mil
NAVFAC NW 1101 Tautog Circle, Suite 203 Silverdale, WA 98315-1101	NTR	Steve Skeehan (360) 396-1114 steve.skeehan@navy.mil
NAVSEA Detachment RASO 160 Main Road - Building 1971 NWS P.O. Box Drawer 260 Yorktown, VA 23691-0260	Lead Environmental Protection Manager	Laurie Lowman (757) 887-7650 laurie.lowman@navy.mil

Entity	Project Title	Contact Information
NAVSEA Detachment RASO 160 Main Road - Building 1971 NWS P.O. Box Drawer 260 Yorktown, VA 23691-0260	Radiological Environmental Protection Manager	Joe Sevcik (757) 887-4483 joseph.sevcik@navy.mil
Washington State Department of Health Office of Radiation Protection P.O. Box 47827 Olympia, WA 98504-7827	Radiation Health Physicist	Anine Grumbles (360) 236-3222 anine.grumbles@doh.wa.gov
Washington State Department of Health Office of Radiation Protection 309 Bradley Boulevard, Ste. 201 Richland, WA 99352	Project Manager	John Martell (509) 946-3798 john.martell@doh.wa.gov
Washington State Department of Ecology 3190 – 160th Avenue SE Bellevue, WA 98008-5452	Project Manager	Ching-Pi Wang (425) 649-7134 cwan461@ecy.wa.gov
Seattle Parks and Recreation 6310 NE 74th Street, Ste. 109E Seattle, WA 98115	Senior Planning and Development Specialist	Kevin Bergsrud (206) 684-5831 kevin.bergsrud@seattle.gov
Seattle Parks and Recreation 6310 NE 74th Street, Ste. 109E Seattle, WA 98115	Senior Environmental Analyst	Jodi Sinclair (206) 684-7292 jodi.sinclair@seattle.gov
TtEC 1230 Columbia Street, Suite 750 San Diego, CA 92101-8536	Project Manager	Lee Boreen (619) 471-3544 lee.boreen@tetratech.com
TtEC 1230 Columbia Street, Ste. 750 San Diego, CA 92101-8536	QCPM/Alternate PQCM	Greg Joyce (360) 780-0371 greg.joyce@tetratech.com
TtEC Project Site	Project Superintendent/ Alternate SSHO	Jerrett Patterson (360) 434-5449 jerrett.patterson@tetratech.com
TtEC Project Site	PQCM/SSHO	Toby Petersen (360) 661-3510 toby.petersen@tetratech.com
TtEC Project Site	RSOR	Jeff Ambrose (TBD) (TBD)
TtEC 1230 Columbia Street, Ste. 750 San Diego, CA 92101-8536	PESM	Roger Margotto, CIH, CSP (619) 471-3503 roger.margotto@tetratech.com.
TtEC 17885 Von Karman Avenue, Ste. 500 Irvine, CA 92614-6213	Program Chemist	Lisa Bienkowski (949) 809-5028 lisa.bienkowski@tetratech.com

Entity	Project Title	Contact Information
TtEC 1050 Hostmark Street, Ste. 202 Poulsbo, WA 98370	Regulatory Compliance Specialist	Jennifer Peters (360) 598-8108 jennifer.peters@tetratech.com

Abbreviations and Acronyms:

BRAC – Base Realignment and Closure
CIH – Certified Industrial Hygienist
CSP – Certified Safety Professional
LLRW – low-level radioactive waste
NAVFAC NW – Naval Facilities Engineering Command Northwest
NAVSEA – Naval Sea Systems Command
NTR – Navy Technical Representative
PESM – Project Environmental Safety Manager
PMO – Program Management Office
PQCM – Project Quality Control Manager
QCPM – Quality Control Program Manager
RASO – Radiological Affairs Support Office
RPM – Remedial Project Manager
RSOR – Radiation Safety Officer Representative
SSHO – Site Safety and Health Officer
TBD – to be determined
TtEC – Tetra Tech EC, Inc.

This page intentionally left blank.

3.0 DEFINABLE FEATURES OF WORK

A DFW is an activity or task separate and distinct from other activities that requires task-specific control activities. The DFW establishes the control measures required to verify both the quality of work performed and compliance with specified requirements, which include inspecting materials and workmanship before, during, and after each DFW. Preparatory and initial phase inspections will be performed on all DFWs, with the exception of mobilization and site cleanup and final inspection (demobilization). Activities that will be covered by the PQCM during the inspections are listed in Table 3-1. The following DFWs have been identified for the project:

- Clearing of vegetation and/or pavement
- Geophysical survey
- Soil characterization sampling
- Radiological surveys and sampling
- Identification and removal of radioactive material
- Excavation and removal of soil/piping
- Removal of radiologically contaminated building components and restoration
- Final Status Surveys
- Backfill placement and compaction
- Asbestos abatement
- Superstructure demolition
- Building 27 hangar structure south face restoration
- Site restoration

This page intentionally left blank.

4.0 SUBMITTALS

This section describes the review and approval process for submittals. TtEC will institute and maintain a submittal register (Appendix B) to track submittals from issuance to approval. A list of required submittals will be developed at the initiation of project activities and updated as necessary. Submittals will be scheduled, reviewed, certified, and managed in accordance with the procedures defined in this section.

Standard Unified Facilities Guide Specification (UFGS) submittal titles are as follow:

- SD-01 Preconstruction Submittals
- SD-02 Shop Drawings
- SD-03 Product Data
- SD-04 Samples
- SD-05 Design Data
- SD-06 Test Reports
- SD-07 Certificates
- SD-08 Manufacturer's Instructions
- SD-09 Manufacturer's Field Reports
- SD-10 Operation and Maintenance Data
- SD-11 Closeout Submittals

Descriptions of the submittals listed above are provided in UFGS Section 014502 (NAVFAC 2009). Not all submittals listed above necessarily apply to the scope of work for this project.

4.1 REVIEW OF SUBMITTALS

Submittals will be reviewed to ensure completeness, accuracy, and contract compliance. Submittal of a certification will be inspected and approved by the PQCM for conformance to the project specifications or certification criteria. All items will be checked and approved by the PQCM or designated representative. Any submittals requiring modification will be returned to the originating organization for correction and then resubmitted for review and approval prior to acceptance. Approved submittals will be stamped, signed or initialed, and dated. During the preparatory phase of the QC inspections, the PQCM or designated representative will ensure that all materials and equipment have been tested and approved. No field activities will be performed without the required approval of applicable submittals.

4.2 SUBMITTAL PROCESS

Required submittals will be provided to project personnel as determined by the distribution schedule. Each submittal will be assigned a unique document control number.

A transmittal form will accompany each submittal. Each transmittal will be identified with:

- Contract and CTO number
- Name and address of the submitting organization
- Date of submittal
- Description of item being submitted, including reference to specification section (if applicable)
- Approval of submitting organization indicating conformance to the requirements

The PQCM will update the submittal register regularly.

4.3 REVIEW AND PROCESSING OF SUBMITTALS THAT DO NOT REQUIRE NAVY APPROVAL

Material submitted for review by the PQCM will indicate whether or not it conforms to established requirements. The PQCM will inform the submitter of the results of the review. The submittal log will be updated to indicate the status and will be submitted with the last CQC report of each month.

Conforming submittals will be transmitted to project and Navy personnel as determined by the distribution schedule. A transmittal form will accompany all items sent to the Navy. The transmittal form will list each item transmitted, the date it was reviewed by the PQCM, and its review status. Nonconforming submittals will be returned to the submitter for correction, resolution of comments, and resubmitted.

4.4 REVIEW AND PROCESSING OF SUBMITTALS THAT REQUIRE NAVY APPROVAL

Submittals reviewed by the PQCM will be transmitted to the Navy in accordance with the project distribution schedule for further review and approval. All items sent to the Navy will use a transmittal form indicating each item transmitted, the date reviewed by the PQCM, and its review status. Upon completing review, the Navy will either return the transmittal form to the PQCM for further action or accept the submittal as complete. The PQCM will advise the submitter of the results of the review in writing and include any comments. The submittal log will be updated to indicate status. Nonconforming submittals may be returned to the submitter for correction, resolution of comments, and resubmitted, if required.

4.5 REVISED SUBMITTALS

Revised submittals will be logged, reviewed, and processed in a manner identical to the initial submittal. Revisions to a submittal will be identified using an alphabetic suffix to the original submittal number. For example, a revision to submittal 18 will be submittal 18(a).

This page intentionally left blank.

5.0 TESTING

The PQCM or designated representative will verify the performance of all tests specified or required by the project-specific plans to ensure that control measures are adequate to provide a product conforming to contract specifications. General requirements for testing procedures to be implemented for this project are included in the Work Plan. The type, number, and frequency of required tests are specified in the Test Plan and Log (Appendix B). These tests include both operational and acceptance testing as appropriate.

5.1 DOCUMENTATION

All test results, both passing and failing, will be documented in the daily CQC Report for the day the results are obtained. Paragraph reference, location where tests were taken, and the sequential control number identifying the test will be given. The test reports will be available for review by the NTR and transmitted with the project closure report.

5.2 LABORATORY SERVICES

An independent testing laboratory will provide laboratory services, as needed. The laboratory will be selected and qualified in accordance with recognized industry and applicable project requirements. All radiological and chemical analysis to be performed during the removal action will be performed by a DoD National Environmental Laboratory Accreditation Program accredited laboratory. QC for radiological and chemical analyses is addressed in the Sampling and Analysis Plan, provided as Attachment 1 to the Work Plan.

5.3 TESTING PLAN AND LOG

The Test Plan and Log (Appendix B) lists tests required by the project specifications and drawings. The Test Plan and Log will be submitted with the last CQC report of each month. Testing will be conducted to verify that control measures are adequate to provide a product conforming to contract specifications. General requirements for testing procedures to be implemented for this project are included in the Work Plan.

This page intentionally left blank.

6.0 QUALITY CONTROL MEETINGS

6.1 COORDINATION AND MUTUAL UNDERSTANDING MEETING

Before beginning work in the field, a coordination and mutual understanding meeting will be held to discuss the QC Program requirements. Navy personnel attending the meeting will include the RPM and NTR. The purpose of this meeting is to develop a mutual understanding with the Navy of the QC details, including forms to be used, administration of on-site and off-site work, coordination of the field activities, production, and the PQCM duties. At a minimum, the TtEC personnel required to attend the meeting will include the PjM, Project Superintendent, PQCM, and SSHO. Minutes of the meeting will be prepared by the PQCM and signed by the PjM and the RPM and/or NTR or designated representative. The meeting may be held in conjunction with the preconstruction meeting.

6.2 QC MEETINGS

After beginning field activities, the PQCM will conduct QC meetings once week. The meetings will be held at the project site and attended by the NTR, Project Superintendent, SSHO, and PQCM. The PQCM will notify the NTR at least 48 hours in advance of each meeting. The following will be covered at each meeting:

- Review the minutes of the previous meeting.
- Review the schedule:
  - Work or testing accomplished since last meeting
  - Rework items identified since last meeting
  - Rework items completed since last meeting
- Review the status of submittals:
  - Submittals reviewed and approved since last meeting
  - Submittals required in the near future
- Review the work to be accomplished in the following 3 weeks, required documentation, and the schedule for the three phases of control and testing:
  - Establish completion date for rework items
  - Required preparatory phase inspections
  - Required initial phase inspections
  - Required follow-up phase inspections
  - Required testing
  - Status of off-site work or testing
  - Required documentation

- Identify deficient conditions.
- Resolve QC and production problems.
- Address items that may require revisions to the PCQC Plan.

7.0 INSPECTION

This section discusses the inspection process for the DFWs that will ensure compliance with the contract. The DFWs for this project are identified in Section 3.0 and listed in Table 3-1.

The PCQC Plan includes implementing the following three phases of control for all aspects of the work specified:

- Preparatory phase
- Initial phase
- Follow-up phase

7.1 PREPARATORY PHASE INSPECTION

The PQCM will conduct preparatory phase inspections prior to starting the DFWs listed in Table 3-1 with the exception of mobilization and demobilization. These inspections shall include the following:

- Review the project-specific plans.
- Ensure that all required procurement forms for supplies and services are approved.
- Ensure that provisions have been made for required QC inspections.
- Ensure that all personnel have the training and certifications required to the work.
- Examine the work area to ensure that all required preliminary work has been completed and complies with the approved project plans.
- Examine the required materials and equipment to ensure that they are properly delivered to the site, conform to specifications, and are properly stored.
- Review the appropriate AHAs to ensure that safety requirements are met.
- Discuss procedures for performing the work, including potential repetitive deficiencies.
- Document workmanship standards for the particular phase of work.
- Ensure that the PCQC Plan for the work to be performed has been accepted by the Navy.

The PQCM will conduct frequent internal inspections of mobilization and demobilization. The PQCM is not required to notify the Navy or the PjM prior to these inspections.

The PjM, RPM, and NTR will be notified at least 2 work days in advance of each preparatory phase activity. This phase will include a meeting conducted by the PQCM and attended by the Project Superintendent and other personnel involved in performing the DFW. When a

subcontractor will perform a DFW, the foreman representing that subcontractor shall attend the preparatory phase meeting.

The items discussed during the preparatory phase meetings will be documented on the Preparatory Inspection Checklist (Appendix B). The PQCM will identify the required level of workmanship to personnel before performing work activities.

7.2 INITIAL PHASE INSPECTION

An initial inspection will be performed soon after beginning a DFW and will include the following:

- Check preliminary work to ensure that it is in compliance with contract requirements.
- Review the Inspection Checklist documenting results of the preparatory meeting.
- Verify full contract compliance, including required control inspections.
- Establish the required level of workmanship, testing, and inspection to ensure that work meets minimum acceptable standards.
- Resolve all differences.
- Check safety requirements to include compliance with and upgrading of the APP/SSHP and AHAs.

The PjM, RPM, and NTR will be notified at least 2 working days in advance of each initial phase activity. The PQCM will document initial inspections for each item using the Initial Phase Inspection Checklist (Appendix B) and attach it to the daily CQC Report. The location of the initial phase inspection and documentation will be identified for future reference and comparison with follow-up inspections.

The initial phase inspection will be reviewed each time a new crew arrives on-site or when DFWs change.

7.3 FOLLOW-UP PHASE INSPECTION

As efforts on a DFW progress, follow-up inspections will be conducted to ensure continued compliance with contract requirements. The frequency of the follow-up inspections will depend on the extent of the work being performed. Each follow-up inspection will be documented on the daily CQC Report. A Follow-up Inspection Checklist will be generated for any deficient conditions identified during the initial inspection and attached to the daily CQC Report when all items are resolved. A final follow-up check will be conducted on any completed work phase prior to the commencement of a subsequent phase.

7.4 RECEIPT INSPECTION

The PQCM will conduct inspections of materials prior to their use and installation. These inspections will be documented on a receipt inspection form and maintained on-site. Material(s) that does not meet design specifications will be rejected and returned to the vendor. Nonconforming material will be segregated and marked accordingly, to prevent inadvertent use. The PQCM will record on the daily CQC Report that a material inspection was performed.

7.5 ADDITIONAL INSPECTIONS

The PQCM may conduct additional inspections on the same DFWs under the following circumstances:

- If the quality of ongoing work is unacceptable as determined by the PQCM, PjM, Project Superintendent, RPM, or NTR
- If the quality of the work is suspected of being below the established acceptance criteria
- If work on a DFW resumes after a substantial period of inactivity
- If other problems develop

7.6 COMPLETION INSPECTION

Completion inspections will be performed as summarized in this section.

7.6.1 Construction Quality Control Completion Inspections

The PQCM will conduct a detailed inspection, prior to the prefinal inspection, when all of the work or an increment of work is deemed to be substantially complete. The work will be inspected for conformance to plans and specifications, workmanship, and completeness. The PQCM will prepare an itemized list of work that does not conform to plans and specifications, exhibits inferior workmanship, or is incomplete. The list will also include outstanding administrative items such as record (as-built) drawings. The list will be included in the QC documentation and submitted to the PjM following the inspection and will specify an estimated date for correction of each deficiency. The completion inspection will be documented on the Completion Inspection Checklist.

7.6.2 Prefinal Inspection

The PjM or designated representative will conduct the prefinal inspection. The RPM, NTR, PQCM, Project Superintendent, and other primary management representative(s), as applicable, will participate. The PjM will schedule the prefinal inspection when notified by the PQCM that the work is ready for inspection. The PQCM is required to verify at this time that all items previously identified as being unacceptable or incomplete will be complete and acceptable by the date of the prefinal inspection. If incomplete or unacceptable work is found during the prefinal inspection, a punch list will be generated by TtEC in consultation with the NTR. A copy of the

punch list will be forwarded to the NTR, the on-site Navy representatives for the Contracting Officer, and the RPM. The original punch list will be maintained by the PQCM.

7.6.3 Final Acceptance Inspection

The PjM will schedule the final acceptance inspection based on notification from the PQCM of readiness. The RPM, Project Superintendent, NTR, PQCM, and other primary management representative(s), as applicable, will participate. Notification will be provided prior to the planned final acceptance inspection date and must include verification that all specific items previously identified as being unacceptable or incomplete will be complete and acceptable by the date of the final acceptance inspection.

7.7 INSPECTION DOCUMENTATION

The PQCM is responsible for maintaining the inspection records. Inspection records will be legible and clearly provide all information necessary to verify that the items or activities inspected conform to the specified requirements. In the case of nonconforming conditions, the PQCM will provide evidence that the conditions were brought into conformance or otherwise accepted by the NTR. All inspection records will be made available to the Navy.

8.0 DOCUMENTATION

Preparation, review, approval, and issuance of documents affecting quality will be controlled to the extent necessary to ensure compliance to specified requirements. Project documents that will be controlled, if issued, include the following:

- Meeting minutes, conference notes, and confirmation notes
- Submittal Register
- Inspection documentation
- Contractor Production Report
- Daily CQC Report
- Material inspection and shipping logs
- NCRs
- Deficiency Notices (DNs)
- DCNs
- NCR log
- FCRs
- FCR/DCN log
- Rework Items List
- Photograph log
- Field logbooks

8.1 DAILY CONTRACTOR QUALITY CONTROL REPORT

The PQCM is responsible for maintenance of current records of QC activities, inspections, and tests performed, including the work of subcontractors and suppliers. The records will include factual evidence that required QC activities and tests were performed. The daily CQC Report will be completed to document site activities covered by the PCQC Plan and will include:

- Records of inspection and /or testing performed
- Identification and location of each DFW and its current phase (preparatory, initial, follow-up) of completion
- Results of inspections and/or testing
- Location and description of deficiencies
- Deficiencies corrected as of the date of the report

- Rework items
- Deviations from plans, difficulties, and resolution
- Test and/or control activities performed with results and references to specifications and/or plan requirements, including the control phase (preparatory, initial, and follow-up) and deficiencies (along with corrective action)
- Material received, with statement as to its acceptability and storage
- Submittals reviewed, including contract reference, reviewer, and action taken
- Off-site surveillance activities, including actions taken

The records will describe both conforming and nonconforming features and include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The daily CQC Report, attached to the Contractor Production Report, will be furnished to the NTR by 10:00 a.m. on the first work day following the date covered by the report, or as agreed to by the NTR. The report need not be submitted for days on which no work is performed. At a minimum, one report will be prepared and submitted for every 7 days of no work and on the last day of a no-work period. All calendar days will be accounted for throughout the life of the contract. The first report following a day of no work will summarize work for that day only. The report submitted on the last work day of each month will include the Rework Items List, Submittal Register, and Test Plan and Log. Copies of the reports will be maintained on-site and will be available for review during business hours.

The daily CQC Report will be signed and dated by the PQCM and contain the following statement: "On behalf of the Contactor, I certify that this report is complete and correct, and equipment and material used and work performed during this reporting period is in compliance with the contract drawings and specifications to the best of my knowledge except as noted in this report." Other appropriate personnel, including subcontractors responsible for completion of activities, will sign and date the report as required. The report will include copies of test reports.

8.2 CONTRACTOR PRODUCTION REPORT

The Contractor Production Report will be prepared for each day work is performed and will be attached to the daily CQC Report prepared for the same day. The Contractor Production Report will be prepared, signed, and dated by the Project Superintendent or designated representative, and will contain the following information:

- Contractor and subcontractor(s) and their area of responsibility
- Trades working on the project that day and number of personnel
- Operating equipment, with hours worked, idle, or down for repair
- Work performed that day, including location, description, weather conditions, and who did the work

- Any delays encountered
- Site visitors and the purpose of the visit
- Job safety evaluations stating what was checked, results, and instructions or corrective actions
- A list of instructions given and/or received and conflicts in plans and/or specifications
- Contractor's verification statement

8.3 LOGBOOKS

The PQCM will maintain a logbook to document QC activities. The information in the logbook is intended to serve as a phone log and memory aide in the preparation of the daily CQC Report and in addressing follow-up questions that may arise.

8.4 PHOTOGRAPHS AND PHOTOGRAPH LOGS

The PQCM will maintain photographs and a photograph log to document site activities. Each photograph will have a date and time stamp on it or the photograph will show a sign board documenting the date and time clearly and legibly in the photograph. The photograph log will identify each photograph by date, time, location, and activity.

8.5 CONFERENCE NOTES AND CONFIRMATION NOTES

In addition to other required documentation, the PQCM is responsible for taking notes and preparing the reports of conferences. Conference notes will be typed and the original report furnished to the Navy within 5 days of the date of the conference for concurrence and subsequent distribution to all attendees. At a minimum, this report will include the following:

- Date and place the conference was held
- List of attendees, including name, organization, and telephone number
- Comments made during the conference and decisions affecting criteria changes
- Conference notes that augment the written comments

The PjM is also responsible for providing a record of discussions, verbal directions, telephone conversations, and so forth in which TtEC personnel or their representatives participate on matters relating to this contract and work. These records, titled Confirmation Notices, will be numbered sequentially and will fully identify participating personnel, subject discussed, and any conclusions reached. The PjM or designated representative will forward a reproducible copy of the confirmation notices to the RPM and NTR within 5 working days.

This page intentionally left blank.

9.0 CHANGE MANAGEMENT

This section describes the DCN and FCR, the two primary vehicles to document project changes.

9.1 DESIGN CHANGE NOTICES

The following sections describe the identification, preparation, and review and approval process for DCNs.

9.1.1 Identification

Any member of the project team may identify the need for a change to the design specifications or drawings. The project team member will notify the Field Engineer, who will evaluate the request and initiate a DCN if determined warranted.

9.1.2 Preparation

The Field Engineer will generate a DCN form (Appendix B) and submit it to the Design Engineer for review and disposition. The DCN will identify the specification requirements, the proposed change, and the reason for the change.

9.1.3 Review and Approval

The PjM, Project Superintendent, and QCPM will review and approve the DCN. It is the responsibility of the PjM to notify the Navy for approval of the DCN prior to making any changes identified on the DCN.

9.1.4 Implementation of Approved DCNs

The Project Superintendent is responsible for the implementation of approved DCNs.

9.1.5 Records

Each approved DCN will be sequentially numbered as follows:

DCN-CTO X-YY

Where:

X is the task order number and YY is the DCN number, beginning with 01.

A DCN log shall be maintained by the PQCM that lists the DCN number, date of DCN, and brief description of contents.

Each DCN will be copied to all the management signatories, the Project Superintendent, PQCM, SHSS, and other personnel as deemed appropriate by the PjM.

Copies of the approved DCN should be posted or otherwise included in daily site briefings as appropriate to ensure that all site personnel are aware of the changes. Copies of DCNs will be issued to all holders of controlled copies. The DCNs must be maintained with the controlled copy of the document that has been changed.

9.2 FIELD CHANGE REQUEST

Site personnel will document changes to the approved plans (except the design specifications and drawings) in the field through the FCR form (Appendix B). At a minimum, the following information will be documented in the FCR form:

- Project name
- CTO number
- FCR number
- Documents to which a change is requested (including revision number if applicable)
- Description of the item or condition for which the change is requested
- Reason for the change
- Recommended disposition
- Cost and schedule implication of the change, if any
- Approval of disciplines
- Approval of the PjM, Project Superintendent, PQCM, PESM, and QCPM and concurrence from the RPM or NTR

9.3 DISTRIBUTION OF DCN AND FCR FORMS

Approved DCN and FCR forms will be distributed to the CTO file record, all CTO personnel that received the original document, and the NTR and RPM. The Navy may request DCNs or FCRs be submitted to the Contracting Officer or their designee.

10.0 NONCONFORMANCE

All deficiencies or nonconforming conditions discovered during inspections or other QC functions will be noted on either a DN or an NCR, as appropriate.

A DN is used to document the failure to develop, document, or implement effectively any applicable element of approved plans or to follow established procedures. A deficiency could lead to a nonconformance.

An NCR is used to document a nonconforming condition that renders the quality of an item, process, or product that has been defined in the specifications or drawings as unacceptable or indeterminate.

Copies of these forms are provided in Appendix B along with the logs used for tracking these documents. All deficiencies and nonconforming conditions will be resolved prior to completion of the project and in the timeliest manner possible. The DN will be used for all conditions that do not affect the final work product. An NCR will be used when a condition may affect the final work product.

The PQCM will be notified of all deficiencies and nonconforming conditions identified during the course of the field activities to ensure that each of these occurrences is documented, reported, and tracked; and that corrective actions are taken and follow-up verification is conducted.

The PQCM will also document deficiencies and nonconforming conditions in the daily CQC Report, noting the items found to be deficient or nonconforming; the date; time, and location; the person who identified the deficiency or nonconformance; and the status of the item to which the deficiency or nonconformance applies.

The PQCM will update the status of the deficiency when it changes. Before the work activities of the day begin, the PQCM will note the deficiencies or nonconforming conditions that require follow-up verification that day. New or changed status will be entered into the file at the end of each day. The daily CQC Report will document completion of the corrective action for each deficiency or nonconformance for that day. Nonconforming conditions or deficiencies that require rework for resolution will be noted on the Rework Items List included in Appendix B.

10.1 ROOT CAUSE ANALYSIS

The DN and the NCR forms both include space to enter information regarding the cause of the problem and the proposed resolution. The determination of the root cause of a deficiency or nonconformance is an integral part of the QC process. Root cause analysis will be made by the PQCM in conjunction with other appropriate site personnel such as the Project Superintendent and the SSHO. Criteria considered in the analysis will include:

- Staff qualifications and training
- Adequacy of procedures and methods
- Adequacy of equipment
- Adequacy of QC measures

Input will be obtained, as necessary, from field staff and technical advisors in order to identify the factors that led to the problem.

10.2 CORRECTIVE ACTION

Following the root cause analysis, the PQCM will evaluate potential solutions (corrective actions) to determine which remedy is most effective in correcting the problem. This process will include all appropriate staff. Potential remedies considered will include:

- Supplemental staff training
- Changes of equipment or modification of equipment currently in use
- Acquisition of supplemental equipment
- Implementation of new procedures or modification of existing procedures
- Changes in QC procedures

Final approval of all remedies will be the responsibility of the PjM.

Successful implementation of corrective action will be documented by the PQCM in the appropriate areas of the DN or NCR. This documentation will be supported by changes to the inspection procedures or schedule as warranted (i.e., the PQCM will not certify that corrective action has been taken until inspection of the actions and the resulting changes in the program are complete).

10.3 CONDITION REQUIRING STOP WORK

If corrective actions are insufficient, resolution cannot be reached, or results of prior work are indeterminate, work may be stopped. The PQCM will direct the PjM to suspend work associated with the nonconformance until corrective action is complete. If there is a disagreement between the PQCM and the PjM, the difference will be brought to the attention of the QCPM until resolution is achieved.

The conditions of the suspension of work will be described in detail on the daily CQC Report and on the Rework Items List, if corrective action is not completed by the end of the working day. Work will not continue until directed by the individual who authorized it.

11.0 QUALITY MANAGEMENT

In addition to the required QC field inspections, the TtEC Quality Program requires a quality management overview of the site QA/QC Program implementation. The PQCM will perform regular internal QC checks on the site implementation of the QA/QC Program. Reports of any deficiencies will be provided to the PjM for corrective action.

Inspections will be performed and checked for the following:

- Conformance with the RWP and associated plans
- Thoroughness of performance
- Identification and completeness of documentation generated during performance

The PQCM will maintain the Rework Item List. This is a list of work items that do not comply with the contract and identify each item that needs rework, the date the item was discovered, the date the item will be corrected, and the date the item was corrected.

The PQCM will ensure that as-built drawings are kept current on a daily basis. The PQCM (or designee) will initial each revision. At the end of the project, updated as-built drawings will be submitted.

This page intentionally left blank.

12.0 REFERENCES

NAVFAC (Naval Facilities Engineering Command). 2009. Unified Facilities Guide Specifications (UFGS) 014502, Submittal Procedures. February.

Shaw (Shaw Environmental and Infrastructure, Inc.). 2011. Final Radiological Remedial Investigation Report; Former Naval Station Puget Sound.

URS (URS Consultants, Inc.). 1996. Environmental Baseline Survey, Naval Station Puget Sound (NAVSTA PS), Seattle, Washington, CTO 0104. January 16.

USACE (U.S. Army Corps of Engineers). 2008. Safety – Safety and Health Requirements. EM-385-1-1. September 15.

This page intentionally left blank.

TABLES

This page intentionally left blank.

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Clearing of vegetation and/or pavement	• Verify that RPM and NTR have been notified. • Verify that management of cleared vegetation and/or pavement protocol is established based on the results of vegetation survey. • Review AHAs. • Verify that PPE is available and meets requirements of the SSHP. • Verify that the area has been walked/visually inspected for items that could interfere with clearing (utilities, rebar, etc.). • Verify that radiation awareness training has been completed and that training is documented. • Verify provisions for traffic controls, when applicable.		• Verify that qualified RCT and SSHO are present at active work areas. • Verify that vegetation and/or pavement is removed throughout the excavation area. • Verify that waste vegetation and/or pavement is being managed as required. • Verify that vegetation removed from radiologically impacted sites is stockpiled at the site of origin. • Verify that the activity is photographed.		• Continue to inspect ongoing activities. • Verify that qualified RCT and SSHO are present at active work areas. • Verify that vegetation and/or pavement stockpiles are maintained as required by the project plans. • Verify that vegetation and/or pavement are disposed of in accordance with the project plans and that the stockpile locations are cleaned up. • Verify that site activities are being photographed. • Verify that photographs are logged and stored.	
Geophysical survey	• Verify that RPM and NTR have been notified. • Verify that survey instrument certification is current and in good condition. • Verify that sensitive locations at the site are delineated and work crews are aware of restricted areas. • Review control points. • Review AHAs. • Review the project plan requirements pertaining to this activity. • Review boundaries and extent of survey. • Verify that radiation awareness training has been completed and training is documented. • Verify that designated personnel have assigned dosimeters and completed NRC Form 4.		• Verify that qualified RCT and SSHO are present at active work areas. • Verify that surveyor has correct control point information. • Verify that the geophysical survey is performed over areas of known or suspected subsurface utilities. • Verify boundaries and extent of survey. • Verify that site activities are being photographed.		• Verify that qualified RCT and SSHO are present at active work areas. • Verify that utility locations are marked in the field and identified to the equipment operators. • Verify that boundaries of survey have been met. • Verify that site activities are being photographed. • Verify that photographs are logged and stored.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Soil characterization sampling	• Verify that the RPM, RASO, and NTR have been notified. • Verify that an approved RWP is available and has been read and signed by assigned personnel. • Verify that project plans requirements pertaining to this activity have been reviewed. • Verify that assigned personnel are trained and qualified. • Verify that training record documentation is being maintained. • Verify that personnel have been given an emergency notification procedure. • Verify that workers assigned dosimetry have completed NRC Form 4. • Verify that radiological controls (fence, posting, etc.) are in place as necessary. • Verify that relevant SOPs and/or manufacturers' instructions are available and have been reviewed for instruments to be used for scanning samples. • Verify that sample locations are properly identified and understood by sample team. • Verify background check. • Verify that calibration of survey instrument is current. • Verify that required equipment is on-site and in working order. • Verify necessary sample containers and labels are available.		• Verify that instruments are as specified in the project plans. • Verify that qualified RCT and SSHO are present at active work areas. • Verify that site activities are being photographed. • Verify that the reference area measurements have been obtained using the procedure described in the project plans. • Verify that daily checks are performed on all portable survey instruments. • Verify that required dosimetry is being worn. • Verify that RWP is available at work site. • Verify that samples and measurements are being collected in accordance with the project plans. • Verify that sample handling and analyses are in accordance with the project plans. • Verify that field logbooks, proper forms, and chain-of-custody documents are in use.		• Verify that site is properly posted and secured, if necessary. • Conduct ongoing inspection of material and equipment. • Verify that qualified RCT and SSHO are present at active work areas. • Verify that required dosimetry is being worn. • Verify that daily instrument checks and background measurements are obtained and documented. • Verify that survey results are documented. • Verify that RWP is available at work site. • Verify that personnel have read and signed the revised RWP, if revision is required. • Verify that samples and measurements are being collected in accordance with the project plans. • Verify that survey instrument is recalibrated after repairs or modifications. • Verify that personnel surveys are performed for all personnel leaving a radiological controlled area. • Verify that RASO is notified of discovered radioactive material. • Verify that area known or suspected to contain radioactive material is isolated. • Verify that site activities are being photographed.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Soil characterization sampling (continued)					• Verify that photographs are logged and stored. • Inspect sample chain of custody and survey log for completeness.	
Radiological surveys and sampling	• Verify that the RPM, RASO, and NTR have been notified. • Verify that an approved RWP is available and has been read and signed by assigned personnel. • Verify that project plans requirements pertaining to this activity have been reviewed. • Verify that assigned personnel are trained and qualified. • Verify that training record documentation is being maintained. • Verify that personnel have been given an emergency notification procedure. • Verify that workers assigned dosimetry have completed NRC Form 4. • Verify that relevant SOPs and/or manufacturers' instructions are available and have been reviewed for equipment to be used for radiological surveys. • Verify that limits and boundaries of surveys have been established and are understood. • Verify background check. • Verify that calibration of survey instrument is within 1 year. • Verify that required equipment is on-site and in working order.		• Verify that radiological instruments are as specified in the project plans. • Verify that qualified RCT and SSHO are present at active work areas. • Verify that site activities are being photographed. • Verify that the reference area measurements have been obtained using the procedure described in the project plans. • Verify that daily checks are performed on all portable survey instruments. • Verify that required dosimetry is being worn. • Verify that RWP is available at work site. • Verify that limits and boundaries of survey are being met. • Verify that samples and measurements are being collected in accordance with the project plans.		• Verify that site is properly posted and secured, if necessary. • Conduct ongoing inspection of material and equipment. • Verify that qualified RCT and SSHO are present at active work areas. • Verify that required dosimetry is being worn. • Verify that any suspected material location is marked, flagged, and documented. • Verify that daily instrument checks and background measurements are obtained and documented. • Verify that survey results are documented. • Verify that RWP is available at work site. • Verify that personnel have read and signed the revised RWP, if revision is required. • Verify that survey data and sample analysis results are reviewed. • Verify that survey activities conform to the project plans. • Verify that boundaries of the survey have been met.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Radiological surveys and sampling (continued)			• Verify that sample handling and analyses are in accordance with the project plans. • Verify that field logbooks, proper forms, and chain-of-custody documents are in use.		• Verify that survey instrument is recalibrated after repairs or modifications. • Verify that personnel surveys are performed for all personnel leaving a radiological controlled area. • Verify that RASO is notified of discovered radioactive material. • Verify that area known or suspected to contain radioactive material is isolated. • Verify that site activities are being photographed. • Verify that photographs are logged and stored. • Inspect sample chain of custody and survey log for completeness.	
Identification and removal of radioactive material	• Verify that RPM, NTR, and RASO have been notified. • Review procedures. Verify background activity and what constitutes a deviation. • Review AHAs. • Verify that equipment, instruments, and materials are on-site, calibrated, and in working order. • Verify that required stockpile and staging areas are established. • Review the project plan requirements pertaining to the activity. • Verify that PPE is available and meets requirements of the SSHP. • Verify that radiation awareness training has been completed and training is documented.		• Verify that qualified RCT and SSHO are present at active work areas. • Verify that required dosimetry is being worn. • Verify PPE of all workers. • Verify that RSOR has evaluated radiological impact of the material prior to any action for each material. • Verify that radiological safety instruction specific to each material has been reviewed by the RSOR and RCT. • Verify that RCT is present during removal of any source.		• Verify that qualified RCT and SSHO are present at active work areas. • Verify that required dosimetry is being worn. • Verify that removal of radioactive material is conducted in accordance with the project plans. • Verify that an additional 1 foot of soil in every direction is excavated after removal of material. • Verify that RCT scanned the excavated area after radioactive material removal. • Verify that personnel surveys are performed for all personnel leaving a radiological controlled area. • Review radiological logbook for completeness of documentation.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Identification and removal of radioactive material (continued)	• Verify that designated personnel have assigned dosimeters and completed NRC Form 4. • Verify that a log and database are established for identified material. • Verify that traffic schedule/routes have been approved by NTR. • Verify that personnel have been given an emergency notification procedure.		• Verify that a surface survey is completed. • Verify that site activities are being photographed. • Verify that proper logging, recording, and photography of found point sources are being done. • Verify that traffic schedule has been approved by CSO.		• Inspect contaminated material handling procedure. • Verify that removed point source has unique identification, documented in the logbook and the drum inventory sheet. • Verify that removed point source storage and management procedure is in accordance with the project plans. • Verify that all bags and drums are marked with a unique identification and information is recorded in the logbook. • Verify personnel/equipment surveys are performed before exiting a radiological controlled area. • Verify that filled drums are stored in approved storage areas. • Verify that liner remains in good condition. • Verify that the log of radioactive material is routinely reviewed by the CHP. • Verify that site activities are being photographed. • Verify that photographs are logged and stored.	
Excavation and removal of soil/piping	• Verify that the RPM and NTR have been notified. • Verify that Utilities Underground Location Center has been notified 72 hours prior to excavation. • Verify that an assignment letter for competent person is on file.		• Verify that the RCT and SSHO are present in an active work area. • Verify that a spotter trained in recognizing underground utilities is present at all times. • Verify that airborne concentrations do not exceed the established levels.		• Verify that RCT and SSHO are present in an active work area. • Verify that a spotter trained in recognizing underground utilities is present at all times. • Verify that airborne concentrations do not exceed the established levels.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Excavation and removal of soil/piping (continued)	• Verify that training requirements are met for all personnel. • Verify that equipment and material are surveyed for radiation and survey results are documented. • Verify that final excavation configurations have been reviewed with the Navy and regulators. • Verify that initial background air sampling has been conducted. • Verify that electrical lines are de-energized, if necessary. • Verify that existing utilities and structures are removed, if necessary. • Verify that proper equipment is on-site to perform work. • Review the project plan requirements pertaining to the activity. • Review the AHAs. • Verify that PPE is available and meets the requirements of the SSHP. • Verify that radiation awareness training has been completed and documented. • Verify that all personnel have assigned dosimeters and completed the NRC Form 4. • Verify that the RWP is in place and that all workers have read the requirements. • Verify that traffic schedule/routes have been approved by the NTR. • Verify provisions for traffic control.		• Verify that air monitoring and initial baseline sampling are being performed per SSHP. • Verify that required dosimetry is being worn. • Verify that all personnel have signed the RWP(s). • Verify that the excavation protocol, as described in the project plans, is being followed. • Verify that dust control is used as necessary. • Verify that site activities are being photographed and logged. • Verify that permit conditions are followed, as applicable. • Verify sediment control per the SWPPP. • Verify that traffic control procedures are being followed.		• Verify that air and soil samples are collected as required. • Verify that trenching excavation is performed in accordance with the project plans. • Verify that open sewer or storm drain lines, temporarily left in place during the removal process, are plugged as described in the project plans. • Verify that pipeline closures are performed in accordance with the project plans. • Verify that required dosimetry is being worn. • Verify that daily safety briefings discuss status of RWP(s). • Verify that RWP is available at the work location. • Verify that RWP is modified in the event of changes to the conditions. • Verify that modified RWP was concurred with by RASO and concurrence is documented. • Verify that tools, material, and equipment are cleaned, wiped down, and surveyed prior to removal. • Verify that excavation protocol, as described in the project plans, is being followed. • Verify that visually stained soil/material is segregated. • Verify that competent person is conducting/logging daily inspection of the excavation and slope stability. • Continue to inspect ongoing work.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Excavation and removal of soil/piping (continued)					• Verify sediment control per the SWPPP. • Verify that personnel surveys are performed for all personnel leaving a radiological controlled area. • Verify that site activities are being photographed. • Verify that photographs are logged. • Verify that traffic control procedures are being followed.	
Removal of radiologically contaminated building components and restoration	• Verify that the RPM and NTR have been notified. • Verify that radiological awareness and other training requirements are met for all personnel. • Verify that proper equipment is on-site to perform work. • Review the project plan requirements pertaining to the activity. • Review AHAs. • Verify that PPE is available and meets the requirements of the SSHP. • Verify that all personnel have assigned dosimeters and completed the NRC Form 4. • Verify that the RWP is in place and that all workers have read the requirements. • Verify status of utilities in the vicinity of the activity. • Verify removal areas are delineated. • Ensure appropriate restoration materials are available.		• Verify that the RCT and SSHO are present in an active work area. • Verify that air monitoring and initial baseline sampling are being performed per SSHP. • Verify that airborne concentrations do not exceed the established levels. • Verify that required dosimetry is being worn. • Verify that all personnel have signed the RWP(s). • Verify that dust control is used as necessary. • Verify that site activities are being photographed. • Verify removal/restoration efforts comply with project plans. • Verify in-progress surveys/monitoring/sampling is performed and documented.		• Verify that RCT and SSHO are present in an active work area. • Verify that airborne concentrations do not exceed the established levels. • Verify that surveys/sampling are performed as required. • Verify that required dosimetry is being worn. • Verify that daily safety briefings discuss status of RWP(s). • Verify that RWP is available at the work location. • Verify that RWP is modified in the event of changes to the conditions. • Verify that modified RWP was concurred with by RASO and concurrence is documented. • Verify that tools, material, and equipment are cleaned, wiped down, and surveyed prior to removal. • Verify personnel surveys are performed before exiting a radiological controlled area.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Removal of radiologically contaminated building components and restoration (continued)			• Verify progress photographs are being taken and logged.		• Continue to inspect ongoing work for compliance with project plans. • Verify progress photographs are being taken and logged.	
Final Status Surveys (including systematic and biased sampling)	• Verify that RPM and NTR have been notified. • Review the project plan requirements pertaining to the activity. • Verify that radiation awareness training has been completed and training is documented. • Verify that designated personnel have assigned dosimeters and completed the NRC Form 4. • Verify that the RWP is in place and that all workers have read the requirements. • Verify that PPE is available.		• Verify that RCT and SSHO are present in an active work area. • Verify that required dosimetry is being worn. • Review sample collection and handling procedures.		• Verify that RCT and SSHO are present in an active work area. • Verify that required dosimetry is being worn. • Verify that samples are collected in accordance with the sample handling procedures. • Inspect field documentation. • Verify that personnel surveys are performed for all personnel leaving the radiological controlled area. • Verify that site activities are being photographed. • Verify that photographs are logged and stored. • Verify that sample locations are surveyed. • Verify sample chain-of-custody form.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Backfill placement and compaction	• Verify that RPM and NTR have been notified. • Verify that necessary equipment is available. • Review the project plan requirements pertaining to the activity. • Verify that adequate material is available for fill. • Verify that site has been surveyed prior to backfill. • Review AHAs. • Verify that PPE is available and meets requirements of SSHP. • Verify that radiation awareness training has been completed and that training is documented, as applicable. • Verify that designated personnel have assigned dosimeters and completed NRC Form 4, as applicable.		• Verify that RCT and SSHO are present in an active work area. • Verify that required dosimetry is being worn. • Verify that samples of proposed materials have been submitted and approved.		• Conduct ongoing inspection of backfilling and compaction operation. • Verify that backfill placement and compaction comply with the project plans. • Verify that site activities are being photographed. • Verify that photographs are logged and stored.	
Asbestos abatement	• Verify that RPM and NTR have been notified. • Review the Subcontractor Asbestos Abatement Plan, including the AHAs. • Verify that radiation awareness training has been completed and training is documented, as appropriate. • Verify that designated personnel have assigned dosimeters and completed the NRC Form 4, as appropriate. • Verify that PPE is available and meets the requirements of the Contractor Asbestos Abatement Plan. • Verify that the RWP is in place and that all workers have read the requirements, as appropriate.		• Verify that RCT and SSHO are present in an active work area, as appropriate. • Verify that required dosimetry is being worn, as appropriate. • Verify that air monitoring is being performed in accordance with the Contractor Asbestos Abatement Plan. • Verify that all personnel have signed the RWP(s), as appropriate.		• Verify that RCT and SSHO are present in an active work area, as appropriate. • Verify that required dosimetry is being worn, as appropriate. • Verify that daily safety briefings discuss status of RWP(s), as appropriate. • Verify that RWP is available at the work location. • Verify that RWP is modified in the event of changes to the conditions, as appropriate. • Verify that modified RWP was concurred with by RASO and concurrence is documented, as appropriate.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Asbestos abatement (continued)			• Verify that the abatement activities are performed in accordance with the Contractor Asbestos Abatement Plan.		• Verify that tools, material, and equipment are cleaned, wiped down, and surveyed prior to removal, as appropriate. • Verify that air monitoring is being performed in accordance with the Contractor Asbestos Abatement Plan. • Verify that the abatement activities are performed in accordance with the Contractor Asbestos Abatement Plan. • Inspect field documentation. • Verify that personnel surveys are performed for all personnel leaving the radiological controlled area, as appropriate.	
Superstructure demolition	• Verify that RPM and NTR have been notified. • Review AHAs. • Verify that PPE is available and meets requirements of the SSHP. • Verify ACM abatement complete. • Review project plans/demolition plan for requirements governing demolition task. • Verify coordination with adjacent building tenants has taken place and schedule has been communicated.		• Verify that the demolition activities comply with the project plans/demolition plan. • Verify that dust control is in use as necessary. • Verify that site activities are being photographed and logged.		• Verify that the demolition activities comply with the project plans/demolition plan. • Verify that dust control is in use as necessary. • Verify that site activities are being photographed and logged.	
Building 27 hangar structure south face restoration	• Verify that RPM and NTR have been notified. • Review AHAs. • Verify that PPE is available and meets requirements of the SSHP. • Verify required materials are on-site and comply with requirements of order. • Review project plans/demolition plan for requirements governing restoration task.		• Verify that the activities comply with the project plans. • Verify that dust control is in use as necessary. • Verify that site activities are being photographed and logged.		• Verify that the activities comply with the project plans. • Verify that dust control is in use as necessary. • Verify that site activities are being photographed and logged.	

TABLE 3-1

DEFINABLE FEATURES OF WORK

ACTIVITY	PREPARATORY	DONE	INITIAL	DONE	FOLLOW-UP	DONE
Site restoration	• Verify that RPM and NTR have been notified. • Review AHAs. • Verify that PPE is available and meets requirements of the SSHP. • Review project plans for requirements governing restoration of surface features (asphalt/concrete paving, vegetation, etc.).		• Inspect site restoration activities and verify compliance with project plans. • Verify that site activities are being photographed (before/after photographs).		• Conduct ongoing inspection of site restoration activities. • Verify that site activities are being photographed. • Verify that photographs are logged and stored. • Verify that construction-related damage has been repaired. • Schedule Pre-final and Final inspections.	

Abbreviations and Acronyms:

AHA – Activity Hazard Analysis
CHP – Certified Health Physicist
CSO – Caretaker Site Office
NRC – Nuclear Regulatory Commission
NTR – Navy Technical Representative
PPE – personal protective equipment
RASO – Radiological Affairs Support Office
RCT – Radiological Control Technician
RPM – Remedial Project Manager
RSOR – Radiation Safety Officer Representative
RWP – Radiation Work Permit
SOP – Standard Operating Procedure
SSHO – Site Safety and Health Officer
SSHP – Site Safety and Health Plan
SWPPP – Stormwater Pollution Prevention Plan

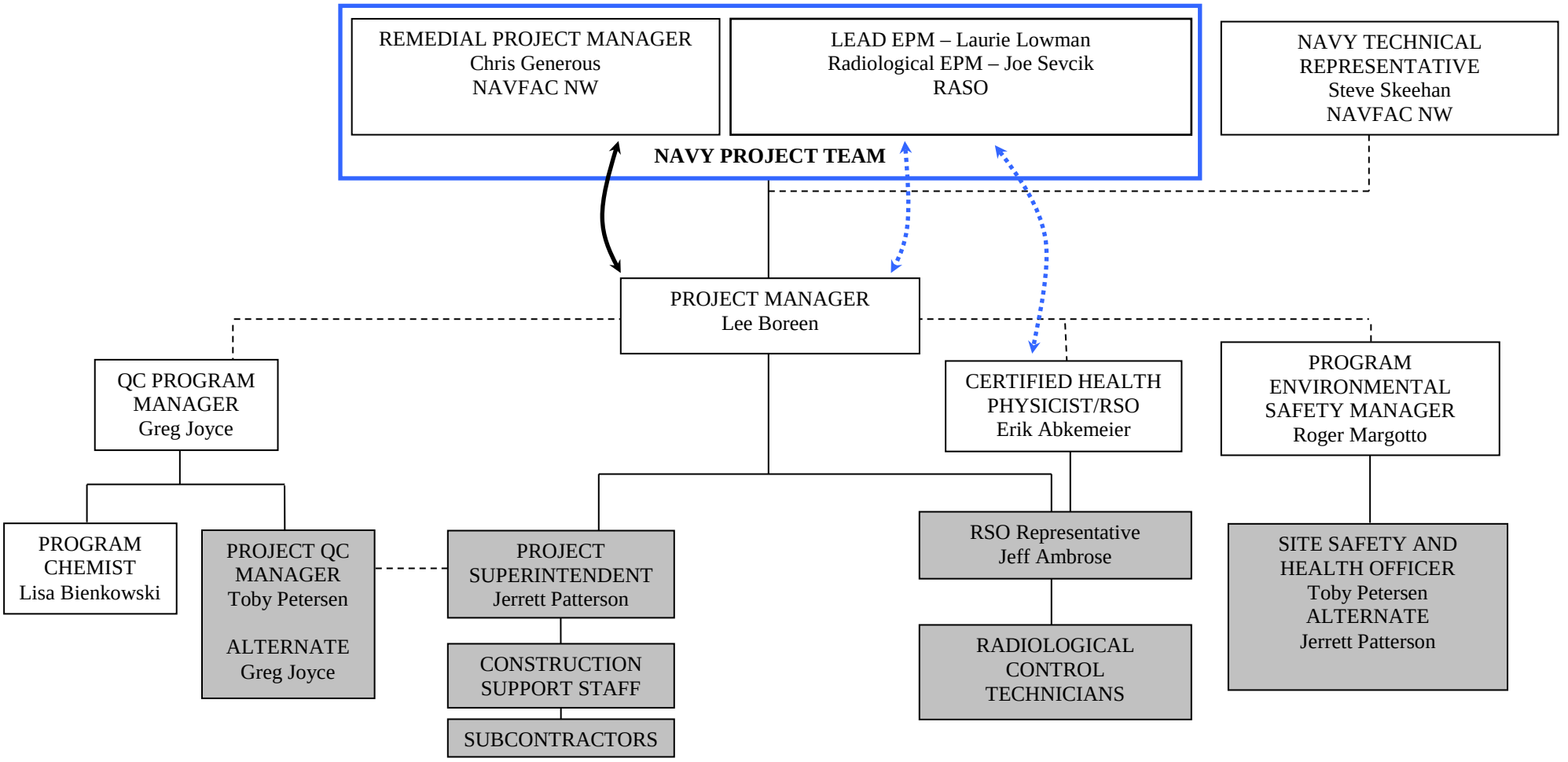
This page intentionally left blank.

FIGURES

This page intentionally left blank.

FIGURE 2-1

PROJECT ORGANIZATION CHART



Legend

- Formal reporting relationship
- Supporting relationship
- Navy/TtEC supporting relationship
- Technical direction and project communication

Staff in shaded boxes are on-site at NAVSTA PS and responsible for field implementation of activities under the Work Plan.

Abbreviations and Acronyms:
EPM – Environmental Protection Manager
NAVFAC NW – Naval Facilities Engineering Command Northwest
NAVSTA PS – Naval Station Puget Sound
QC – quality control
RASO – Radiological Affairs Support Office
RSO – Radiation Safety Officer
TtEC – Tetra Tech EC, Inc.

APPENDIX A

DELEGATION OF AUTHORITY LETTERS AND RESUMES

This page intentionally left blank.

TETRA TECH EC, INC.

April 16, 2013

Mr. Toby Petersen
Tetra Tech EC, Inc.
1050 NE Hostmark, Suite 202
Poulsbo, WA 98370

Subject: **Project Quality Control Manager**

Reference: Contract No. N62473-10-D-0809,
Radiological Environmental Multiple Award Contract, Contract Task Order (CTO) No. 0011,
Naval Station Puget Sound, Seattle, WA

Dear Mr. Petersen:

In accordance with the terms of the Tetra Tech EC, Inc. (TtEC) Contract No. N62473-10-D-0809, this letter notifies you of your appointment as the Project Quality Control Manager for CTO No. 0011, Radiological Materials Time-Critical Removal Action at Former Naval Station Puget Sound, Seattle, Washington.

As the designated Project Quality Control Manager, you will be responsible for managing the site-specific quality control requirements in accordance with the approved plan. You will be responsible for conducting quality control meetings, performing the three phases of control, and performing submittal review. You will be required to be present during all field activities to ensure that any testing is conducted in accordance with approved plans. In addition, you will be required to prepare the necessary quality control certification and documentation.

You have the authority and responsibility for suspending work when conditions adverse to quality are identified and for directing the correction of all nonconforming work.

This letter is effective immediately until modified by the Quality Control Program Manager with concurrence of the TtEC Project Manager, the NAVFAC SW Remedial Project Manager, and the Resident Officer in Charge of Construction.

Sincerely,

Gregory D Joyce

Gregory D Joyce, ASQ CQM
Quality Control Program Manager
Tetra Tech EC, Inc.

cc: Lee Boreen, Project Manager

1230 Columbia Street, Suite 750, San Diego, CA 92101
Tel 619.234.8690 Fax 619.234.8591
www.tteci.com

Experience Summary

Education

Various Coursework, Navy EOD Basic Course, EOD School, 1988
Various Coursework, Navy EOD Assistant Training, EOD School, 1985
Various Coursework, EOD Phase I Chemical Basic, November 1987
Designated Master EOD Technician, June 1994

Registrations/Certifications

Training

10-hour OSHA Construction Safety & Health; October 2003
30-hour OSHA Construction Safety & Health; June 2007
40-hour OSHA Course; July 2000
40-hr OSHA Hazardous Waste Health/Safety Training; July 2000
8-hour OSHA Refresher; April 2012
Construction Quality Management for Contractors; May 2006
DOT Employee Training DOT/HM-126F; February 2012
Environmental and Safety Supervisor Course; October 2003
First Aid/CPR inclusive; March 2010
First Aid/CPR Qualification; March 2010
OSHA Hazardous Waste Worker Physical; August 2011
OSHA Supervisor Training; October 2003
Waste Management Employee Training Program; February 2012
Explosive Driver Certification; January 2012

Corporation Project Experience

Navy NVRC ADAK, Adak, Alaska, UXO Lead, 8/7/00 to 10/20/00

Previous Experience (Construction)

Project Quality Control Manager and Site Health & Safety Officer for Tetra Tech EC Inc.
NAVFAC NW: Environmental Multi-Award Contract (EMAC)
Task Order: JP01, TCRA, Prevent Further Landfill Erosion at Area 1 Beach Landfill, NAS Whidbey Island, WA. CY 2012

Project QC Manager for a TCRA, which involved the placement of large armor rock to implement a short-term stabilization of the seawall to prevent further erosion. This TCRA will be followed up with the design and construction of a permanent coastal erosion protection system to ensure the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedy remains effective at the Area 1 Former Beach Landfill into the future and eliminates the potential for continued erosion.

Project Quality Control Manager & Field Technical Lead for Tetra Tech EC Inc.
NAVFAC SW: Environmental Multi-Award Contract (EMAC)
Task Order: KR02, Land Use Controls and Road Repairs at Former Naval Air Facility Adak, AK. CY 2010

Project QC Manager for this remote site LUC repair action project that included work at 23 different CERCLA and ADEC sites. This project included an extensive QC element with regards to landfill seawall/cap repairs, road construction and repairs, and other LUC improvements. Implemented the 3-phases of QC control during the project to ensure key QC objectives were met. Acted as Tetra Tech's QC representative with the client and led the weekly QC meetings with the client throughout the 5-month field season. **Achieved over 5,000 hours of work with no loss-time or recordable injuries.** This project was completed on time and within the specified budget.

Project Quality Control Manager and Site Health & Safety Officer for Tetra Tech EC Inc.
NAVFAC NW: Environmental Multi-Award Contract (EMAC)
Task Order: KR01, Pipeline Decommissioning Project, Former Naval Air Facility Adak, AK. CY 2009

Project QC Manager for this large-scale remote project that involved decommissioning over 46,300 lf of deteriorated bulk fuel distribution systems throughout the downtown area, eliminating the potential release of residual fuels. Implemented 3-phases of QC control during the project to ensure Definable Features of Work (DFW), Client interests and Environmental Compliance objectives were met. As Tetra Tech's QC representative with the client led the weekly QC meetings with the client, AEDC and interested stakeholders throughout the 5-month field season**.** As lead operator for the Mobile Water Treatment System, treated and discharged 78,000 gallons in total of POL-contaminated waters. Prepared and conducted daily safety briefings. **Achieved over 13,500 hours without a lost workday.** Ensured site compliance with requirements; federal, state, and OSHA regulations, and all aspects of the SHSP, including but not limited to, AHA, air monitoring, use of PPE, decontamination, and the safe use of engineering controls. This project was completed on time and within the specified budget.

Site Health & Safety Officer for Bristol Environmental & Engineering Services Corporation
U. S. Army Corps of Engineers (USACE) Alaska District
Contract Number: W911KB-07-C-005, Bethel Bank Stabilization Project; Bethel, Alaska. CY 2007

Site Health & Safety Officer for the construction of a class "B" riprap retaining wall to stabilize the riverbank along the seawall and across the entrance to Browns Slough. Assisted in the drafting of the Accident Protection Plan. Conducted daily safety briefings and verified equipment inspections. Inspect barge working surfaces, fall protection and railings. Inspected spill protection secondary containment system. Reviewed and briefed weather conditions for working on a floating platform. Filed a NOTAM notification with the U.S. Coast Guard for a vessel of restricted maneuverability. All work was performed from an anchored barge with a long reach excavator to install 17,100 cubic yards of rock for this emergency repair.

Project Quality Control Manager and Field Technical Lead for Tetra Tech EC Inc.
NAVFAC NW: Remedial Action Contract (RAC III)
Task Order: 56, Installation of Groundwater Cutoff Walls and PCS Remediation, Former Naval Air Facility Adak, AK. CY 2006

Project QC Manager for this large, remote site remedial action project. This project included an extensive QC element with regards to the installation of two groundwater cutoff walls that generated several thousand tons of PCS requiring off-island disposal. Implemented 3-phases of QC control during the project to ensure key QC objectives were met. As Tetra Tech's QC representative with the client and led the weekly QC meetings with the client, and AEDC throughout the 5-month field season. Additional roles fulfilled during the field season were Alternate Health & Safety and Field Sampling Lead. This project was completed on time and within the specified budget

SSHO/Quality Control Manager for Bristol Environmental & Engineering Services Corporation
U. S. Army Corps of Engineers, Alaska District: Site Investigation and Drum Removal Action.
Iliamna, Alaska. CY 2005

SSHO/QC Manager for this small, sampling intensive site investigation and drum removal action. Implemented 3-phases of QC control to ensure definable features of work were met. Directed geophysical data collection efforts for identify (2) major drum burial locations. Prepared and briefed potential environmental and biological hazards associated with exposed chemicals of concerns. Monitored chemical constituents identified in the sampling process to confirm PPE requirements and issued changes as required. Managed the sampling process, from in-situ sample collection to reviewing analytical data developed at the laboratory for environmental compliance. The Alaska Department of Environmental Management in September 2007 issued a closure letter confirming that the cleanup was complete and no further action is required

Site Health & Safety Officer for Bristol Environmental & Engineering Services Corporation
U. S. Army Corps of Engineers, Alaska District: White Alice Tram and Debris Removal
St. Lawrence Island, Alaska. CY 2005

SSHO for a large, extremely remote field camp activity that involved the demolition and removal of the White Alice Tram tower facility, associated cabling, general debris, PCB-contaminated soil and concrete, Northeast Cape St. Lawrence Island, Alaska. Responsible for daily safety meetings, PPE selection, sanitation plan, drinking water verification and food inspections. Taught and supervised a high risk rappelling operation that led to the remove of 26 tons of metal debris from the Kangukhsam Mountain side. Assisted in waste stream management and the manifesting of hazardous waste for off-island disposal. Bristol received the following safety awards in fiscal year 2005 from the USACE for work on this project:

- Alaska District, Contractor of the Year, 2005
- Alaska District, Safety Innovation Award, 4th Quarter
- Alaska District, Safety Performance Award, 4th Quarter

Previous Experience (UXO)

June 12	LASEOD; Former Adak Naval Air Station, Adak, Alaska. Provide UXO Escort in support of Biological Assessment, Wetland/Tundra Delineation, and Cultural Landscape and Historical Features Survey.
May 12	Tetra Tech EC, Inc: Hill Air Force Base, Utah. UXO Tech III, Team Leader for RI/FS intrusive investigation.
Mar-Apr 12	Bay West Environmental Inc: Camp Ripley, MN. UXO Tech III, Construction support.
Jan-Feb 12	Tetra Tech EC: Naval Weapons Station Seal Beach Detachment Fallbrook, California. UXO III, Team Leader and Explosive Driver in support of instrumented assisted surface search and intrusive investigations.
Oct-Nov 11	LASEOD: Total Force Training Center FT McCoy, Sparta, Wisconsin. UXO III, Team Leader in support of Intrusive operations.
Sept-Oct 11	URS Corporation: Former Adak Naval Air Station, Adak, Alaska. Provide UXO Escort in support of Biological Assessment, Wetland/Tundra Delineation, and Cultural Landscape and Historical Features Survey.

May-Aug 11	Delta Environmental Technical: Makua Military Reservation. Oahu, Hawaii. Third Party QA Representative evaluating contractor compliance in support of Intrusive and geophysical data collections operations.
Oct-Apr 11	Donaldson Enterprises, Inc: Pohakuoa Training Area (PTA) Hawaii. UXO Tech III. Provide UXO escort in support of Archeological and Botanical surveys
.	
May-Sept 10	Tetra Tech EC, Inc: Former Adak Naval Air Station Adak, Alaska. Site Health & Safety & Quality Control Manager. **Construction Project**.
Mar 10	OER: Former Seneca Army Depot. Seneca, NY. UXO Tech III, Construction Support.
Jan-Mar 10	Donaldson Enterprises, Inc: Makua Military Reservation. Oahu, Hawaii. Site Health & Safety/Quality Control Manager. Vegetation removal, surface clearance, Mag and dig operations and cultural (Native Hawaiian) feature identification and documentation.
Mar-May 09	Parsons: Former Orlando Chemical Yard. Orlando, FL. UXO III, Team Leader, supporting Intrusive (**Chemical/CAIS Kit**) Investigations.
Jan-Feb 09	OER: Former Great Salt Plains Bombing Range Alfalfa County, OK. UXO III, Team Leader, supporting Intrusive Investigations and Demolition Operations.
Nov-Dec 08	OER: Pohakuoa Training Area (PTA) Hawaii. Senior UXO Supervisor; Davy Crockett Weapons System Project. **Depleted Uranium Survey.**
Oct 08	OER: FT. Carson, CO. Senior UXO Supervisor; Davy Crockett Weapons System Project. **Depleted Uranium Survey.**
May-Sept 08	EODT: Former Adak Naval Air Station Adak, Alaska. Site Health & Safety. Supporting Geophysical Data Collection, Intrusive Activities and Demolition Operations
Mar-Apr 08	Bay West Environmental Inc: Nellis Air Force Base, NV. Site Health & Safety (AF MMRP) Comprehensive Site Evaluation (CSE) Phase II.
Jan-Feb 08	Donaldson Enterprises, Inc: Waikoloa, HI (Former Waikoloa Maneuver Area/Nansay Combat Range) UXO III, Team Leader for instrument assisted surface search.
Sept 07	Parsons: Victorville, CA (Former Precision Bombing Range) Site Health & Safety (FUDS MMRP Site Inspection Project).
Aug 07	Parsons: Amarillo, TX (Former Amarillo AFB) Site Health & Safety. (FUDS MMRP Site Inspection Project).
May 07	Parsons: Alexandria, LS (Former Alexandria AAF Gunnery Range) Site Health & Safety. (FUDS MMRP Site Inspection Project).
May 07	Parsons: Yazoo, MS (Former Yazoo Bombing Range) Site Health & Safety. (FUDS MMRP Site Inspection Project).
Apr 07	Bristol Construction: Fairbanks, AK (Yukon Range, Eielson Air Force Base) UXO III, Team member for surface sweep operations/construction support.

Apr–Oct 06	Tetra Tech EC, Inc: Former Adak Naval Air Station Adak, Alaska. Site Health & Safety/Quality Control Manager. **Construction Project**.
Oct-Dec 05	Bristol Environmental & Engineering Services Corporation: Camp Lejeune North Carolina. Site Health & Safety/Quality Control Manager. Intrusive activity, demolition operations and QA certification of OE related scrap.
Sept-Oct 05	Bristol Environmental & Engineering Services Corporation: Iliamna, Alaska. Site Health & Safety. **Construction Project**.
Jun-Sept 05	Bristol Environmental & Engineering Services Corporation: St Lawrence Island, Alaska. Site Health & Safety. **Construction Project**.
Apr-May 05	Tetra Tech EC, Inc: Beaumont Site 1 San Bernardino, CA. UXO III, Team Leader for intrusive operations.
Mar-Apr 05	Bristol Environmental & Engineering Services Corporation: Eareckson Air Station, Shemya Island Alaska. UXO III. Construction support.
Feb-Mar 05	Tetra Tech EC, Inc: Jackson Park Housing Complex, Bremerton, WA. UXO III, team member for intrusive operations.
Dec 04	Environmental Chemical Corporation: Lakewood, CO. Quality Control Manager. Compliance and Regulatory review of data collected during the Adak 04 field season.
Oct-Nov 04	Tetra Tech FW, Inc: Anniston, AL. Site Health & Safety /Quality Control Manager supporting intrusive and demolition operations.
Jun-Sept 04	Environmental Chemical Corporation: Former Adak Naval Air Station Adak, Alaska. UXO Quality Control Manager supporting intrusive operations.
Nov-Jan 04	Tetra Tech FW, Inc: Savanna Army Depot Savanna, IL UXO III, Team Leader for intrusive operations.
Sept-Oct 03	Tetra Tech FW, Inc: Former Adak Naval Air Station Adak, AK. Site Superintendent & SUXOSS for the thermal treatment of ordnance related scrap.
Sept 03	Tetra Tech FW, Inc: Naval Ordnance Station Indian Island, WA. UXO III Construction support.
Sept 03	Tetra Tech FW, Inc: Tetra Tech FW Inc: Jackson Park Housing Complex Bremerton, WA UXO III Construction support.
Aug 03	Tetra Tech FW, Inc: Jackson Park Housing Complex Bremerton, WA. UXO III, in support of Construction operations.
Jun-Jul 03	Tetra Tech FW, Inc: Oak Harbor, WA UXO III for diving and associated equipment maintenance.
May-Jun 03	Tetra Tech FW, Inc: Jackson Park Housing Complex Bremerton, WA. UXO III, team member for intrusive operations.

Dec-May 03	Tetra Tech FW, Inc: Former Lowery Bombing and Gunnery Range, Aurora, CO. UXO III, Team leader for intrusive operations.
May-Nov 02	Foster Wheeler Environmental Corporation: Former Adak Naval Air Station Adak, AK Quality Control Assistant supporting intrusive operations.
May 02	Foster Wheeler Environmental Corporation: Jackson Park Housing Complex Bremerton, WA. UXO III, team member for intrusive operations.
Mar 02	Foster Wheeler Environmental Corporation: Former Alameda Naval Air Station Alameda, CA. UXO III, **Heavy Equipment operator for intrusive operations**.
Dec-Jan 02	Environmental Chemical Corporation: Camp Elliott MCAS Miramar, CA. UXO II, team member for instrument assisted surface search.
Oct-Nov 01	Foster Wheeler Environmental Corporation: Jackson Park Housing Complex Bremerton, WA. UXO III, team member for intrusive operations.
Aug-Oct 01	Environmental Chemical Corporation: Former Adak Naval Air Station Adak, AK. UXO II, team member for intrusive operation. **Dive team member for instrument assisted bottom survey.**
Aug 01	Foster Wheeler Environmental Corporation: National Archives Washington, D.C. UXO III, conducted research in support of Jackson Park Housing Complex Bremerton, WA project.
Apr-Jul 01	Foster Wheeler Environmental Corporation: Jackson Park Housing Complex Bremerton, WA. UXO III, team member for intrusive operations.
Oct-Feb 01	Foster Wheeler Environmental Corporation: Jackson Park Housing Complex Bremerton, WA. UXO III, **team member for diving operations for intrusive activity.**
Aug-Oct 00	Foster Wheeler Environmental Corporation: Former Adak Naval Air Station Adak, AK. UXO III, geophysical data collection team member.

Publications & Presentations

Professional Accomplishments

Professional Affiliations

Member (#63295349), American Society of Quality; March 2004

Discipline Codes

UXO Certified Specialist (EOD), Y

Skill Set

Technical Expertise

Professional References

Related Company Information

Payroll Number: 502453
Employment Status: Full
Preferred First Name: Toby
Office Location: Poulsbo
Hire Date: 5/4/09
Years with Other Firms: 20
Years with Current Firm: 5
Total Years' Experience: 25
Supervisor:
Office Phone:
Cell Phone:
Fax:
E-mail Address: Toby.Petersen@tetratech.com
Other E-mail Address (if any): tjpeod@aol.com
Resume Last Revised: 2012-07-06

APPENDIX B

CONTRACTOR QUALITY CONTROL FORMS

This page intentionally left blank.

TETRA TECH EC, INC.

CONTRACTOR PRODUCTION REPORT

Date:

Contract No.	Title & Location:	Report No.
N62473-10-D-0809		

Contractor:	Superintendent:
AM Weather:	PM Weather:

Work Performed Today

Work Location & Description	Employer	Number	Trade	Hours

Was a job safety meeting held this date?	Yes:		Total work hours on site this date:	0.0
(If yes, attach a copy of meeting minutes.)	No:			
Were there any lost time accidents this date?	Yes:			
(If yes, attach a copy of completed OSHA report.)	No:		Cumulative work hours from previous report:	
Was trenching/scaffolding/HV electrical/high work done this date?	Yes:			
(If yes, attach statement or checklist showing inspection performed.)	No:			
Was hazardous material/waste released to the environment?	Yes:		Cumulative work hours since start of work:	
(If yes, attach description of incident and proposed action.)	No:			

List safety actions taken today/safety inspections conducted:

Remarks:

Contractor Superintendent

Date

CONTRACTOR PRODUCTION REPORT						Page 2 of 2	Date: 1/0/1900
Contract No. N62473-10-D-0809	**Title & Location:**						Report No. 0

Rental Equipment	Vendor	PO/MOA#	Charge #	Start Date	Rate	Daily Hrs	P.O.P. Expires

Materials	Vendor	PO #	Charge #	QTY REC'D	ACCUM QTY	P O QTY	P.O.P. Expires

____________________________ 01/00/00

Contractor Superintendent **Date**

TETRA TECH EC, INC		
NAVFAC SW RADIOLOGICAL EMAC CONTRACT NO. N62473-10-D-0809 SAN DIEGO, CA	REPORT NO:	
	PROJECT:	
	PROJECT NO:	
	SUBCONTRACTOR:	
	LOWER TIER SUB:	
CONTRACTOR QUALITY CONTROL REPORT	DATE:	
	TASK:	
	LOCATION	

SEE CONTRACTOR DAILY PRODUCTION SUMMARY REPORT FOR INFORMATION ON SAFETY, WEATHER, SUBCONTRACTOR HOURS AND AREAS OF RESPONSIBILITY:

SUMMARY OF CONSTRUCTION PROGRESS AND QUALITY CONTROL ACTIVITIES PERFORMED:

Tests Performed and Results:

Materials Received:

Deficiencies Noted with Proposed or Implemented Corrective Action:

JOB SAFETY: (LIST OBSERVATIONS)

COMMENTS: ADDRESS ANY CHANGES (FCR/DCN), MEETING RESULTS OR OTHER INFORMATION

Contractor's Verification: On behalf of the Contractor, I certify this report is complete and correct, and all materials and equipment used and work performed during this reporting period are in compliance with the contract plans and specifications to the best of my knowledge, except as may be noted above.

NAME:	TITLE/COMPANY: PQCM
SIGNATURE:	DATE:

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

DEFICIENCY NOTICE

TASK ORDER # _____ DN # _____ DATE _____

LOCATION: _____ ROICC / RPM

1. Plan, Procedure, Specification, or Drawing (Clearly state the requirement)

2. Description of Deficiency

QC verification of corrective action required: **Yes** _____ **No** _____

Prepared by: _____ **Approved by:** _____

3. Corrective Action

_____ _____ _____
Organization Signature Date

4.

Corrective action verified by: _____ Date _____

Comments:

_____ _____
Program Quality Control Manager Date

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

DESIGN CHANGE NOTICE (DCN)

TASK ORDER # _____ DCN # _____ DATE _____

LOCATION _____ NTR / RPM _____

1. Document to be changed. Identify revision, date, section, drawing, etc.

2. Description of Change (Items involved, submit sketch, if applicable): **(Use continuation sheet if necessary)**

Engineering "HOLD" placed on all activities in area defined herein pending receipt of formally revised document(s) and / or DCN.
Released for construction basis of modifications prescribed by this DCN.

3. Reason for Change (Attach additional information if needed)

4. Originator (Print name and sign)		Title	Date
Reviewed by: (Print name and sign)		Title	Date
Task Order Manager (Print name and sign)	Date	Program Quality Manager (Print name and sign)	Date
NTR Acknowledgement (Print name and sign)	Date	RPM Approval (Print name and sign)	Date

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

DESIGN CLARIFICATION REQUEST

TASK ORDER # _____ **DC#** _____ **DATE** _____

Submitted to: _____

1. Document reference. Identify revision, date, section, drawing, etc.

2. Clearly state requirement or describe drawing as shown. (Attach additional info if needed)

3. Information requested or proposed change. (Attach additional information if needed)

4. Response

Does response require an FCR or DCN **YES** ☐ **NO** ☐

FCR ☐ **DCN** ☐

Task Order Manager (Print name and sign)	**Date**

TETRA TECH EC, INC.

NAVY RADIOLOGICAL ENVIRONMENTAL MULITPLE AWARD ACTION CONTRACT (Rad EMAC)

CONTRACT NO. N62473-10-D-0809

FIELD CHANGE REQUEST (FCR)

TASK ORDER # _____ FCR # _____ DATE _____

LOCATION: _____ NTR / RPM _____

1. Document to be changed. Identify revision, date, section, drawing, etc.

2. Description of existing requirement and proposed change (Attach sheet if necessary)

3. Reason for Change (Attach sheet if necessary)

4. Originator: (print name and sign)		**Title**	**Date**
Reviewed by: (print name and sign)		**Title**	**Date**
Site Superintendent (Print name and sign)	**Date**	**Task Order Manager (Print name and sign)**	**Date**
TtEC Program QC Manager (Print Name and Sign)	**Date**	**NTR Acknowledgement (Print name and sign)**	**Date**

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

Initial Phase Inspection Checklist

Task Order No.: _____ Date: _____
Definable Feature: _____ Spec Section: _____

I. Personnel Present:

	Name	Position	Company / Government
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

(List additional personnel on reverse side)

II Identify full compliance with procedures identified at preparatory inspection. Coordinate plans, specifications, and submittals.
Comments:

III Preliminary Work. Ensure preliminary work is complete and correct. If not, what action is taken?
Actions:

IV Establish Levels of Workmanship

1. Where is the work located? _____
2. Is a sample panel required? Yes _____ No _____
3. Will the initial wok be considered as a sample? Yes _____ No _____
   (If yes, maintain in present condition as long as possible.)

V Resolve any differences.
Comments:

VI Check Safety
1. Review job conditions using Site Health and Safety Plan and job hazard analysis.
2. Review job conditions using using EM-385-1-B151.

Initial Phase Inspection Checklist

Comments:

Site CQC Representative

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

MONTHLY REWORK ITEMS LIST

Task Order Number: _____ Project: _____ Date: _____

Number	Identification of item requiring rework	Date Identified	Date Corrected	Remarks

_____
Site CQC Representative Date

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

NONCONFORMANCE REPORT

TASK ORDER # _____ **NCR#** _____ **DATE** _____

LOCATION: _____ **ROICC/RPM**

1. Plan, Procedure, Specification, or Drawing (Clearly state the requirement)

2. Description of Nonconforming Item or Condition

Did nonconforming condition require suspension of work activities Yes ☐ No ☐

If yes, explain requirement to restart work activities: _____

Prepared by: _____ Title _____ Date _____

3. Corrective Action

- ☐ use-as-is
- ☐ repair
- ☐ rework to specificaion
- ☐ other - specify: _____

Comments:

Organization _____ Signature _____ Date _____

NONCONFORMANCE REPORT

4. Evaluation of Proposed Disposition

Evaluator _____ Title _____

Accept	
Accept with comments	
Reject	
Reject with comments	

Comments:

Signature _____ Date _____

Evaluator _____ Title _____

Accept	
Accept with comments	
Reject	
Reject with comments	

Comments:

Signature _____ Date _____

5. Verification

Verification required Yes ☐ No ☐

Verified by: _____ _____ _____
Signature Title Date

Approved by: _____ _____
Program QC Manager Date

TtEC
RMAC

Preparatory Inspection Checklist

Task Order No.: _____ Date: _____

Definable Feature: _____ Spec Section: _____
ROICC Notified _____ ____ ____

I Permits

Have all necessry permits been obtained? Yes ____ No ____

Are the permits on site? Yes ____ No ____

II Sampling Process

Is all sampling equipment on site? Yes ____ No ____

Are sampling labels on site? Yes ____ No ____

Are COCs on site? Yes ____ No ____

Do sampling personnel clearly understand the sample identification procedure? Yes ____ No ____

Has sampling decon procedures been established? Yes ____ No ____

Are proper sample preservation procedures in place? Yes ____ No ____

Has the laboratory been notified of sample shipment? Yes ____ No ____

Has waste disposal processes been established? Yes ____ No ____

Do sampling personnel understand the sampling procedures? Yes ____ No ____

Comments:

VII Safety

1. Review applicable portion of the Task Order Site Health and Safety Plan.
Comments

2. Activity Hazard Analysis approved? Yes ___X___ No _____

VIII Navy comments during meeting.

TtEC
RMAC

Preparatory Inspection Checklist

I. Personnel Present:

	Name	Position	Company / Government
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	(List additional personnel on reverse side)		

Site CQC Representative

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

Preparatory Inspection Checklist

Task Order No.: _____ Date: _____
Definable Feature: _____ Spec Section: _____
NAVFAC SW notification _____ 48 Hours in Advance Yes ____ No ____

I Submittals

1. Review submittals and/or submittal register. Have all applicable submittals been approved?
Yes _____ No _____

If No, what items have not been submitted?
Comments

2. Are all materials on hand? Yes _____ No _____

If No, what items are missing?
Comments

3. Check approved submittals against delivered materials. (This should be done as materials arrive.)
Comments

II Material Storage

Are materials stored properly? Yes _____ No _____

If No, what actions is taken?

III Specifications

1. Review each paragraph of Specification

Preparatory Inspection Checklist

2. Discuss procedure for accomplishing the work.

3. Clarify any differences.

IV Preliminary Work and Permits

Ensure preliminary work is correct and permits are on file. Yes _____ No _____

If No, what action is taken?

V Testing

1. Identify test to be performed, frequency, and by whom.

2. When required?

3. Where required?

4. Review testing play.

5. Has test facilities been approved?

Preparatory Inspection Checklist

VI Safety

1. Review applicable portion of the Task Order Site Health and Safety Plan.
2. Review applicable portion of EM385-1-1.

Comments

3. Activity Hazard Analysis approved? Yes _____ No _____

VIII Navy comments during meeting.

TETRA TECH EC, INC.
NAVY RADIOLOGICAL ENVIRONMENTAL MULTIPLE AWARD CONTRACT (Rad EMAC)
CONTRACT NO. N62473-10-D-0809

Preparatory Inspection Checklist

I. Personnel Present:

	Name	Position	Company / Government
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

(List additional personnel on reverse side)

Site CQC Representative

TETRA TECH EC, INC.
NAVY REMEDIAL ACTION CONTRACT (RAD EMAC)
CONTRACT NO. N62473-10-D-0809

SUBMITTAL REGISTER

Contract Number: N62473-10-D-0809					Project Title:								Location:			
							Contractor Action			Approving Authority Action				Contracting Officer / Contractor		
Specification Section Number	SD No and Type of Submittal Material or product	Specification Paragraph Number	Classification / Approval By CO	Govt. or A/E Reviewer	Transmittal Control No.	Planned Submittal Date	Action Code	Date of Action	Date FWD to Approving Authority / Date recd. From Contractor	Date FWD to other Reviewer	Date Received from other Reviewer	Action Code	Date of Action	Mailed to Contractor / Received from Approving Authority	Remarks
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)

Action Code: NR: Not Reviewed AN: Approved as Noted A: Approved RR: Disapproved; Revise and Resubmit (Others may be prescribed by Transmittal Form)

TETRA TECH EC, INC.
NAVY REMEDIAL ACTION CONTRACT (RAD EMAC)
CONTRACT NO. N62473-10-D-0809

TEST PLAN and LOG

CTO Number: 11 CTO Manager: Lee Boreen
Project Radiological Materials TCRA at Former Naval Station Puget Sound Location: Seattle, Washington

Spec. Section	Paragraph No.	Test Procedure	Test Name	Test Frequency	Test Responsibility	Tested By	Date Completed	Remarks
Remedial Action Work Plan	12.7.7.1	ASTM D 1557	lab compaction characteristics of soil using modified effort	1 test for each aggregate material type	independent material testing laboratory			
Remedial Action Work Plan	12.7.7.1	ASTM D6938	in-place density & water content of soil & soil-aggregate by nuclear methods	min. 1 test per 50' of trench length & 2' of fill depth	independent material testing laboratory			See Section 12.7.7.1 for specific requirements & applicability
Remedial Action Work Plan	12.7.7.2	ASTM D6938	in-place density & water content of soil & soil-aggregate by nuclear methods	min. 1 test per 500 ft^2 of fill area & 2' of fill depth	independent material testing laboratory			See Section 12.7.7.1 for specific requirements & applicability

ATTACHMENT 3

ENVIRONMENTAL PROTECTION PLAN/ WASTE MANAGEMENT PLAN

This page intentionally left blank.

U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

ATTACHMENT 3

FINAL

ENVIRONMENTAL PROTECTION PLAN/ WASTE MANAGEMENT PLAN

July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION AT FORMER NAVAL STATION PUGET SOUND SEATTLE, WASHINGTON

Prepared by:

TETRA TECH EC, INC.
1230 Columbia Street, Suite 750
San Diego, California 92101-8536

Jennifer Peters
Environmental Compliance Manager

Lee Boreen
Project Manager

TABLE OF CONTENTS

TABLE OF CONTENTS

(Continued)

PAGE

TABLES

APPENDICES

ABBREVIATIONS AND ACRONYMS

ACM	asbestos-containing material
ALARA	as low as reasonably achievable
APP	Accident Prevention Plan
ARAR	applicable or relevant and appropriate requirement
AWSR	Asbestos Waste Shipment Record
BACT	best achievable control technology
BMP	best management practice
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CTO	Contract Task Order
cy	cubic yard
DEHP	bis(2-ethylhexyl)phthalate
DOT	Department of Transportation
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPP	Environmental Protection Plan
HMR	Hazardous Material Regulations
LLRW	low-level radioactive waste
MOU	Memorandum of Understanding
MSDS	material safety data sheet
NAVFAC NW	Naval Facilities Engineering Command Northwest
NAVSTA PS	Naval Air Station Puget Sound
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
non-LLRW	non-low-level radioactive waste
NTR	Navy Technical Representative
PCB	polychlorinated biphenyl

ABBREVIATIONS AND ACRONYMS
(Continued)

PjM	Project Manager
POTW	publicly owned treatment works
PPE	personal protective equipment
ppm	parts per million
PSCAA	Puget Sound Clean Air Agency
RASO	Radiological Affairs Support Office
RCRA	Resource Conservation and Recovery Act
RPM	Remedial Project Manager
RPP	Radiation Protection Plan
RSOR	Radiation Safety Officer Representative
SAP	Sampling and Analysis Plan
SSHP	Site Safety and Health Plan
SWPPP	Stormwater Pollution Prevention Plan
TBC	to be considered
TCRA	time-critical removal action
TSCA	Toxic Substances Control Act
TSP	Task-specific Plan
TtEC	Tetra Tech EC, Inc.
WAC	Washington Administrative Code
WMP	Waste Management Plan

1.0 INTRODUCTION

This Environmental Protection Plan (EPP) identifies the applicable environmental regulatory requirements for conducting the radiological materials time-critical removal action (TCRA) at the former Naval Station Puget Sound (NAVSTA PS) located in Seattle, King County, Washington. It also identifies waste management and disposal requirements in Section 4.0, Waste Management Plan (WMP).

This EPP/WMP will be used in conjunction with the Radiological Removal Action Work Plan (Work Plan) to which it is attached, along with Task-specific Plans (TSPs) and the Radiation Protection Plan (RPP), which are also attachments to the Work Plan. This EPP/WMP will also be used with the Accident Protection Plan (APP)/Site Safety and Health Plan (SSHP) (TtEC 2013), which is prepared separately. Additional plans referenced herein, such as the Asbestos Abatement Plan, will also be followed.

Additional plans referenced herein, such as the Asbestos Abatement Plan, will also be followed.

Information on the site location and history, project organization, site conditions, and prior removal actions is provided in the Work Plan. Environmental regulatory requirements for the project activities are discussed in this plan along with the measures to be implemented to ensure compliance with applicable Department of the Navy (Navy), federal, state, and local requirements.

Future changes to this EPP/WMP will be made in accordance with the Project Contractor Quality Control Plan requirements.

1.1 REGULATORY FRAMEWORK

The Naval Facilities Engineering Command Northwest (NAVFAC NW) plans to conduct a radiological materials TCRA at the former NAVSTA PS. This TCRA is being conducted in accordance with the Navy's Environmental Restoration Program using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. The Washington State Department of Ecology (Ecology) is the lead regulatory agency for the radiological cleanup at former NAVSTA PS. The TCRA will follow the substantive requirements of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Per Title 40 *Code of Federal Regulations* (CFR) Section 300.415 (3)(b)(1), any release, regardless of whether the site is included on the National Priorities List (former NAVSTA PS is not), where the lead agency (NAVFAC NW) makes the determination that there is a threat to public health or welfare or the environment, the lead agency may take any appropriate removal action to abate, prevent, minimize, stabilize, mitigate, or eliminate the

release or threat of release. The threat to public health or welfare or the environment is appropriate based on the following factors:

- Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants
- The presence of high levels of hazardous substances, pollutants, or contaminants in soils largely at or near the surface

A radiological remedial investigation was conducted at the former NAVSTA PS from April through December 2010. The lead agency (NAVFAC NW) has determined that, based on the results of the investigation, a TCRA will be performed.

1.2 SCOPE OF WORK

The following activities will be performed during the radiological materials TCRA at the former NAVSTA PS:

- Removal of radiologically contaminated Building 27 components, including associated radiological surveys and waste management, and subsequent demolition of the Building 27 South Shed and restoration of the south face of the original Building 27 hangar structure.
- Removal of radiologically contaminated Building 2 components, including associated radiological surveys, restoration, and waste management. The ventilation system will be removed if contamination is found above TCRA project release criteria. Sections with contamination that is not above project release criteria may be left in place.
- Removal of radiologically contaminated soil surrounding Buildings 2, 12, and 27, including additional characterization, associated radiological surveys, restoration, and waste management.
- Removal and replacement of radiologically contaminated storm drain system components (e.g., catch basins, pipe, and appurtenances) associated with Buildings 2 and 27, including additional assessments, associated radiological surveys, restoration, and waste management.
- Disposal of non-low-level radioactive waste (non-LLRW) in a permitted landfill and low-level radioactive waste (LLRW) in a licensed LLRW waste disposal facility.

This EPP identifies the applicable environmental regulatory requirements that pertain to the above activities. The components included in the EPP are:

- Identification of regulatory requirements that may be applicable to project activities (Section 2.0)

- Project environmental protection requirements for specific project activities, including soil handling, fugitive dust control, asbestos abatement and demolition, hazardous materials management, and stormwater management and erosion control procedures (Section 3.0)
- A WMP that identifies specific waste handling procedures and requirements (Section 4.0)
- Spill/release response procedures and reporting requirements (Section 5.0)
- Training requirements (Section 6.0)
- Procedures for regulatory inspections (Section 7.0)

This page intentionally left blank.

2.0 COMPLIANCE WITH REGULATORY REQUIREMENTS

On-site project activities must comply with the substantive requirements of federal and state applicable or relevant and appropriate requirements (ARARs) and other environmental statutes, unless a waiver can be justified. These statutes include those established by the U.S. Environmental Protection Agency (EPA) and other federal agencies, and those established by the state of Washington (state in which the release occurred) if the state's standards are promulgated, are more stringent than the federal standards, and are identified in a timely manner. The ARARs for the work that will be executed at former NAVSTA PS are documented in the Action Memorandum (Shaw 2013) and summarized in Tables 2-1, 2-2, and 2-3 of this plan.

Off-site activities such as waste transport and disposal must comply in full with the applicable laws and regulations, not just substantive requirements.

The NCP (40 CFR 300.5) defines "applicable" requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site." Only those promulgated state standards that are identified by a state in a timely manner and that are equal to or more stringent than federal requirements may be applicable.

The NCP (40 CFR 300.5) further defines "relevant and appropriate" requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site." Like "applicable" requirements, the NCP also provides that only those promulgated state requirements that are identified in a timely manner and are more stringent than corresponding federal requirements may be relevant and appropriate.

To be considered (TBC) guidance consists of guidelines or advisories that are issued by the federal or state government, but which are neither legally binding nor promulgated (EPA 1988). However, these guidelines may be used when necessary to ensure protection of public health and the environment and when they have not been superseded. If no ARARs address a particular circumstance at a CERCLA site, then TBC guidance can be used to establish remedial guidelines or targets.

The EPA identifies three categories of ARARs for this project as follows:

- Radionuclide-specific ARARs – Radionuclide-specific requirements include laws or requirements that set concentration limits or ranges for specific hazardous substances in various environmental media. These requirements provide site cleanup levels, or a basis for calculating cleanup levels, for radionuclides of concern in the designated media. Radionuclide-specific ARARs are also used to indicate an acceptable level of discharge, to determine treatment and disposal requirements for a particular removal action activity, and to assess the effectiveness of a removal action alternative. In the event that a chemical has more than one requirement, the most stringent of the requirements is applied.
- Location-specific ARARs – Location-specific requirements set restrictions on the types of removal action activities that can be performed based on the location of the site or other site-specific characteristics. Alternative removal actions may be restricted or precluded based on federal and state citing laws for hazardous waste facilities, proximity to wetlands or floodplains, or proximity to man-made features such as existing landfills, disposal areas, or historic buildings. Location-specific ARARs provide a basis for assessing these restrictions during the formulation and evaluation of site-specific remedies.
- Action-specific ARARs – Action-specific requirements set controls or restrictions on the design, implementation, and performance of specific removal action activities. After removal action alternatives are developed, action-specific ARARs specify performance levels, actions, or technologies, as well as specific cleanup levels for discharge or residual chemicals, and provide a basis for assessing the feasibility and effectiveness of the removal action alternatives.

In addition, regulations pertaining to handling and disposal of asbestos, lead-based paint, and other wastes that may also be present are included for evaluation and are discussed in the WMP (Section 4.0).

3.0 SPECIFIC ENVIRONMENTAL REQUIREMENTS

This section describes specific environmental protection requirements and procedures to be implemented as part of the radiological materials TCRA activities. The APP/SSHP (TtEC 2013) addresses many of these activities as they pertain to worker safety and health. The RPP addresses radiological controls. The principal activities to be accomplished under this TCRA are listed in Section 1.2.

3.1 RADIOLOGICALLY CONTAMINATED SOIL REMOVAL

The removal of radiologically contaminated soil will be facilitated through the use of hand-held radiological survey equipment and analysis of laboratory samples following the procedures outlined in the Work Plan and associated RPP.

All excavated soils will be loaded directly into bins and disposed of as radiologically contaminated waste in accordance with the WMP (Section 4.0).

Although hazardous waste is not anticipated on this project, there is some documentation that site soils have areas where contamination (heavy metals, potential fuel, and other contaminants) is present. Solid waste, including excavated soils that will be disposed of off-site, even if managed as radiologically contaminated, must also be characterized properly for disposal following the Resource Conservation and Recovery Act (RCRA) and Washington State Dangerous Waste regulations. This requirement is described further in Section 4.0.

The following subsections address specific soil removal and management activities and controls that will be in place to protect the environment during these activities.

3.1.1 Excavation Management

The soil excavation activities will minimize disturbance to natural vegetation to the extent possible and keep the excavation size as small as possible to facilitate the removal needs. Asphalt and concrete pavement will be removed as necessary to access the underlying soil. The resulting debris will be screened and recycled or disposed of per the WMP.

Contaminated soil removal activities should result in limited and focused areas of ground disturbance with minimal to low potential for erosion or significant runoff. Dust control is addressed in Section 3.5. Stormwater pollution prevention is addressed in Section 3.7.

3.1.2 Excavation and Decontamination Water Management

Groundwater is expected to be shallow in some locations, and excavations could be infiltrated with groundwater or, if raining, surface water could run into the excavation. Water in

excavations causes several issues: 1) increases the chance that the sides of the excavation could collapse making the overall excavation larger; 2) makes it difficult for workers to see and get clear access to pipes; and 3) if removed, the water has to be properly managed and disposed of.

Excavation dewatering, if performed, will be temporary and only for purposes of allowing workers access to enter the excavation or facilitate replacement of drain sections. It is not anticipated that large volumes of excavation water will be generated, as not all lines are expected to be deep enough to encounter significant groundwater. The work will be scheduled during the drier months to minimize the effects of rainwater and groundwater.

Decontamination of personnel and equipment using water should also be minimal because dry brushing and other engineering controls and best management practices (BMPs) should be in place to minimize the need for use of water.

To minimize the volume of water generated from open excavations, drain restoration and backfilling will be conducted as soon as possible after confirmatory radiological screening and sampling results permit.

Worker safety with regard to excavations is addressed in the APP/SSHP (TtEC 2013), while excavation water management and disposal are addressed in the WMP.

Once soil removal is complete and conformational surveys demonstrate that radiological contamination has been removed to the identified cleanup levels, the areas will be restored to their original grade and groundcover conditions (or better).

3.1.3 Clean Soil Stockpiles

Excavations will be backfilled using imported fill material that has been verified through analysis to meet the acceptance criteria specified in the Sampling and Analysis Plan (SAP). Written certification from the proposed source that its material meets the acceptance criteria stated in the SAP for chemical constituents can be used in lieu of analysis. However, analysis for radionuclides of concern cannot be waived. To the extent feasible, imported fill material will be delivered to the site when needed and not stockpiled. However, if stockpiling becomes necessary, the stockpile will be placed on a plastic liner (minimum 10-mil thickness) and covered at all times when material is not being added or removed. Stockpiles would be constructed with a berm around the pile to prevent the soil from escaping and rainwater from entering the stockpile. The stockpile would be built and maintained to protect against run-on and runoff. The stockpile would be inspected on a daily basis to ensure that the appropriate controls are in place and effective. Additional inspections would be conducted after heavy rainfall events or high winds.

3.1.4 Unanticipated Contamination

Often during the course of excavating, unanticipated materials or indications of unknown contamination are encountered. If the excavated material appears to contain potentially hazardous materials based on the presence of odors, buried containers or debris, or stained or discolored soil, work will immediately be discontinued in that area and the Navy Technical Representative (NTR) and/or Navy Remedial Project Manager (RPM) will be contacted for further direction. The Project Manager (PjM) will contact the Project Environmental Safety Manager so that necessary site safety measures can be addressed. At the present time, all excavated materials are managed as radiologically contaminated waste as addressed in the WMP.

Specific notification requirements are provided in the APP/SSHP (TtEC 2013).

3.2 RADIOLOGICALLY CONTAMINATED DRAIN REMOVAL

Removal of underground drain lines will require excavating and managing soil. Some of this soil may be contaminated with radiological materials and potentially other site contaminants. Materials, including concrete and asphalt, and overlying soil will be removed and screened for radiological contamination as specified in the RPP and TSP. All excavated soils and storm drain components will be disposed of off-site as specified in the WMP as radiologically contaminated waste. No soil will be reused to backfill excavations.

Once pipes and surrounding soil have been removed, final radiological survey methods will be followed, and physical samples will be collected to confirm that cleanup levels have been achieved. Once this is confirmed, the drains will be replaced (or terminated if they are no longer required), the excavation will be backfilled with clean fill material, and the surface conditions will be restored to match pre-existing conditions (or better).

Drains located within the building footprint will require concrete cutting or jackhammering of the slab for access to the pipes. Radiological surveys and/or sampling will be performed in accordance with the Work Plan and associated TSP for concrete pavement, underlying soils, and drain components.

Concrete cutting and jackhammering can generate fugitive dusts, which will be controlled through the use of wet cutting methods and/or water mist as described in Section 3.5.

3.3 RADIOLOGICALLY CONTAMINATED BUILDING COMPONENT REMOVAL

The removal of radiologically contaminated building components will be facilitated through use of hand-held radiological survey equipment and analysis of laboratory samples (if required) following the procedures identified in the RPP and TSP. Radiological surveys, establishment of radiation protection and work areas, and the handling of radiologically contaminated material will be directed by the Radiation Safety Officer Representative (RSOR) following the Work Plan

and associated RPP. Radiologically contaminated material will be disposed of as outlined in the WMP (Section 4.0).

Solid waste, including building components removed for disposal, must also be characterized properly for disposal following RCRA and Washington State Dangerous Waste regulations. This process is also described in the WMP. The following subsections describe other types of components that must be managed and characterized for proper disposal where present.

3.3.1 Lead-based Paint

Some of the materials to be removed could be coated with lead-based paint. Some surface removal of lead-based paint with a solvent may also be necessary to facilitate removal of surface radiological contamination. Health hazards of lead-based paint and solvent use, and control of these hazards, are addressed in the APP/SSHP (TtEC 2013). The characterization and disposal of materials coated with lead-based paint are addressed in the WMP.

3.3.2 Other Potential Hazardous Building Components

Removal of radiologically contaminated building components may involve items that require special handling. For example, fluorescent lighting fixtures will be present. These fixtures may have mercury-containing lamps and/or ballasts containing polychlorinated biphenyls (PCBs). In addition, other lamps such as sodium vapor or high-intensity discharge bulbs may be present in fixtures and also likely contain mercury. Thermostats or control panel devices may contain liquid mercury in ampoules, and emergency/backup lighting systems may contain lead acid batteries. These types of materials must be carefully removed and managed. Management of these materials is addressed in the WMP. Workers who handle these materials must be properly trained.

3.4 ASBESTOS ABATEMENT

To facilitate the radiological surveys and removal of radiologically contaminated building materials and components, and prior to demolishing the Building 27 South Shed, some asbestos-containing material (ACM) may need to be removed. ACM is known to exist in the form of 9-inch by 9-inch asbestos floor tiles in Building 2 and roofing and exterior wall board (transite) on Building 27. Other potential ACMs may be present as well (e.g., behind walls, under flooring, in ducting).

Asbestos removal activities, including renovation or demolition activities, are subject to state and local regulations requiring the building owner to conduct a survey for the presence, location, and quantity of asbestos. An asbestos survey will be performed to assess the presence and location of ACM. An Asbestos Hazard Emergency Response Act-accredited building inspector will conduct the surveys and collect samples depending on the materials to be removed and the extent of removal or demolition. The abatement contractor will be licensed in the state of Washington

and will prepare and submit to Tetra Tech EC, Inc. (TtEC), an Asbestos Abatement Plan for the removal of ACM identified by the survey. This plan will describe the means and methods, air monitoring strategies, removal, and disposal that are consistent with regulatory requirements in the state of Washington, King County, and city of Seattle.

Prior to the removal of asbestos, including for demolition and/or renovation activities, a notice must be filed with state and local agencies as specified in the regulations. For demolition activities, Puget Sound Clean Air Agency (PSCAA), Regulation III, Section 4.03, requires an Asbestos/Demolition Notification and filing fee 10 days before any friable asbestos is removed and before demolition begins. Washington State demolition requirements are listed in *Washington Administrative Code* (WAC) 296-155-775. In addition, the Washington State Department of Labor and Industries must be notified of any abatement projects 10 days prior to beginning abatement activities.

The abatement contractor will submit all notices and filing fees to the appropriate agencies within the required time frames. The abatement contractor is also responsible for asbestos waste removal and packaging, transport, and disposal activities. Asbestos must be disposed of as specified in the WMP.

3.5 FUGITIVE DUST CONTROL

Soil excavation, operation of construction equipment and trucks, concrete cutting or breaking, debris and building component removal, and demolition activities have the potential to result in fugitive dust emissions.

The Federal Clean Air Act (CAA) (42 *United States Code* 7401 and 40 CFR Part 50), Washington State CAA, and PSCAA (Regulation I, Section 9.15) regulate fugitive dust that may be generated during site activities. Fugitive dust from project activities could contain radiological contaminants or silica dusts that present worker and public hazards. Asbestos, if not removed prior to cutting, breaking, or demolition activities, is also a contaminant that may be present in dusts. Asbestos emissions are regulated under the National Emissions Standard for Asbestos (40 CFR, Chapter 61, Subpart M).

Work involving radioactive material and any corresponding exposure to ionizing radiation must be purposeful and performed in a manner sufficient to ensure the protection of staff, members of the public, and the environment. TtEC applies industry recognized principles to radiological work so that exposure to ionizing radiation is maintained in accordance with corporate procedure NLP-01, As Low As Reasonably Achievable (ALARA) Program.

Fugitive dust will be controlled using the best achievable control technology (BACT). BACT will consist of keeping dust-prone work areas adequately moist and visually monitoring for dust. During the remediation of radiologically contaminated building components, all doors, windows, and other penetrations will be enclosed in sheet plastic, and a high-efficiency particulate air vacuum will be used to collect dust directly at the point of any activity that will generate dust (e.g., sawing, grinding, or scabbling). In addition, monitoring for total dust will be performed using real time air monitoring equipment as identified in the APP/SSHP (TtEC 2013); this will provide an indicator as to when BACT will be implemented for fugitive dust control and for worker exposure control. The Air Emissions Plan (Attachment 5 of the Work Plan) will also be implemented. This plan is consistent with Washington State Air Emission License application requirements for the radiological removal action at the former NAVSTA PS.

Trucks and other site vehicles will operate at slower speeds to minimize dust generation. In addition, construction equipment and trucks will not track soil or mud onto roadways. Decontamination areas for tires and tracks and/or clean construction entrances (as necessary) will be provided to minimize tracking of mud and soil and also to prevent the spread of potential contamination into adjacent areas. When possible, waste bins will be staged close to the excavation site within reach of operating equipment so that the need for travel is minimized.

Clean soil stockpiles, if required, will be maintained as outlined in Section 3.1.3 to minimize wind erosion and dust generation.

Asbestos abatement will be performed using industry-standard work methods and procedures that ensure asbestos is adequately wetted to prevent the release of particulates and ensure there are no visible emissions. The asbestos abatement plan will specify the means and methods that will be used and explain how air monitoring and sampling will be performed.

3.6 HAZARDOUS MATERIALS MANAGEMENT

Small amounts of hazardous materials such as gasoline, diesel, spray paint, and small containers of petroleum, oil, lubricants, or encapsulants will likely be used on-site. Hazardous materials needed for project activities will be identified on an inventory and a material safety data sheet (MSDS) prior to bringing the material on-site in accordance with Hazard Communication Program requirements. Subcontractors must submit an inventory and MSDSs to TtEC prior to beginning work. A hazardous material is defined as any material that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may pose a substantial hazard to human health or the environment.

The handling and storage of hazardous materials will be minimized to the extent possible to limit potential environmental and health impacts. Expected container size will generally range from approximately 1 quart to 5 gallons. Hazardous materials will be stored in the project support

staging area according to fire safety and environmental regulatory requirements. Incompatible materials will be segregated, and flammable materials will be kept in flammable materials storage lockers when not in use.

All personnel will be responsible for ensuring that these hazardous materials are properly maintained and not spilled. If a spill should occur, the spill procedures in Section 12.0 of the SSHP (TtEC 2013) must be adhered to, including notification requirements. An MSDS for each hazardous material will be readily available at the project site.

3.7 STORMWATER POLLUTION PREVENTION

Because the total area of ground disturbance required to accommodate contaminated soil and drain system removal and demolition of the Building 27 South Shed superstructure is less than 1 acre, coverage under the Construction Stormwater General Permit is currently not required for this project, and a Stormwater Pollution Prevention Plan (SWPPP) and Notice of Intent are not required. Should the project scope grow to include additional land disturbance, the need for coverage, including preparation of a SWPPP, will be reevaluated if the disturbed area will equal or exceed 1 acre.

This section includes a discussion of BMPs for stormwater management and erosion control that will be implemented on this project during soil disturbing activities in addition to the practices described in Sections 3.5 (Fugitive Dust Control) and 3.6 (Hazardous Materials Management). The BMPs are determined based on the specific site conditions to ensure that the most appropriate and best measures are implemented. Examples of physical BMPs include mulching, nets and blankets, plastic covering, storm drain inlet protection, gradients, and silt fences. Examples of nonphysical BMPs include good housekeeping practices, proper management of hazardous materials and waste, and spill prevention. Specific soil control activities and BMPs identified in this plan are based on the Ecology Stormwater Management Manual for Western Washington (Ecology 2005).

The site is a relatively flat piece of property bordering the western shore of Lake Washington. However, the ground surface elevation increases and is sloped near the National Oceanic and Atmospheric Administration overpass and heading toward Pump Station 98. Surface stormwater runoff generally flows over the ground from west to east/northeast where low spots in the topography exist. Surface water drainage from NAVSTA PS flows to Lake Washington via either the stormwater collection system or as surface runoff. The storm drains were installed in the 1940s and 1950s. The existing storm water system runs along the west side of Building 27 and south of Building 27. The two lines connect at manhole-160 and discharge into Lake Washington. Catch basins that connect to the storm water lines are present along the west, south, and east sides of Building 27.

When project activities impact the flow, clean runoff will be directed to existing stormwater conveyances. Soil excavation and demolition activities will require varying degrees of stormwater management, including temporary protection from erosive forces and runoff protection, as necessary. The native soil is silt, sand, and gravel with boulders (glacial till). However, most of the areas requiring remediation are composed of fill material consisting of sand and gravel.

3.7.1 Potential Stormwater Pollution Sources

Potential stormwater pollutant sources for the TCRA activities include spills of hydraulic oil and/or fuel from operating equipment such as excavators, trucks, vehicles, and portable generators; potential hazardous materials releases or runoff from exposed soil or demolition activities where lead or other contaminants may be present (e.g., lead-based paints); and erosion. Existing contamination is also possible in some of the site soils, including heavy metals, volatile and semivolatile organics, and radiological contamination.

3.7.2 Pollution Prevention Practices

3.7.2.1 Construction Equipment Usage and Spill Prevention

Heavy construction equipment used in support of this project presents a potential method to introduce petroleum into stormwater runoff. Equipment will be regularly inspected for leaks to help prevent stormwater runoff into storm drains. Spill response kits containing absorbent pads will be stationed nearby in the event of a leak from equipment. Hydraulic oil or fuel could leak from construction equipment. Large leaks near storm drain inlets could possibly affect stormwater discharging into Lake Washington. If a spill of a hazardous substance or petroleum occurs, it could flow overland in the general direction of Lake Washington; however, unless it enters a storm drain or catch basin, the spill is unlikely to reach the lake due to land contours and the small quantities of hazardous material that will be used on the project. Using temporary containment controls such as absorbents and earthen berms will help prevent overland flow of spills into Lake Washington, where possible. If a spill or leak occurs, the notification procedures in Section 12.0 of the SSHP (TtEC 2013) will be immediately implemented.

3.7.2.2 Wastewater Management

Decontamination of site workers and equipment may be required periodically. When required, personnel will be decontaminated at designated stations. Equipment will be decontaminated at a pre-constructed decontamination area. The area will be designed to collect decontamination wastewater, which will be collected and handled in accordance with the WMP. Wastewater from the personnel decontamination stations will also be collected and stored for proper disposal.

Water used during asbestos abatement and demolition activities will be of sufficient volume to control visible emissions; however, care will be exercised during these activities to minimize the

potential for this water to result in runoff from the work area. Measures will be implemented, as necessary, to protect and prevent potentially contaminated water from reaching nearby storm drain inlets. Prior to beginning demolition activities, floor drains or other conduits where runoff of hazardous materials could lead to the spread of contamination will be identified and blocked or terminated.

3.7.2.3 Gasoline, Diesel Fuel, and Lubricating Oil Management

The storage of gasoline, diesel fuel, grease, and lubricating oils on-site is expected to be minimal. The number of vehicles and heavy equipment used for the project activities is not large (i.e., one or two mini-excavators, one all-terrain forklift, one flatbed truck, and several pick-up trucks). Fueling and minor servicing activities for the equipment will be conducted on-site; however, oil changes and full servicing will not be done on-site. BMPs will be implemented for stormwater pollution prevention, including the following measures:

- Drip pans will be used, when feasible, when transferring gasoline, diesel fuel, grease, lubricating oils, and other potential pollutants.
- Vehicles and equipment will be inspected for leaks and worn fluid bearing lines prior to use and on a daily basis.
- Vehicles and equipment will be maintained in good condition to prevent the potential for leaks.
- Storm drains will be covered for maintenance, fueling, and servicing activities that are conducted near the storm drain.

Small amounts (less than 100 gallons total) of petroleum oil, gasoline, or diesel may be stored at a designated equipment servicing area. Stored hazardous material will be listed on the hazardous materials inventory and will be tracked. BMPs will be implemented for the storage of petroleum products for stormwater pollution prevention. BMPs for the material storage will include:

- Ensuring that the material is not stored directly on the ground
- Ensuring that the containers are protected from the weather
- Ensuring that storm drains in the vicinity of the material storage are covered
- Ensuring that all containers are maintained in good condition, including secured lids and proper labeling
- Ensuring that spill kits are maintained and located next to the material storage

3.7.2.4 Good Housekeeping Practices

Good housekeeping practices are designed to maintain a clean and orderly work environment. Often, an effective first step for preventing stormwater pollution is to use common sense to improve basic housekeeping methods. A clean and orderly work area reduces the possibility of

accidental spills caused by mishandling chemicals and equipment and reduces safety hazards. The following good housekeeping practices will be implemented:

- Garbage, waste materials, and construction debris will be regularly picked up and disposed of.
- The site will be maintained in an orderly condition.
- Good housekeeping practices will be reviewed with workers at the beginning of the project site activities.
- Prior to demolition of the Building 27 South Shed, a walkthrough will be conducted by the Project Superintendent and Project Quality Control Manager to ensure any floor drains or other conduits to the environment are covered or terminated, lines that could contain oil are evaluated and drained (if required), abatement has been sufficiently performed, and hazardous materials such as lamps, ballasts, batteries, thermostats, and other materials have been removed or secured so that demolition activities have less potential to spread contamination to adjacent areas.

3.7.2.5 Preventive Maintenance

Preventive maintenance involves the regular inspection and testing of equipment and operational systems. The program should prevent breakdowns and failures by adjustment, repair, or replacement of equipment. The following preventive maintenance practices will be implemented:

- Construction equipment will be maintained on a regular basis.
- Any leaking construction equipment will be repaired or replaced.
- Any stormwater management devices that are not performing as planned will be maintained, repaired, or replaced.
- Records of all preventive maintenance activities will be maintained.

3.7.3 Regular Site Inspections

Routine visual inspections identify conditions that may give rise to contamination of stormwater runoff. Visual inspections will be conducted and documented regularly and during storm events. A visual inspection is a means of confirming that chosen measures are in place and producing the intended result. The following actions will be taken as part of the visual inspection program:

- Physical BMPs, where installed, will be inspected weekly and during storm events.
- Project equipment will be checked regularly to identify leaks.
- Records of these daily inspections will be maintained.

3.7.4 Sediment and Erosion Controls

Grass and other protective ground covers such as asphalt and concrete will be removed during project activities, resulting in the exposure of underlying soil to wind and rain. In addition, soil excavation will be performed, which further exposes soil to erosion potential. Because the soil surface is unprotected, soil particles can easily become airborne due to wind and/or are washed away by rain. Erosion at the construction site will be controlled using the BMPs indicated in the introduction to this section.

Physical BMPs will be selected based on slope and potential for erosion, location and presence of stormwater conveyances (e.g., storm drains or ditches), and the potential for stormwater runoff to occur that could reach surface water. The need for physical stormwater BMPs may also depend upon weather (rainfall and season) and the time between starting excavation and completing final site stabilization.

Stabilization on this project includes one or both of the following:

- Areas where concrete or asphalt was removed will be repaved with asphalt or concrete.
- Areas where grass was removed will be replaced either by sod or a grass seed mat.

Physical BMPs on this project may include the following. Use and specifications for these BMPs, as presented in the Ecology Stormwater Manual for Western Washington, are included in Appendix A.

BMP C101 – Preserving Natural Vegetation

Natural vegetation such as grass and shrubs will be preserved to the maximum extent practicable, and areas that are to be preserved will be marked with orange snow fence or other means to keep construction equipment from tracking onto these areas. Because the site soils are highly disturbed and mostly fill, there is little or no native topsoil present.

During excavation and trenching, if trees are present, attempts will be made to trench around them. As few roots as possible will be cut. If roots are cut, they will be cut clean and the cut root ends will be painted with a wood dressing such as asphalt based paint.

BMP C103 – High Visibility Plastic or Metal Fence

Fencing may be used in areas of this project to 1) restrict clearing to approved limits; 2) prevent disturbance of areas required to be left undisturbed; or 3) limit construction traffic to designated construction entrances or roads.

Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

BMP – Other – Control Construction Access

Construction access and activities will primarily occur on paved areas with access points onto public roads. Some areas of the site will require travel from unpaved areas onto roadways. Construction materials needed for the project will be transported over roads into the site to on-site staging areas. Waste disposal bins will be located as close as possible to the location where soil excavation is being conducted, minimizing travel of equipment back and forth. Equipment will not enter or track into excavations or contaminated soils. If they do, they will be properly decontaminated prior to leaving the area.

If sediment is tracked off-site, public roads shall be cleaned thoroughly at the end of each day or more frequently during wet weather, if necessary, to prevent sediment from entering waters of the state. Sediment shall be removed from roads by shoveling or pickup sweeping.

BMP C233 – Silt Fence

Silt fences may be installed on the down slope side of disturbed excavation areas to provide a temporary physical barrier to sediment and to reduce runoff velocities of overland volumes. No conventional erosion controls (e.g., straw bale sediment barriers, silt fencing) will be installed along the entirety the site because of the short time needed for construction at individual excavation locations.

A silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment pond. The only circumstance for which overland flow can be treated solely by a silt fence, rather than by a sediment pond, is when the area draining to the fence is 1 acre or less and flow rates are less than 0.5 cubic foot per second. The silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.

BMP C120 – Temporary and Permanent Seeding and/or BMP C121 – Mulching

Disturbed areas that are not to be paved will be graded and seeded or sodded, as appropriate, to reestablish native grasses similar to those which were removed or disturbed. Mulching may be applied as needed or mats with seed and mulch may be applied. Mulch provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture; holding fertilizer, seed, and topsoil in place; and moderating soil temperatures. These plants need to be watered until they are well established.

BMP C140 – Dust Control

Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters (also see Section 3.5). For this project, control of dust is an integral part of worker and public protection, and similar dust control methods are addressed in the APP/SSHP (TtEC 2013), including monitoring for total dusts. Building demolition can also be a source of fugitive dust, which needs to be controlled using BACT. In areas (including roadways) that are subject to air movement of dust where on- and off-site impacts to roadways, drainage ways, or surface waters are likely, dust generation will be limited by the following:

- Clear only those areas where immediate activity will take place, leaving the remaining areas in original condition to the extent possible and maintaining the original groundcover as long as possible.
- Sprinkle the site with water until the surface is wet and repeat as necessary. To prevent carryout of mud onto streets, refer to the Control Construction Access BMP.
- Lower speed limits. High vehicle speed increases the amount of dust stirred up from unpaved surfaces.
- Encourage the use of alternate, paved routes, if available.
- Restrict use by tracked vehicles and heavy trucks to prevent damage to road surfaces and base.
- Remove mud and other dirt promptly so it does not dry and turn into dust.
- Limit dust-causing work on windy days (also applies to building demolition activities).
- Use truck drive-over strips, if warranted and feasible.

BMP C220 – Storm Drain Inlet Protection

There are several storm drain inlets within the work site that could potentially receive surface runoff from the construction site. Drain inlet protection helps prevent coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area. Protection may be necessary for storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap. Inlet protection may be used anywhere to protect the drainage system.

All of the methods for storm drain inlet protection are prone to plugging and require frequent maintenance. Drainage areas should be limited to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard, especially during high rainfall events. Types of drain protection may include the following:

- Where drop inlets are present on paved or earthen ground, catch basin filters will be placed into the inlet.

- Where curb inlets are present, either a curb and gutter sediment barrier or a block and gravel curb inlet protection structure will be placed around the inlet.
- Where culvert inlets are present, a culvert inlet sediment trap will be placed into the inlet.

Inserts should be designed by the manufacturer for use at construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. The maintenance requirements can be reduced by combining a catch basin filter with another type of inlet protection. This type of inlet protection provides flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way.

4.0 WASTE MANAGEMENT PLAN

This section describes procedures for compliance with potential waste management requirements applicable to this project. On-site activities must meet substantive requirements. Off-site activities, such as waste transport and disposal, must fully comply with all laws and regulations.

The primary waste currently identified for this project is radiologically contaminated soil and debris. Other project wastes include ACMs and demolition debris. Recyclable solid wastes may include concrete, asphalt, and scrap metal. Hazardous wastes are not currently anticipated on this project based on known and anticipated site conditions and information from prior surveys and investigations. All project solid wastes must be evaluated and characterized in accordance with RCRA and the Washington State Dangerous Waste regulations. If fluorescent lamp ballasts (see Section 4.7) are removed from building lamp fixtures for disposal, they must be managed in accordance with the Toxic Substances Control Act (TSCA).

When recycled and managed properly, some solid wastes are exempted from being considered hazardous waste even though they may have hazardous materials in or on them (e.g., potentially scrap metal coated with lead-based paint that is recycled and materials considered universal waste [see Section 4.7]).

This WMP includes the procedures that will be implemented to manage the waste streams anticipated on this project, as listed in Table 4-1.

4.1 RADIOLOGICALLY CONTAMINATED WASTE

The control of radioactive waste is addressed in Section 3.21 of the RPP and summarized below.

A Memorandum of Understanding (MOU) between TtEC and a government-designated waste contractor will be developed, and will identify interfaces and commitments for the transfer of radioactive materials. Waste disposal bins will be delivered for use and removed when full by this waste contractor. An active MOU will be maintained by the RSOR.

The estimated volumes of radioactive waste to be generated are listed below. Waste volumes will be minimized by complying with contamination control practices (Section 3.15 of the RPP) and implementing segregation and survey practices. A government-designated LLRW contractor contracted to the client (i.e., the Navy through the Army Joint Munitions Command) will provide brokerage services, including waste characterization sampling, waste containers, waste manifests, and transportation of radioactive materials/waste generated on the project.

- Soil – 2,123 cubic yards (cy) (Building 2 – 96 cy; Building 12 – 63 cy; Building 27 – 1,631 cy; Storm Drains – 333 cy)
- Building Materials – 122 cy (Building 2 – 7 cy; Building 27 – 115 cy)
- Pipe and Catch Basins – 14 cy (Building 2 – 1 cy; Building 27 – 1 cy; Storm Drains – 12 cy)
- Concrete/Asphalt Pavement Debris – 212 cy (Building 2 – 11 cy; Building 12 – 16 cy; Building 27 – 185 cy)
- Ventilation Ductwork – 100 cy (Building 2 – 90 cy; Building 27 – 10 cy)

Soil, sludge, pipe, and debris, including used personnel protective equipment (PPE) and disposable sampling equipment, will typically be processed for final disposition in disposal bins, segregated as required by material type. When filled, bins will be transferred to the custody and control of the government-designated waste contractor. Decontamination water from sampling or equipment/personnel decontamination performed within the radiologically controlled area will be collected in water-tight containers and transferred to the government-designated waste contractor for disposal. As detailed in corporate procedure NLP-02, Radioactive Material Accountability, commodities are stored in a locked radioactive materials storage area controlled by the RSOR, and will periodically be packaged and transferred to the government-designated waste contractor for disposal.

Radioactive material will be packaged, stored, shipped, and disposed of as required by the government-designated LLRW waste contractor in accordance with applicable federal, state, and local regulations. In addition, any further sampling for waste characterization (RCRA and Washington State Dangerous Waste regulations) for any material that is managed as radioactive material will be performed by the contractor designated in the MOU.

Contaminated building materials will be wrapped or bagged within the Class 1 survey unit in which they are generated. The packaged materials will then be removed to a secondary waste preparation area outside the Radiologically Controlled Area access control point, located within the adjacent Class 2 survey unit. At this location, the packaged materials will receive an additional layer of wrapping or bagging prior to being transferred to the controlled bin storage area located near the building exit. Floor areas where wrapping/bagging will occur will be covered with plastic sheeting to minimize the potential for spreading contamination.

Prior to establishing the bin storage area, a 100 percent gamma scan survey of the surface area will be performed using Ludlum 2350-1 meters with Ludlum 44-10 2-inch by 2-inch sodium iodide detectors to establish an initial radiological status survey. At the completion of work, a 100 percent gamma scan survey of the surface area will be performed using Ludlum 2350-1 meters with Ludlum 44-10 2-inch by 2-inch sodium iodide detectors to establish a final radiological status survey. Any areas outside the mean background plus three sigma

investigation level will be further investigated with static gamma readings, and remediated if warranted.

4.2 CONTINGENCY FOR DANGEROUS WASTE OR MIXED WASTE

If additional non-LLRWs are generated, TtEC will characterize these wastes through generator knowledge or sampling and analysis. Currently, there are no anticipated hazardous or dangerous wastes on this project and, as stated above, any further sampling for waste characterization (RCRA and Washington State Dangerous Waste regulations) for any material that is managed as radioactive material will be performed by the LLRW waste contractor. Should suspected hazardous or dangerous waste be generated, or should it appear likely that it will be generated, the Project Superintendent or Site Safety and Health Officer will notify the Project Manager and the Environmental Compliance Manager, as well as the Navy, so that procedures for handling the waste can be identified and plans can be updated accordingly.

Handling of hazardous wastes that are also regulated as radiologically contaminated material is subject to regulations for mixed waste, which will be followed by the contractor.

4.3 RADIOLOGICALLY CONTAMINATED SOIL AND DEBRIS

Specific waste handling, storage, packaging, and transportation requirements exist for LLRWs. TtEC will manage all radiological aspects of this project until materials are turned over to the LLRW waste contractor under Radioactive Material License No. 29-31396-01, which is issued and subject to regulatory enforcement by the United States Nuclear Regulatory Commission. Project activities incorporate the requirements to maintain compliance with the current version of corporate procedure RP1-1, Radiological Protection Program, and these procedures are included in the RPP.

All soil (including overlying vegetation), sludge, pipe, building debris, and PPE will be managed as radioactive waste. However, it is anticipated that building debris generated by demolition of the Building 27 South Shed will not be radioactive because the structure will not be demolished until radiologically contaminated materials and components have been removed and radiological free release status has been achieved. TtEC will survey, remove, package (in containers provided by the government-designated waste contractor), and temporarily store all radiologically impacted materials on-site pending turnover to the MOU contractor. Containers will be properly labeled and marked. TtEC will relinquish these materials to the LLRW waste contractor who will characterize, transport and dispose of all radiological waste in accordance with all applicable federal, state, and local regulations.

If any of the radiological waste contains other known hazards, such as asbestos that is radiologically contaminated, this information will be provided to the MOU contractor. This material will be packaged by the abatement contractor, as required by the asbestos regulations, and contained in radiological waste bins.

4.4 ASBESTOS WASTE

ACM is known to exist within and/or on the exterior of Buildings 2 and 27, including the Building 27 South Shed, in the form of transite panels, roofing material, and floor tiles. ACM will be removed to the extent necessary to perform radiologically contaminated material removal in the buildings. Previously unidentified ACM may be discovered (e.g., pipe insulation) as surveys are performed or materials and components are removed from the buildings. Prior to the demolition of the Building 27 South Shed, an asbestos survey will be performed to sufficiently identify the presence, location, and quantity of ACM to facilitate scoping of the asbestos abatement contractor and demolition contractor and preparation of the asbestos abatement and demolition plan. The asbestos survey will ensure that abatement and demolition of this structure comply with federal, state, and local regulations, including submittal of required abatement/demolition notices to state and local agencies. Additional information on asbestos is included in Section 3.4.

An asbestos abatement contractor licensed in the state of Washington will be used for all asbestos identification, sampling, removal, transportation, and disposal. The abatement contractor will prepare an Asbestos Abatement Plan and submit it to TtEC for the work being performed. Asbestos waste will be kept adequately wet and will be packaged properly for disposal in accordance with management regulations for friable and nonfriable waste. Used PPE and potential ACMs such as poly sheeting, used filters, etc., will be disposed of as asbestos waste. Asbestos waste will be transported off-site within 10 days of generation by a licensed transporter to a Navy-approved solid waste facility licensed to receive asbestos waste.

An Asbestos Waste Shipment Record (AWSR) will be prepared to track shipments of friable and nonfriable asbestos from the site to the landfill. The asbestos abatement contractor will prepare and sign all shipment records and submit all original signed AWSRs back to TtEC, signed by the receiving disposal facility within 35 days of shipment. The disposal of asbestos waste will be handled in accordance with state of Washington and PSCAA requirements.

If asbestos waste is also radiologically contaminated, it will be contained in radiological waste bins provided by the MOU contractor, who will dispose of the waste.

4.5 DEMOLITION DEBRIS

Demolition of the Building 27 South Shed will occur after radiological free release status has been achieved. The resulting demolition debris will be properly segregated (as required), characterized, and disposed of or recycled. Demolition debris from this process may consist of metal, wood, and other material such as gypsum board and other miscellaneous materials and is anticipated to be nonhazardous waste. Lead-based paint is anticipated to be present on painted surfaces based on the age of the facility. Scrap metal coated with lead-based paint is recyclable as long as the recycling facility is informed that lead-based paint is present.

Building debris that contains painted surfaces and is intended for disposal may require sampling and analysis to characterize the waste for disposal. In many cases, debris that is painted with lead-based paint is characterized as nonhazardous for lead when representative samples of the waste materials are collected and analyzed. This depends, in part, on to what degree the components of this wastestream are segregated. Because lead-based paint is likely to be present, those building components that are intended for disposal (e.g., not scrap metal segregated for recycling) will be sampled and analyzed to characterize the waste properly for disposal.

At the present time, the demolition means and methods have not been fully identified, and it is not feasible to determine the exact number of samples or composite subsamples that will be required for characterization of the building debris wastestream. However, once the demolition contractor has been retained, the Environmental Compliance Manager and PjM will evaluate the degree of segregation that is anticipated in order to prepare a focused Waste SAP for characterization of this wastestream. In some cases, it is possible to pre-characterize building debris prior to demolition being performed as long as the components (type and percentage of the whole) of the waste that will be disposed of (rather than segregated and recycled) can be estimated and samples of these materials can be obtained. A representative sample is defined in the Dangerous Waste Regulations at WAC 173–303-040 as "a sample which can be expected to exhibit the average properties of the sample source."

Ecology recommends suggested sampling plans, which contain two basic approaches (with variations) for designating a lead painted building. The guidance, Suggested Sampling Plans for Building Debris Disposal, can be found at http://www.ecy.wa.gov/programs/hwtr/dangermat/sampleplans.html. The two basic approaches are:

- Screen and separate building components that are designated as dangerous waste for dangerous waste disposal.
- View the entire building or demolition debris pile as a single wastestream. Depending on test results, the debris pile is managed either entirely as solid waste or as dangerous waste.

Concrete, asphalt, and scrap metal that are not radiologically impacted will be recycled to the extent practicable.

4.6 EXCAVATION AND DECONTAMINATION WATER

Generation of a large volume of excavation water is not anticipated. Generation will be limited to that which is necessary to permit safe entry into the excavation for workers to replace drain systems. Water removed from an excavation that is due to groundwater infiltration, and any decontamination water generated from wet decontamination of personnel or equipment, will be held in a fractionation tank located near the excavation. The water will be allowed to settle in fractionation tanks to remove total suspended solids and then will be filtered through a bag filter

to remove remaining solids. Water will be analyzed for radionuclides and other potential contaminants (as required) for discharge into the sanitary sewer subject to the permit requirements of the receiving publicly owned treatment works (POTW). Pretreatment of the water may be required prior to discharge depending on the contaminants and contaminant levels in the water.

If the water cannot be discharged to the POTW, it will be disposed of through a commercial solid waste transport and disposal company. If radiologically contaminated, the water will be disposed of through the MOU waste handler in containers provided through the MOU.

Solids settling in the fractionation tank must be collected and properly disposed of per this WMP as radiologically contaminated waste.

4.7 UNIVERSAL AND PCB WASTES

Work associated with the buildings, primarily demolition of the Building 27 South Shed, could result in the generation of the wastes listed below, which will require disposal:

- PCB-containing fluorescent light ballasts (regulated under TSCA)
- Non-PCB fluorescent light ballasts (may be Washington State-only dangerous waste)
- Mercury-containing fluorescent, high-intensity discharge, or sodium vapor lamps (universal waste)
- Mercury-containing thermostats or switches (universal waste)
- Batteries (such as those found in emergency lighting systems) (universal waste)

Standards for universal waste management are found in the Washington State Dangerous Waste regulations at WAC 173-303-573. Standards for management of fluorescent lamp ballasts containing PCBs are contained in 40 CFR 761.

4.7.1 Universal Waste

Universal waste, when managed under the Universal Waste Handling Requirements, is not fully regulated under the hazardous/dangerous waste regulations even though these wastes likely would be characterized as hazardous if disposed of. It is anticipated that this project would (if these items are generated) manage universal wastes as a small quantity universal waste generator (defined as one who does not accumulate 11,000 pounds or more total of universal waste [batteries, mercury-containing equipment, and lamps calculated collectively] and/or who does not accumulate more than 2,200 pounds of lamps at any time). To meet the less stringent requirements that universal waste rules allow, the following handling and disposal practices will be met if these items are generated. Fact Sheets are provided in Appendix B with specific information on handling each type of universal waste. These sheets contain more information on disposal and recycling options and transportation requirements for each type of universal waste.

If universal or PCB wastes are generated, TtEC's Environmental Compliance Manager, a waste management specialist, will provide guidance in the management, transport, and disposal of these wastes, including proper profile sheets, manifests, labeling, and marking as required by federal and state regulations, including Department of Transportation (DOT) Hazardous Material Regulations. In addition, training for personnel handling these materials must be provided and documented.

If any of the universal wastes are radiologically contaminated, the waste will be turned over to the MOU contractor for proper disposal.

4.7.1.1 Training

A small quantity handler of universal waste must inform all employees who handle or have responsibility for managing universal waste of the proper handling and emergency procedures appropriate to the type(s) of universal waste handled at the facility. On this project, only select individuals will be responsible for management and handling of universal waste and control of the universal waste storage area.

4.7.1.2 Storing and Labeling Universal Wastes

The storage area needs to be clearly marked and protected so that the wastes are not damaged while stored.

Containers must be properly labeled with:

- The words "Universal Waste"
- The accumulation start date (date removed)
- Identification of the contents (e.g., batteries, lamps)

4.7.2 Spills or Releases

A small quantity handler of universal waste must immediately contain all releases of universal wastes and other residues from universal wastes if spilled, and must determine whether any material resulting from the release is a dangerous waste. If so, management of the waste must comply with applicable requirements of the Washington State Dangerous Waste regulations (may be hazardous waste).

Persons removing and handling any of these materials shall exercise care not to break items or allow items to leak (especially mercury). If handling is required, mercury ampoules will be removed over a secondary containment structure.

4.7.3 Recycling, Transporting, and Disposing of Universal Wastes

Universal wastes must be sent to destination facilities that treat, dispose of, or recycle universal waste. The transporter must have a valid RCRA Site identification number, and the collection facility must comply with state requirements. Ecolights Northwest is a local facility that recycles universal wastes.

4.7.4 Lighting Ballasts

Fluorescent lighting fixtures use an electronic component called a ballast, which contains a small capacitor. Ballasts manufactured prior to 1978 commonly contain PCBs. The PCBs are found in the capacitor oil and in the tar-like "potting compound" that surrounds the capacitor. Ballasts made after 1978 are usually marked "No PCBs."

The EPA regulates wastes containing 50 parts per million (ppm) PCBs and greater. Ecology regulates wastes containing from 2 to 50 ppm PCBs. Both agencies have extensive requirements for the management and disposal of PCB wastes. PCB ballasts do not require management as a state-only dangerous waste if they are managed in accordance with 40 CFR 761 requirements (WAC 173-303-9904), as these regulations are considered stringent.

Some ballasts manufactured after 1978 may contain a PCB replacement called DEHP. This chemical, also known as bis(2-ethylhexyl)phthalate, is a probable human carcinogen and may be designated a Washington State toxic dangerous waste (potentially WT02 waste code).

PCB ballasts will be removed and evaluated (for a date and/or "PCB free" indication) and placed in a metal container such as a drum (segregated as required). All containers must be kept tightly sealed. They must be marked with the PCB mark (yellow PCB label) and have a log of the date and amounts added to the container. Waste containers can only be stored in the work area for 30 days after the first PCB ballast is added to the container. Then they must be stored in a greater than 30-day PCB storage area in accordance with 40 CFR 761 storage area requirements. In general, this requires adequate protection from the rain (walls and roof) and sufficient protection from potential leaks. These storage areas also must be regularly inspected.

PCB and non-PCB ballasts (segregated) can be disposed of through local Seattle companies such as Total Reclaim, which is a subsidiary of Ecolights Northwest (local universal waste recycling facility).

PCB shipments must be accompanied by a Uniform Hazardous Waste Manifest as specified in TSCA regulations by licensed transporters with an EPA Identification Number. PCBs are regulated for transportation by the DOT as a Class 9 environmentally hazardous substance. Only DOT-trained personnel are allowed to perform a DOT regulated hazardous material function (see Section 6.0, Training).

PCB ballasts that are radiologically contaminated will be turned over to the MOU contractor for proper disposal.

4.8 COMMON TRASH

Trash from the TtEC project field office and site that is not related to the removal activities (e.g., paper, lunch waste, plastic containers) will be disposed of in an on-site dumpster that is regularly emptied by a waste management vendor. Recyclable materials such as paper and cardboard will be segregated from the common trash, when feasible, to minimize the volume of waste sent to the landfill.

4.9 NONRADIOACTIVE WASTE TRANSPORTATION AND DISPOSAL

TtEC will subcontract with transporters and disposal facilities that are internally reviewed per TtEC EHS Procedure 1-4 (Subcontractor Selection and Management) to ensure these transporters and facilities are operating in compliance with federal and state regulations and operating permits for the intended wastestream. These facilities ultimately must be approved by the Waste Generator of Record (the Navy) for this facility who is ultimately responsible for waste generated and disposed of during this project. The Waste Generator of Record may require an EPA identification number for this facility. TtEC is not the Waste Generator of Record and cannot sign any waste characterization or disposal paperwork. The following describes the waste transportation and disposal process.

4.9.1 Waste Profile Sheets

As required by the disposal facility, a waste profile sheet will be filled out and submitted for signature by the Waste Generator of Record for each wastestream being disposed of. It is currently anticipated that a waste profile sheet will be required for asbestos waste, demolition debris waste, universal wastes, and PCB ballasts. The signed waste profile sheets are submitted to the facility for acceptance, and typically a permit or wastestream identification numbers are assigned.

4.9.2 Waste Manifest or Bill of Lading

An appropriate shipping document such as a nonhazardous or hazardous waste manifest or bill of lading will be used for the shipment of waste and recycled debris. For solid wastes that are not hazardous or TSCA regulated (PCB ballasts), either a bill of lading or a nonhazardous waste manifest will be used for each shipment (each truckload or bin) to document the wastestream and quantity of waste shipped. Wastes that are DOT Hazardous Material Regulations (HMR) regulated (e.g., that exhibit one of the nine hazard classes) will be transported in accordance with these regulations.

- PCB ballasts are regulated under TSCA and must be shipped using a uniform hazardous waste manifest. Note – DOT HMR applies for transportation of this wastestream and it is regulated as a class 9 hazardous material.
- Ballasts that are non-PCB but carry the WT02 waste code for DEHP (state only dangerous waste) will be shipped on a nonhazardous waste manifest.
- Asbestos waste must be shipped using an AWSR. Note – DOT HMR applies for friable asbestos waste transportation and is regulated as a class 9 hazardous material.
- Universal wastes such as mercury lamps, batteries, and mercury thermostats are regulated under the WAC Universal Waste standards and can be shipped using a bill of lading or a nonhazardous waste manifest. Note – DOT HMR applies for these wastes depending on the waste characteristics and may be regulated as a class 8 (e.g., mercury thermostats, lead acid batteries) or 9 (e.g., bulbs) hazardous material.
- Recyclable materials and nonhazardous demolition debris will be accompanied by a nonhazardous waste manifest or straight bill of lading. These materials do not require a DOT HMR hazard classification.
- Common trash does not require any transportation documentation other than a contract for services.
- Wastewater discharge to a POTW will require some form of discharge approval notice from the POTW. This will be determined upon discussion with the POTW operator after sample results are submitted for their approval to discharge. Wastewater that is not approved for discharge will be characterized and disposed of using a nonhazardous waste manifest.

4.9.3 Disposal Documentation and Recordkeeping

Estimated or actual weights will be obtained as required (TSCA, universal wastes). The weight or volume will be recorded on the manifest for each wastestream being transported off-site for disposal or recycling.

The manifest or bill of lading will be signed by the Waste Generator of Record and Transporter #1 on the date of shipment for any regulated wastes that require a Generator signature or require profiling. The Generator copy will be retained for the Generator's Records after these signatures are obtained. TtEC will make a copy of the Generator copy and retain for its records.

TtEC will document each shipment of waste or recyclable material from this project in a spreadsheet. Weight tickets will be retained for payment (as required).

Generator Responsibility – PCB waste regulated under TSCA requires that a Certificate of Disposal be issued to the Waste Generator of Record within 30 days of disposal of that waste. The Certificate of Disposal must be retained for recordkeeping. In addition, the signed terminal manifest must be sent to the Waste Generator of Record within 45 days of the shipment date listed on the manifest. An Exception Report must be prepared if the generator of PCB waste

subject to manifesting requirements does not receive a signed copy of the manifest that accompanied the shipment to a commercial storage or disposal facility within 45 days of the shipment. The generator of the PCB waste must attempt to determine the status of the waste by contacting the transporter and designated disposal facility prior to preparing an exception report. Records must be kept of any correspondence. The generator shall submit the exception report to the EPA within 45 days from the date on which the generator should have received the manifest. The signed terminal manifest and Certificate of Disposal will be sent to the generator. Likewise, discrepancies of more than 10 percent of weight or variation in piece count for PCB wastes must be resolved between the generator and the disposal facility within 15 days of notice of the discrepancy. If not resolved, a discrepancy report must be submitted to the EPA.

This page intentionally left blank.

5.0 SPILL/RELEASE RESPONSE PROCEDURES AND REPORTING REQUIREMENTS

A spill is any unauthorized release, including leaking, pumping, emitting, emptying, discharging, injecting, escaping, leaching, disposing, or dumping of oil or hazardous substances. The Navy has defined spills in two manners on prior projects: nonemergency and emergency. These are defined below with the procedures to be implemented. All project personnel must be familiar with these response and reporting requirements outlined below.

Spills must be reported and properly cleaned up. The site is not on Navy property. The Navy RPM will notify the facility owner if spills occur on the premises. If the spill or release is potentially associated with radiological contamination, the Radiological Affairs Support Office (RASO) will also be notified.

Spill prevention measures are addressed in Section 8.2.2 of the APP (TtEC 2013). BMPs are identified throughout the EPP.

5.1 NONEMERGENCY SPILL

A nonemergency spill is defined as:

- A discharge of a known material or hazardous substance of 10 gallons or less
- A spill that can be cleaned up by TtEC without posing an immediate threat to human health or the environment
- A material/substance that is **not** released into any waterway, including storm drains

The nonemergency spill response procedure is as follows:

- Stop the source of the spill if safe to do so.
- Contain the spill by keeping it away from drains or waterways and blocking off drains located near the spill if there is a chance the spill will reach them.
- Clean up the spilled material wearing the proper PPE.
- Handle the spill debris/material and contact the Environmental Compliance Manager to determine waste characterization and disposal requirements.
- Immediately notify the Project Superintendent, PjM, and NTR or RPM.

5.2 EMERGENCY SPILL EVENT

An emergency spill is defined as:

- Any release of a known or unknown material or hazardous substance that poses an immediate threat to human health or the environment
- A release not classified as a nonemergency spill event
- A release greater than 10 gallons
- Any release into any waterway or storm drain

The emergency spill response procedure is as follows:

- For threats to human health and unknown properties, immediately evacuate to a predetermined safe location according to Section 12.0 of the SSHP (TtEC 2013a).
- If others are in the area, warn them and direct them to the predetermined safe location.
- Immediately call 911 if persons are injured or there is a fire or explosion (see Section 12.0 of the SSHP).
- Immediately notify the Project Superintendent, PjM, and NTR or RPM. Ecology and the Washington State Department of Health will also be notified.

Additional information can be found in the Emergency Response Plan (Section 12.0 of the SSHP, including Table 12-1, which provides contact telephone numbers).

6.0 TRAINING

All project personnel, including TtEC employees and TtEC subcontractors, must complete the following training as designated:

- **General Environmental Awareness** – All applicable project personnel working on-site will attend General Environmental Awareness orientation training prior to beginning site activities. This training will include a review of the specific environmental requirements to be adhered to and implemented throughout the project, including regulatory and Navy environmental requirements.
- **Asbestos, Lead, and Radiological Awareness Training** – All project personnel working on-site will be given asbestos awareness, lead awareness, and radiological awareness training.
- **Waste Management** – Project personnel involved in waste management, handling, storage, and disposal, including subcontractors working on-site unsupervised by TtEC, will be trained under the TtEC Waste Management Employee Training Program. If hazardous or dangerous waste is generated, this training also includes the RCRA/Dangerous Waste generator training requirement for personnel who are directly involved in waste operations. Universal waste handlers will be trained as specified in Section 4.7.1.1.
- **Hazard Communication Training** – Under the Occupational Safety and Health Administration, all contractors must complete hazard communication training. All project personnel working on-site will receive this training upon mobilization.
- **DOT** – Every person performing a DOT function (e.g., managing containers of universal waste or PCB ballasts, since these materials may be regulated by DOT) must be properly trained in DOT Hazardous Materials Management. Certificates of training will be maintained at the project site. DOT training requirements apply to all personnel who select packaging; prepare hazardous materials or wastes for transportation; are responsible for the safety of the transportation of hazardous materials or wastes; load, unload, or handle hazardous materials or wastes; test, recondition, repair, modify, mark, or otherwise represent containers as qualified for use in transporting hazardous materials or wastes; or operate a vehicle used to transport hazardous materials or wastes.
- **Recordkeeping** – The records documenting the applicable employee training will be readily available at the project site.

This page intentionally left blank.

7.0 REGULATORY INSPECTIONS AND AUDITS

If project personnel are contacted by a regulatory agency for an inspection of the site, the Project Superintendent will immediately contact the PjM, NTR, and RPM. TtEC will follow the direction from the RPM/NTR. In the event of contacts by regulatory agencies regarding radiological operations, the RASO will also be notified.

Project personnel will not grant site access or answer questions from unauthorized personnel. Any outside party requesting access to inspect the site will be referred to the Project Superintendent, who will immediately initiate the appropriate notification to the PjM and the Navy. In conjunction with Navy requirements and direction, TtEC Corporate Compliance Procedures for Environmental Inspections by Regulatory Agencies will be followed.

This page intentionally left blank.

8.0 REFERENCES

Ecology (Washington State Department of Ecology). 2005. Storm Water Management Manual for Western Washington (Volumes 1–3). Publication Numbers 05-10-029 through 05-10-033. February.

EPA (U.S. Environmental Protection Agency). 1988. Office of Emergency Response. Publication Number EPA/540/G-89/006. CERCLA Compliance with Other Laws Manual, Interim Final. August.

Shaw (Shaw Environmental & Infrastructure, Inc.). 2013. Final Action Memorandum. Former Naval Station Puget Sound, Seattle, Washington. May

TtEC (Tetra Tech EC, Inc.). 2013. Final Accident Prevention Plan/Site Safety and Health Plan. Former Naval Station Puget Sound, Seattle, Washington. July.

This page intentionally left blank.

TABLES

This page intentionally left blank.

TABLE 2-1

RADIONUCLIDE-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Constituent of Concern	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Federal			
Cesium-137 Radium-226 Strontium-90	10 CFR 20.1402	Specify radiological criteria for decommissioning of licensed facility under the NRC for unrestricted use for an average member of the critical group TEDE (i.e., dose greater than or equal to 25 mrem per year), and ensuring that the residual radioactivity has been reduced to levels that are ALARA.	Relevant and appropriate to actions at the site since the criteria provided specifically address cleanup standards and control of COCs at the site for unrestricted land use. Since the site was not a licensed NRC facility, the requirements are not legally applicable for a remediation conducted at the site. Instead, both are considered relevant and appropriate requirements under the circumstances of the release of the hazardous substances at the site. Specifically, the medium and substances, the actions or activities, and the type of place regulated by the requirements are sufficiently similar to the circumstances at the site and the requirements are well-suited to the site.
	10 CFR 20.1403	Specify radiological criteria for decommissioning of licensed facility under the NRC for restricted use utilizing institutional controls to achieve TEDE of 25 mrem per year for an average member of the critical group and 100 mrem/year if institutional controls on the site fail.	Relevant and appropriate to actions at the site since the criteria provided specifically address cleanup standards and control of COCs at the site. Institutional controls would be used to limit the radiation dose to potential receptors until the site is no longer required to do so. Since the site was not a licensed NRC facility, the requirements are not legally applicable for a remediation conducted at the site. Instead, both are considered relevant and appropriate requirements under the circumstances of the release of the hazardous substances at the site.
	40 CFR 192.12(b)(1) and 40 CFR 192.41(b)	Combined exposure limits for cleanup of radon decay products in buildings designated for remedial action.	Relevant and appropriate to sites with radioactive contamination that is currently, or may potentially, result in radon that is caused by site related contamination migrating from the soil into buildings.
	40 CFR 192.12(a), 40 CFR 192.32(b)(2), and 40 CFR 192.41	Concentration limits for cleanup of radium-226, radium-228, and thorium in soil at sites designated for remedial action.	Relevant and appropriate to sites with soil contaminated with radium-226, radium-228, and/or thorium.

TABLE 2-1

RADIONUCLIDE-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Constituent of Concern	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
State			
Cesium-137 Radium-226 Strontium-90 (Continued)	WAC 246-246-020	A site is acceptable for unrestricted use if: • The residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 0.25 milliSievert (25 mrem) per year, including that from groundwater sources of drinking water. • The residual radioactivity has been reduced to levels that are ALARA. Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal.	Relevant and appropriate to actions at the site since the criteria provided specifically address cleanup standards and control of COCs at the site for unrestricted land use. Since the site was not a licensed State of Washington facility, the requirements are not legally applicable for a remediation conducted at the site. Instead, both are considered relevant and appropriate requirements under the circumstances of the release of the hazardous substances at the site.
	WAC 246-246-030	Provides the requirements for legally enforceable institutional controls that provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 0.25 milliSievert (25 mrem) per year.	Relevant and appropriate to actions at the site since the criteria provided specifically address cleanup standards and control of COCs at the site. Institutional controls would be used to limit the radiation dose to potential receptors. Since the site was not a licensed State of Washington facility, the requirements are not legally applicable for a remediation conducted at the site. Instead, both are considered relevant and appropriate requirements under the circumstances of the release of the hazardous substances at the site.

TABLE 2-1

RADIONUCLIDE-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Constituent of Concern	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Cesium-137 Radium-226 Strontium-90 (Continued)	WAC 246-232-080	Radioactive material must not be transferred except as provided in this section.	Relevant and appropriate for transfer of radiologically contaminated materials from TtEC to the government and Navy contractor for low-level radioactive waste shipment. TtEC has an NRC radioactive material license, and has filed for reciprocity to conduct radiological work within the state of Washington. Radiological work on the project will follow requirements of the Radiation Protection Plan in accordance with the TtEC NRC radioactive material license.
	WAC 246-246-220	Requirements for use of all ionizing radiation, radiation machines, and radioactive materials to ensure maximum protection of the public health and the maximum safety to all persons at, or in the vicinity of, the place of use, storage, or disposal thereof.	Applicable to all persons who receive, possess, use, transfer, own, or acquire any source of radiation.
	WAC 246-246-221	Establishes standards for protection against radiation hazards.	Relevant and appropriate to actions at the site.
	WAC 246-246-222	Requirements for notices, instructions, and reports by licensees or registrants to individuals engaged in work under a license or registration.	Applicable to all persons who receive, possess, use, transfer, own, or acquire any source of radiation licensed by or registered with the department.
	WAC 246-246-232	Prescribes rules governing licensing of radioactive materials.	Relevant and appropriate to actions at the site.
	WAC 246-246-235	Prescribes requirements for issuance of a license.	Relevant and appropriate to actions at the site.

TABLE 2-1

RADIONUCLIDE-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Constituent of Concern	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Cesium-137 Radium-226 Strontium-90 (Continued)	WAC 246-246-247	Establishes application requirements and procedures for the issuance of a radioactive air emissions license and for the regulation of those emissions.	Relevant and appropriate to actions at the site.
	WAC 246-246-247	Establishes requirements for packaging, preparation for shipment, and transportation of radioactive material.	Relevant and appropriate to actions at the site.
	WAC 246-246-247	Rules governing generators and brokers of LLRW seeking to dispose waste at any commercial disposal facility in the state of Washington.	Relevant and appropriate to actions at the site.

Abbreviations and Acronyms:

ALARA – as low as reasonably achievable
ARAR – applicable or relevant and appropriate requirement
CFR – *Code of Federal Regulations*
COC – constituent of concern
LLRW – low-level radioactive waste
mrem – millirem
NRC – Nuclear Regulatory Commission
TBC – to be considered
TEDE – total effective dose equivalent
TtEC – Tetra Tech EC, Inc.
WAC – *Washington Administrative Code*

TABLE 2-2

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Location	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Federal			
Floodplain	Executive Order No. 11988, Floodplain Management 40 CFR § 6.302(b) and 40 CFR 6, Appendix A, § 6(a)(1), (3), and (5) (at the end of § 6.1007)	Evaluate potential effects of actions in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain. Action that will occur in a floodplain (i.e., lowlands) and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	Relevant and appropriate because actions will occur in areas near shorelines of Lake Washington, a relatively flat, potentially flood-prone area. Although no development will occur with this removal action, some demolition and renovation of existing structures and earthwork will occur. Substantive compliance will be achieved through avoiding, to the extent practical, long and short-term adverse impacts to floodplain areas by: preservation of natural and existing environment to the extent possible; preservation and protection of existing wetlands if present; restoration of disturbed areas where appropriate following action; and implementing best management practices to control stormwater runoff to adjacent areas and surface waters.
Coastal Zone	Coastal Zone Management Act (16 USC §§ 1451–1464) 16 USC § 1456(c) 15 CFR § 930	Conduct activities in a manner consistent with approved state management programs. Proposed actions must be consistent with state coastal zone management as governed by the Washington State Shoreline Management Act, including the King County's Shoreline Master Program.	Relevant and appropriate because King County shares coastlines with salt water and manages coastlines in accordance with the Coastal Zone Management Act. The requirements of this statute are applicable to construction or development activities along major lakes, such as Lake Washington, which are considered part of the coastal zone.
National Historic Preservation Act	16 USC § 470; 36 CFR 800 40 CFR 6.301(b)	Requires federal agencies to take into account the effect of any federally assisted undertaking or licensing on any property with historic,	Applicable because Buildings 2 (Assembly & Repair Shop) and 27 are listed as contributing buildings in the Sand Point Historic District (1998) and the Naval

TABLE 2-2

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Location	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
National Historic Preservation Act (continued)		architectural, archaeological, or cultural value that is included in or eligible for inclusion in the National Register of Historic Places. Section 106 consultation with Department of Archaeology and Historic Preservation (DAHP) and local Historic District boards (where appropriate) will ensure substantive compliance conditions are identified which are protective of historic resources during these undertakings.	Air Station Seattle National Register of Historic Places District (2010). The Navy consulted with the State Historic Preservation Officer with the DAHP. Plans for demolition and renovation of these buildings were determined by the DAHP to have no adverse effect. All work, including renovation and demolition, must meet the requirements specified in the consultation memorandum for preservation of historic features of these buildings during demolition or renovation.
Archaeological Resources Protection Act	16 USC § 470	Specifies actions that must be taken to preserve archaeological resources. Section 106 consultation with DAHP and tribes (where appropriate) will ensure substantive compliance conditions are identified which are protective of archaeological resources during these undertakings.	Applicable should suspect archaeological resources be uncovered during the work. The Navy consulted with the DAHP. Substantive compliance with this Act will be met by meeting the requirements specified in the DAHP consultation memorandum to halt work and notify DAHP and tribes if any archaeological resources are uncovered during construction.
Historic Site, Buildings, Objects, and Antiquities Act	16 USC §§ 461–467	Requires preservation of historic sites, buildings, and objects of national significance.	Applicable because Buildings 2 (Assembly & Repair Shop) and 27 are listed as contributing buildings in the Sand Point Historic District (1998) and the Naval Air Station Seattle National Register of Historic Places District (2010). The Navy consulted with the State Historic Preservation Officer with the DAHP. Plans for demolition and renovation of these buildings were determined by the DAHP to have no adverse effect. All work, including renovation and demolition must meet the requirements specified in the consultation memorandum for preservation of historic features of these buildings during demolition or renovation.

TABLE 2-2

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Location	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
State			
Coastal Zone Shoreline	Washington State Shoreline Management Act WAC 173-27-060 90.58 RCW	Requires that federal agency activities in or affecting Washington's coastal zone shall be consistent to the maximum extent practicable with the enforceable policies of the most recent federally approved Washington State coastal zone management program pursuant to the Federal Coastal Zone Management Act. Local agencies (City of Seattle Shoreline Master Program) are designated to review activities for consistency.	Applicable if any activities occur within 200 feet of Lake Washington and have the potential to impact surface water activities.
Endangered Species	16 USC 1531 et seq. 50 CFR Parts 17, 225, 402).	The Endangered Species Act protects fish, wildlife, and plants that are threatened or endangered (T/E) with extinction. T/E species that occur or may occur within the adjacent Lake Washington Watershed include Puget Sound Chinook salmon, bull trout, and steelhead.	Relevant and appropriate. Project activities should not be affecting a T/E-listed species or habitat and no in-water activities are planned, though projects must identify presence of T/E-listed species and determine potential effect. Conduct activities that do not harm or result in a take of these species.
Archaeological and Cultural Resources	Executive Order 05-05 RCW 27.53	Requires state agencies with capital improvement projects to integrate the Department of Archaeology and Historic Preservation (DAHP), the Governor's Office of Indian Affairs, and concerned tribes into their capital project planning process. If there is federal involvement in the project: federal funding, permit, or license. If there is federal funding or permitting, then the Section 106 consultation process of the National Historic Preservation Act applies.	Applicable. This statute protects archaeological and cultural sites on both public and private lands in Washington State from unauthorized excavation or disturbance. The Navy consulted with the DAHP. Substantive compliance with this Act will be met by meeting the requirements specified in the DAHP consultation memorandum to halt work and notify DAHP and tribes if any archaeological resources are uncovered during construction. Consultation will also be required with the Seattle Landmark Preservation Board to address reconstruction of the Building 27 south hangar wall.

TABLE 2-2

LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Abbreviations and Acronyms:

§ – section
ARAR – applicable or relevant and appropriate requirement
CFR – *Code of Federal Regulations*
DAHP – Department of Archaeology and Historic Preservation
RCW – *Revised Code of Washington*
TBC – to be considered
T/E – threatened or endangered
USC – *United States Code*
WAC – *Washington Administrative*

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Action	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
General Remediation Including Excavation and Demolition	RCW 90.48. Construction and industrial stormwater general permit	Construction site operators are required to be covered by a Construction Stormwater General Permit if they are engaged in clearing, grading, and excavating activities that disturb 1 or more acres and discharge stormwater to surface waters of the state. Smaller sites may also require coverage if they are part of a larger common plan of development that will ultimately disturb 1 acre or more. Operators of regulated construction sites are required to: Develop stormwater pollution prevention plans; implement sediment, erosion, and pollution prevention control measures; and obtain coverage under this permit.	**ARAR** – Applicable for site activities involving excavation, grading, or other soil disturbance activities exceeding 1 acre. Should the project activities result in disturbance of 1 or more acres of land, a SWPPP will be developed to meet the substantive compliance requirements of the Construction Stormwater General Permit, which includes implementation and maintenance of appropriate BMPs to control erosion, control pollution, and control runoff during construction until the site is stabilized. Even if the 1-acre threshold is not met for this ARAR, appropriate BMPs will still be evaluated and implemented during fieldwork to control runoff, erosion, and keep pollutants out of stormwater.
Discharge of Aqueous Waste to Surface Water	Clean Water Act Effluent Guidelines 40 CFR 122 and 125 State Discharge Permit Program; National Pollutant Discharge Elimination System (NPDES) Program (WAC 173-216, -220)	Provides requirements for point source discharges of pollutants to surface water. No pollutants shall be discharged to any surface water of the state from a point source, except as authorized by an individual permit issued pursuant to chapters 216 or 220, or as authorized by a general permit issued pursuant to chapter 173-226 WAC.	Relevant and appropriate to discharges of pollutants that will or may enter a surface water body from activities such as building demolition, excavation and clearing activities, or treated washwater to surface water if point-source discharged. On-site discharges must comply with substantive requirements of the individual or general NPDES permit. If the discharge is considered an "offsite" discharge, dischargers must comply with both the substantive and administrative requirements of the permit.

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Action	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Discharge of Aqueous Waste to Surface Water (Continued)			Management of nonpoint-source construction stormwater will be addressed through substantive compliance with the Construction Stormwater General Permit if land disturbance exceeds 1 acre, including implementation of BMPs for erosion control, runoff control, and pollution prevention. Actual NPDES program requirements will be reviewed as part of project final design.
Air Emissions	Clean Air Act National Ambient Air Quality Standards Particulates 40 CFR 50 40 CFR 52, Subpart WW	40 CFR 50 establishes maximum concentrations for particulate matter and fugitive dust emissions. 40 CFR 52, Subpart WW outlines the implementation, maintenance and enforcement of National Ambient Air Quality Standards in the State of Washington.	Applicable for on-site activities that generate particulate matter and fugitive dust emissions from land disturbing activities, vehicle traffic, or during activities such as demolition. Standards have been deferred to the state. See State Air Quality Regulations.
	40 CFR 61 Subpart H and I	National Emission Standards for Hazardous Air Pollutants under the Clean Air Act that apply to radionuclides.	Relevant and appropriate at sites with cleanup of radioactive contamination.
	WAC 173-480-040 Ambient standard WAC 173-480-070 Emission monitoring and compliance procedures	Emissions of radionuclides in the ambient air shall not cause a maximum effective dose equivalent of more than 10 mrem per year to the whole body to any member of the public.	Relevant and appropriate to potential emissions from work under the removal action. Substantive compliance will be achieved through implementation of DOH-approved procedures and methods set forth in WAC 246-247; calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Action	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Air Emissions (Continued)	WAC 246-247-040 WAC 246-221-070	These regulations require all new construction and significant modifications of emissions units to utilize BARCT and require all existing emission units and nonsignificant modifications to utilize ALARACT in controlling emissions to the environment.	Applicable because fugitive, diffuse, and point source emissions of radionuclides to the ambient air may result from activities, such as demolition. Substantive compliance will be achieved through implementation of BARCT and ALARACT and meeting the limitations on radioactive air emissions contained in WAC 246-247-040.
	40 CFR 61.145 (Subpart M) National Emission Standard for Asbestos Regulation III, Article 4: Asbestos Control Standards (Puget Sound Clean Air Agency)	Emission standards for demolition and renovation. To determine which notification requirements and emission control procedures apply per Section 145(a), the owner or operator of a demolition or renovation activity and prior to the commencement of the demolition or renovation, thoroughly inspects the affected facility or part of the facility where the demolition or renovation operation will occur for the presence of asbestos, including Category I and Category II nonfriable ACM. If there is at least 260 linear feet of pipes or at least 160 square feet of other components or at least 35 cubic feet of facility components where the length of area could not be measured previously, then the demolition requires a notice to be submitted prior to commencing demolition (b), and specific procedures to be followed (c).	Relevant and appropriate if asbestos-containing materials are present and will be removed to some degree during demolition and renovation. The substantive requirements of this ARAR will be met by evaluating the existing building asbestos survey information and, if required, conducting additional evaluation of suspect ACM should it be encountered as well as following the emission control requirements in part c of this section by following requirements of PSCAA, the delegated state asbestos NESHAP authority. Asbestos handling will be by qualified and appropriately licensed personnel only.

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Action	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Air Emissions (Continued)	Chapter 70.94 RCW WAC 173-400 and 173-470 General standards for maximum emissions	Ambient air quality standards for total suspended particulates and fine particulates. The term "fugitive emissions" refers to unintended emissions made airborne by forces of wind, man's activity, or both. Mandates that reasonable precautions be taken to prevent particulate matter from becoming airborne and must maintain and operate the source to minimize emissions. PSCAA Regulation I, Section 9.15 contains precautions to minimize visible fugitive dust emissions.	These regulations may be applicable in connection with activities that demolish existing structures; remove/transport/ convey debris and/or excavated materials; disturb the soil during excavation; disturb soil or other exposed surfaces during construction of haul roads, etc.
Generation of Hazardous Wastes and Testing of Solid Waste	RCRA methods for identification and evaluation of solid and hazardous wastes 40 CFR 261, Subparts A, B, C and D; 40 CFR 262.11	Specific requirements for what a solid waste is and identifying when a solid waste is regulated as a hazardous waste. Establishes analytical requirements for testing solid waste to determine if regulated as hazardous waste. Determination may be by generator knowledge and/or testing of a representative sample of the waste. Listing of hazardous waste is not based on sampling data.	Applicable because solid wastes will be generated during this project, including demolition debris, concrete, asphalt, soil, sludge, piping, etc. All solid wastes must be evaluated at the point of generation to determine if they are hazardous waste. Based on the scope and site information, no listed hazardous waste is anticipated and hazardous waste quantities (characteristic wastes), if any are generated, are believed to be minimal. All waste must be properly characterized prior to disposal. Also see Washington State Dangerous Waste Regulations.

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Action	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Generation of Hazardous Wastes	WAC 173-340 WAC 173-340-515 MTCA chapter 70.105D RCW	Promulgated under MTCA to establish administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances have come to be located. MTCA defines a two-step process for establishing cleanup requirements for individual sites. This chapter implements chapter 70.105D RCW, which provides a workable process to accomplish effective and expeditious cleanups in a manner that protects human health and the environment. It is intended to address releases of hazardous substances caused by past activities. An independent cleanup action for a release of nonradiological hazardous constituents.	Applicable because solid wastes will be generated during this project, including demolition debris, concrete, asphalt, soil, sludge, piping, etc. All solid wastes must be evaluated at the point of generation to determine if they are dangerous or hazardous waste. Based on the scope and site information, no listed dangerous or hazardous waste is anticipated and waste quantities (characteristic wastes) if any are generated, are believed to be minimal. All waste must be properly characterized prior to disposal at an appropriate disposal facility.
Disposal Off-Site	RCRA Land Disposal Restrictions 40 CFR 268, Subparts A, B, C, D, and E "Land Disposal Restrictions," WAC 173-303-140(4)	Establishes restrictions on land disposal of untreated hazardous wastes and provides treatment standards for hazardous wastes that are to be land disposed. These treatment standards are to a great extent concentration-based. However, certain wastes are required to be treated by a specified technology prior to land disposal.	Relevant and appropriate if hazardous waste is disposed of on-site or transported off-site to be land disposed. Off-site disposal requires compliance with administrative and substantive requirements Hazardous waste generation is not anticipated during the TCRA.

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Action	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Disposal Off-Site (Continued)	Dangerous Waste Regulations, WAC 173-303	This regulation applies for the evaluation of a solid waste to determine if such waste is or is not a dangerous or mixed waste (radiological and RCRA hazardous). These state rules regulate the generation, handling, storage, and disposal of dangerous waste and include the RCRA definitions of hazardous waste within. Washington also has a category of dangerous waste called "State-Only Dangerous Waste," which does not meet the definition of a RCRA hazardous waste. Guidance document for sampling building debris with lead-based paint: http://www.ecy.wa.gov/programs/hwtr /demodebris/pages2/sampleplans.html	Applicable because solid wastes will be generated during this project, including demolition debris, concrete, asphalt, soil, sludge, piping, etc. All solid wastes must be evaluated at the point of generation to determine if they are dangerous waste. Substantive requirements of these regulations are applicable to solid waste managed during the removal action. Specifically, solid waste generated for removal from the site during this removal action would be subject to the dangerous waste designation procedures to ensure proper management. For example, disposal of lead-based paint is not specifically regulated, but results of a representative sample of waste containing lead-based paint will determine if it is a dangerous waste. Where waste disposal will take place in a permitted solid waste landfill that is outside the site boundaries, both substantive and administrative requirements of applicable regulations must be met.
	Washington Solid Waste Management Act (RCW 70.95) Solid Waste Handling Standards (WAC 173-350) RCRA Subtitle D 42 USC 6941-6949; 40 CFR Parts 275, 258	These regulations are applicable to the disposal of nonhazardous waste generated during remedial activities. These standards set minimum functional performance standards for the proper handling and disposal of solid waste, identifies functions necessary to assure effective solid waste handling programs at both the state and local level, and follows priorities for the management of solid waste.	Applicable for disposal of solid waste characterized as nonhazardous. Because the disposal of soil and debris will take place in a permitted solid waste landfill that is outside the site boundaries, both substantive and administrative requirements of applicable regulations must be met for this activity.

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Action	Law or Regulation	Requirement of Law/Regulation	ARAR/TBC Status
Disposal Off-Site (Continued)	49 *United States Code* 5101–5127 49 CFR Parts 171–173, 177 WAC 446-50, Chapter 46.48 RCW WAC 246-231	These regulations are applicable to the movement of hazardous materials on public highways. The Washington State Patrol adopted by reference the federal Hazardous Materials Transportation Act regulations governing transportation of hazardous materials on public highways. WAC 24-231 applies to the packaging, preparation for shipment, and transportation of radioactive material, which will be performed by the government-designated waste contractor.	If waste generated is hazardous and must be transported to a treatment or disposal facility, the following regulations are applicable: • 49 CFR Part 171, describing general requirements and hazardous waste shipments • 49 CFR Part 172, providing a table of hazardous materials and prescribing labeling and placarding • 49 CFR Part 173, providing general requirements for shipping and packaging by shippers • 49 CFR Part 177, regulating hazardous material shipment by highways
	40 CFR 61.150	Contains regulations for the handling and disposal of regulated asbestos wastes during demolition or renovation. Requires no visible emissions during collection, processing, packaging and transport of any asbestos containing waste material and use of adequately wet methods. Wrapping, marking, labeling, transport, and disposal, including recordkeeping, are specified.	Relevant and appropriate if asbestos-containing materials will be removed and disposed of. Asbestos containing material includes Category 1 or Category 2 non-friable asbestos containing materials (>1 percent non-friable). Off-site activities will comply with administrative and substantive requirements.

TABLE 2-3

ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Abbreviations and Acronyms:

ACM – asbestos-containing material
ARAR – applicable or relevant and appropriate requirement
ALARACT – as low as reasonable achievable control technology
BARCT – best available radionuclide control technology
BMP – best management practice
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CFR – *Code of Federal Regulations*
mrem – millirem
MTCA – Model Toxics Control Act
NESHAP – National Emission Standard for Hazardous Air Pollutants
NPDES – National Pollutant Discharge Elimination System
POTW – publicly owned treatment works
PSCAA – Puget Sound Clean Air Agency
RCRA – Resource Conservation and Recovery Act
RCW – *Revised Code of Washington*
SWPPP – Stormwater Pollution Prevention Plan
TBC – to be considered
TCRA – time-critical removal action
WAC – *Washington Administrative Code*

TABLE 4-1

ANTICIPATED WASTE STREAMS

Waste	Sampling	Anticipated Disposal
Radiologically contaminated soil	Survey [a]	Dispose of per Section 4.3.
Radiologically contaminated pipe	Survey [a]	Dispose of per Section 4.3.
Radiologically contaminated sludge	Survey [a]	Dispose of per Section 4.3.
Radiologically contaminated building components	Survey [a]	Dispose of per Section 4.3.
Non-radiologically contaminated building components	[b] Sampling and analysis needs are TBD depending on segregation and disposal method.	Dispose of per Section 4.5. Sampling may be required for painted demolition debris where lead-based paint is known or suspected to be present for waste that is not scrap metal and that is segregated for recycling.
Asbestos-containing materials	Survey [a]	Dispose of per Section 4.3 if radiologically contaminated but notify the MOU contractor. Dispose of per Section 4.4 if not radiologically contaminated.
Excavation and decontamination water	Survey [a] Sampling and analysis needs are TBD depending on disposal method.	Dispose of per Section 4.6 (at this time is TBD).
PCB ballasts, mercury-containing lamps or thermostats, or batteries	Manage for proper disposal [c]	Dispose of per Section 4.3 if radiologically contaminated. Dispose of per Section 4.7.
Concrete and asphalt	Survey [a]	Dispose of per Section 4.3 if radiologically contaminated. Recycle through concrete and asphalt recycling company
Common trash	None	Dispose of per Section 4.8.

Notes:

[a] Follow survey and sampling protocol in the Task-specific Plans.

[b] A demolition debris sampling and analysis plan will be prepared once the demolition and segregation strategy is known after the demolition subcontractor is identified. Waste may be sampled prior to demolition (preferable if it can be done) or from the wastestream after demolition depending upon the demolition and segregation strategy. Representative samples will be required of the "whole" wastestream.

[c] Universal wastes require handling and disposal in order to meet the less stringent waste rules and not be considered hazardous waste. They must not be broken or mishandled. PCBs are regulated under the Toxic Substances Control Act. Non-PCB ballast may also be state-only Dangerous Waste.

Abbreviations and Acronyms:

PCB – polychlorinated biphenyl
TBD – to be determined

This page intentionally left blank.

APPENDIX A

STORMWATER BEST MANAGEMENT PRACTICES GUIDANCE AND IMPLEMENTATION

This page intentionally left blank.

BMP C101: Preserving Natural Vegetation

Purpose

The purpose of preserving natural vegetation is to reduce erosion wherever practicable. Limiting site disturbance is the single most effective method for reducing erosion. For example, conifers can hold up to about 50 percent of all rain that falls during a storm. Up to 20-30 percent of this rain may never reach the ground but is taken up by the tree or evaporates. Another benefit is that the rain held in the tree can be released slowly to the ground after the storm.

Conditions of Use

- Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.
- As required by local governments.

Design and Installation Specifications

Natural vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.

The preservation of individual plants is more difficult because heavy equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor, and the work involved. Local governments may also have ordinances to save natural vegetation and trees.
- Fence or clearly mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- *Construction Equipment* - This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Placing a fenced buffer zone around plants to be saved prior to construction can prevent construction equipment injuries.
- *Grade Changes* - Changing the natural ground level will alter grades, which affects the plant's ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary and should be checked. Trees can tolerate fill of 6 inches or less. For shrubs and other plants, the fill should be less.

  When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile

system protects a tree from a raised grade. The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches of the soil and cuts of only 2-3 inches can cause serious injury. To protect the roots it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant.

- *Excavations* - Protect trees and other plants when excavating for drainfields, power, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers. If it is not possible to route the trench around plants to be saved, then the following should be observed:

  Cut as few roots as possible. When you have to cut, cut clean. Paint cut root ends with a wood dressing like asphalt base paint.

  Backfill the trench as soon as possible.

  Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

Some problems that can be encountered with a few specific trees are:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.
- The windthrow hazard of Pacific silver fir and madronna is high, while that of Western hemlock is moderate. The danger of windthrow increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils less than 20 inches deep) have a low windthrow hazard.
- Cottonwoods, maples, and willows have water-seeking roots. These can cause trouble in sewer lines and infiltration fields. On the other hand, they thrive in high moisture conditions that other trees would not.
- Thinning operations in pure or mixed stands of Grand fir, Pacific silver fir, Noble fir, Sitka spruce, Western red cedar, Western hemlock,

Pacific dogwood, and Red alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots, and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

Maintenance Standards

- Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.
- If tree roots have been exposed or injured, "prune" cleanly with an appropriate pruning saw or lopers directly above the damaged roots and recover with native soils. Treatment of sap flowing trees (fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

BMP C103: High Visibility Plastic or Metal Fence

Purpose

Fencing is intended to: (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and, (4) protect areas where marking with survey tape may not provide adequate protection.

Conditions of Use

To establish clearing limits, plastic or metal fence may be used:

- At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared.
- As necessary to control vehicle access to and on the site.

Design and Installation Specifications

- High visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least four feet in height. Posts for the fencing shall be steel or wood and placed every 6 feet on center (maximum) or as needed to ensure rigidity. The fencing shall be fastened to the post every six inches with a polyethylene tie. On long continuous lengths of fencing, a tension wire or rope shall be used as a top stringer to prevent sagging between posts. The fence color shall be high visibility orange. The fence tensile strength shall be 360 lbs./ft. using the ASTM D4595 testing method.
- Metal fences shall be designed and installed according to the manufacturer's specifications.
- Metal fences shall be at least 3 feet high and must be highly visible.
- Fences shall not be wired or stapled to trees.

Maintenance Standards

- If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

BMP C120: Temporary and Permanent Seeding

Purpose

Seeding is intended to reduce erosion by stabilizing exposed soils. A well-established vegetative cover is one of the most effective methods of reducing erosion.

Conditions of Use

- Seeding may be used throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a Bonded Fiber Matrix. The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, erosion control blankets should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch over hydromulch and blankets.
- Retention/detention ponds should be seeded as required.
- Mulch is required at all times because it protects seeds from heat, moisture loss, and transport due to runoff.
- All disturbed areas shall be reviewed in late August to early September and all seeding should be completed by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.
- At final site stabilization, all disturbed areas not otherwise vegetated or stabilized shall be seeded and mulched. Final stabilization means the completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as pavement, riprap, gabions or geotextiles) which will prevent erosion.

Design and Installation Specifications

- Seeding should be done during those seasons most conducive to growth and will vary with the climate conditions of the region. Local experience should be used to determine the appropriate seeding periods.
- The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1. Seeding that occurs between July 1 and August 30 will require irrigation until 75 percent grass cover is established. Seeding that occurs between October 1 and March 30 will require a mulch or plastic cover until 75 percent grass cover is established.
- To prevent seed from being washed away, confirm that all required surface water control measures have been installed.

- The seedbed should be firm and rough. All soil should be roughened no matter what the slope. If compaction is required for engineering purposes, slopes must be track walked before seeding. Backblading or smoothing of slopes greater than 4:1 is not allowed if they are to be seeded.
- New and more effective restoration-based landscape practices rely on deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical the subgrade should be initially ripped to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches the rototilling process should be done in multiple lifts, or the prepared soil system shall be prepared properly and then placed to achieve the specified depth.
- Organic matter is the most appropriate form of "fertilizer" because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form. A natural system typically releases 2-10 percent of its nutrients annually. Chemical fertilizers have since been formulated to simulate what organic matter does naturally.
- In general, 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer can be used at a rate of 90 pounds per acre. Slow-release fertilizers should always be used because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil tests to determine the exact type and quantity of fertilizer needed. This will prevent the over-application of fertilizer. Fertilizer should not be added to the hydromulch machine and agitated more than 20 minutes before it is to be used. If agitated too much, the slow-release coating is destroyed.
- There are numerous products available on the market that take the place of chemical fertilizers. These include several with seaweed extracts that are beneficial to soil microbes and organisms. If 100 percent cottonseed meal is used as the mulch in hydroseed, chemical fertilizer may not be necessary. Cottonseed meal is a good source of long-term, slow-release, available nitrogen.
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. Mulch may be made up of 100 percent: cottonseed meal; fibers made of wood, recycled cellulose, hemp, and kenaf; compost; or blends of these. Tackifier shall be plant-based, such as guar or alpha plantago, or chemical-based such as polyacrylamide or polymers. Any mulch or tackifier product used shall be installed per manufacturer's instructions. Generally, mulches come in 40-50 pound bags. Seed and fertilizer are added at time of application.

- Mulch is always required for seeding. Mulch can be applied on top of the seed or simultaneously by hydroseeding.
- On steep slopes, Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products should be used. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer's instructions. Most products require 24-36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.

BFMs and MBFMs have some advantages over blankets:

- No surface preparation required;
- Can be installed via helicopter in remote areas;
- On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety;
- They are at least $1,000 per acre cheaper installed.

In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.

- When installing seed via hydroseeding operations, only about 1/3 of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. One way to overcome this is to increase seed quantities by up to 50 percent.
- Vegetation establishment can also be enhanced by dividing the hydromulch operation into two phases:
    1. Phase 1- Install all seed and fertilizer with 25-30 percent mulch and tackifier onto soil in the first lift;
    2. Phase 2- Install the rest of the mulch and tackifier over the first lift.

An alternative is to install the mulch, seed, fertilizer, and tackifier in one lift. Then, spread or blow straw over the top of the hydromulch at a rate of about 800-1000 pounds per acre. Hold straw in place with a standard tackifier. Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:

1. Irrigation
2. Reapplication of mulch
3. Repair of failed slope surfaces

This technique works with standard hydromulch (1,500 pounds per acre minimum) and BFM/MBFMs (3,000 pounds per acre minimum).

- Areas to be permanently landscaped shall provide a healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetal health and vitality, improves hydrologic characteristics, and reduces the need for irrigation. This can be accomplished in a number of ways:

  Recent research has shown that the best method to improve till soils is to amend these soils with compost. The optimum mixture is approximately two parts soil to one part compost. This equates to 4 inches of compost mixed to a depth of 12 inches in till soils. Increasing the concentration of compost beyond this level can have negative effects on vegetal health, while decreasing the concentrations can reduce the benefits of amended soils. Please note: The compost should meet specifications for Grade A quality compost in Ecology Publication 94-038.

  Other soils, such as gravel or cobble outwash soils, may require different approaches. Organics and fines easily migrate through the loose structure of these soils. Therefore, the importation of at least 6 inches of quality topsoil, underlain by some type of filter fabric to prevent the migration of fines, may be more appropriate for these soils.

  Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.

- Areas that will be seeded only and not landscaped may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Native topsoil should be re-installed on the disturbed soil surface before application.
- Seed that is installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed that is installed as a permanent measure may be installed by hand on small areas (usually less than 1 acre) that will be covered with mulch, topsoil, or erosion blankets. The seed mixes listed below include recommended mixes for both temporary and permanent seeding. These mixes, with the exception of the wetland mix, shall be applied at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Local suppliers or the local conservation district should be consulted for their recommendations because the appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the local authority may be used.

Table 4.1 represents the standard mix for those areas where just a temporary vegetative cover is required.

Table 4.1
Temporary Erosion Control Seed Mix

	% Weight	% Purity	% Germination
Chewings or annual blue grass *Festuca rubra var. commutata* or *Poa anna*	40	98	90
Perennial rye - *Lolium perenne*	50	98	90
Redtop or colonial bentgrass *Agrostis alba* or *Agrostis tenuis*	5	92	85
White dutch clover *Trifolium repens*	5	98	90

Table 4.2 provides just one recommended possibility for landscaping seed.

Table 4.2
Landscaping Seed Mix

	% Weight	% Purity	% Germination
Perennial rye blend *Lolium perenne*	70	98	90
Chewings and red fescue blend *Festuca rubra var. commutata* or *Festuca rubra*	30	98	90

This turf seed mix in Table 4.3 is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.

Table 4.3
Low-Growing Turf Seed Mix

	% Weight	% Purity	% Germination
Dwarf tall fescue (several varieties) *Festuca arundinacea var.*	45	98	90
Dwarf perennial rye (Barclay) *Lolium perenne var. barclay*	30	98	90
Red fescue *Festuca rubra*	20	98	90
Colonial bentgrass *Agrostis tenuis*	5	98	90

Table 4.4 presents a mix recommended for bioswales and other intermittently wet areas.

Table 4.4
Bioswale Seed Mix*

	% Weight	% Purity	% Germination
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	75-80	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10-15	92	85
Redtop bentgrass *Agrostis alba* or *Agrostis gigantea*	5-10	90	80

** Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix*

The seed mix shown in Table 4.5 is a recommended low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Other mixes may be appropriate, depending on the soil type and hydrology of the area. Recent research suggests that bentgrass (agrostis sp.) should be emphasized in wet-area seed mixes. Apply this mixture at a rate of 60 pounds per acre.

Table 4.5
Wet Area Seed Mix*

	% Weight	% Purity	% Germination
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	60-70	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10-15	98	85
Meadow foxtail *Alepocurus pratensis*	10-15	90	80
Alsike clover *Trifolium hybridum*	1-6	98	90
Redtop bentgrass *Agrostis alba*	1-6	92	85

** Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix*

The meadow seed mix in Table 4.6 is recommended for areas that will be maintained infrequently or not at all and where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. The appropriateness of clover in the mix may need to be considered, as this can be a fairly invasive species. If the soil is amended, the addition of clover may not be necessary.

Table 4.6
Meadow Seed Mix

	% Weight	% Purity	% Germination
Redtop or Oregon bentgrass *Agrostis alba* or *Agrostis oregonensis*	20	92	85
Red fescue *Festuca rubra*	70	98	90
White dutch clover *Trifolium repens*	10	98	90

Maintenance Standards

- Any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows) shall be reseeded. If reseeding is ineffective, an alternate method, such as sodding, mulching, or nets/blankets, shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the local authority when sensitive areas would otherwise be protected.

- After adequate cover is achieved, any areas that experience erosion shall be reseeded and protected by mulch. If the erosion problem is drainage related, the problem shall be fixed and the eroded area reseeded and protected by mulch.
- Seeded areas shall be supplied with adequate moisture, but not watered to the extent that it causes runoff.

BMP C121: Mulching

Purpose

The purpose of mulching soils is to provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches that can be used. Only the most common types are discussed in this section.

Conditions of Use

As a temporary cover measure, mulch should be used:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed during the wet season and during the hot summer months.
- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.
- Mulch may be applied at any time of the year and must be refreshed periodically.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 4.7. Note: Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

Mulch used within the ordinary high-water mark of surface waters should be selected to minimize potential flotation of organic matter. Composted organic materials have higher specific gravities (densities) than straw, wood, or chipped material.

Maintenance Standards

- The thickness of the cover must be maintained.
- Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

Table 4.7
Mulch Standards and Guidelines

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2"-3" thick; 5 bales per 1000 sf or 2-3 tons per acre	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw may be reduced by half when used in conjunction with seeding. In windy areas straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits. Straw should be used only if mulches with long-term benefits are unavailable locally. It should also not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	No growth inhibiting factors.	Approx. 25-30 lbs per 1000 sf or 1500 - 2000 lbs per acre	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Fibers longer than about ¾-1 inch clog hydromulch equipment. Fibers should be kept to less than ¾ inch.
Composted Mulch and Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit (unless exempt).	2" thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Composted mulch has a coarser size gradation than compost. It is more stable and practical to use in wet areas and during rainy weather conditions.
Chipped Site Vegetation	Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.	2" minimum thickness	This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.
Wood-based Mulch	No visible water or dust during handling. Must be purchased from a supplier with a Solid Waste Handling Permit or one exempt from solid waste regulations.	2” thick; approx. 100 tons per acre (approx. 800 lbs. per cubic yard)	This material is often called “hog or hogged fuel.” It is usable as a material for Stabilized Construction Entrances (BMP C105) and as a mulch. The use of mulch ultimately improves the organic matter in the soil. Special caution is advised regarding the source and composition of wood-based mulches. Its preparation typically does not provide any weed seed control, so evidence of residual vegetation in its composition or known inclusion of weed plants or seeds should be monitored and prevented (or minimized).

BMP C140: Dust Control

Purpose

Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.

Conditions of Use

- In areas (including roadways) subject to surface and air movement of dust where on-site and off-site impacts to roadways, drainage ways, or surface waters are likely.

Design and Installation Specifications

- Vegetate or mulch areas that will not receive vehicle traffic. In areas where planting, mulching, or paving is impractical, apply gravel or landscaping rock.
- Limit dust generation by clearing only those areas where immediate activity will take place, leaving the remaining area(s) in the original condition, if stable. Maintain the original ground cover as long as practical.
- Construct natural or artificial windbreaks or windscreens. These may be designed as enclosures for small dust sources.
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, refer to Stabilized Construction Entrance (BMP C105).
- Irrigation water can be used for dust control. Irrigation systems should be installed as a first step on sites where dust control is a concern.
- Spray exposed soil areas with a dust palliative, following the manufacturer's instructions and cautions regarding handling and application. Used oil is prohibited from use as a dust suppressant. Local governments may approve other dust palliatives such as calcium chloride or PAM.
- PAM (BMP C126) added to water at a rate of 0.5 lbs. per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to the increased infiltration of water into the soil and reduced evaporation. In addition, small soil particles are bonded together and are not as easily transported by wind. Adding PAM may actually reduce the quantity of water needed for dust control, especially in eastern Washington. Since the wholesale cost of PAM is about $ 4.00 per pound, this is an extremely cost-effective dust control method.

Techniques that can be used for unpaved roads and lots include:

- Lower speed limits. High vehicle speed increases the amount of dust stirred up from unpaved roads and lots.
- Upgrade the road surface strength by improving particle size, shape, and mineral types that make up the surface and base materials.

- Add surface gravel to reduce the source of dust emission. Limit the amount of fine particles (those smaller than .075 mm) to 10 to 20 percent.
- Use geotextile fabrics to increase the strength of new roads or roads undergoing reconstruction.
- Encourage the use of alternate, paved routes, if available.
- Restrict use by tracked vehicles and heavy trucks to prevent damage to road surface and base.
- Apply chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments.
- Pave unpaved permanent roads and other trafficked areas.
- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- Limit dust-causing work on windy days.
- Contact your local Air Pollution Control Authority for guidance and training on other dust control measures. Compliance with the local Air Pollution Control Authority constitutes compliance with this BMP.

Maintenance Standards Respray area as necessary to keep dust to a minimum.

BMP C151: Concrete Handling

Purpose

Concrete work can generate process water and slurry that contain fine particles and high pH, both of which can violate water quality standards in the receiving water. This BMP is intended to minimize and eliminate concrete process water and slurry from entering waters of the state.

Conditions of Use

Any time concrete is used, these management practices shall be utilized. Concrete construction projects include, but are not limited to, the following:

- Curbs
- Sidewalks
- Roads
- Bridges
- Foundations
- Floors
- Runways

Design and Installation Specifications

- Concrete truck chutes, pumps, and internals shall be washed out only into formed areas awaiting installation of concrete or asphalt.
- Unused concrete remaining in the truck and pump shall be returned to the originating batch plant for recycling.
- Hand tools including, but not limited to, screeds, shovels, rakes, floats, and trowels shall be washed off only into formed areas awaiting installation of concrete or asphalt.
- Equipment that cannot be easily moved, such as concrete pavers, shall only be washed in areas that do not directly drain to natural or constructed stormwater conveyances.
- Washdown from areas such as concrete aggregate driveways shall not drain directly to natural or constructed stormwater conveyances.
- When no formed areas are available, washwater and leftover product shall be contained in a lined container. Contained concrete shall be disposed of in a manner that does not violate groundwater or surface water quality standards.

Maintenance Standards

Containers shall be checked for holes in the liner daily during concrete pours and repaired the same day.

BMP C220: Storm Drain Inlet Protection

Purpose To prevent coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Protection should be provided for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap. Inlet protection may be used anywhere to protect the drainage system. It is likely that the drainage system will still require cleaning.

Table 4.9 lists several options for inlet protection. All of the methods for storm drain inlet protection are prone to plugging and require a high frequency of maintenance. Drainage areas should be limited to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe treatment may be required.

Table 4.9
Storm Drain Inlet Protetion

Type of Inlet Protection	Emergency Overflow	Applicable for Paved/ Earthen Surfaces	Conditions of Use
Drop Inlet Protection			
Excavated drop inlet protection	Yes, temporary flooding will occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area Requirement: 30' X 30'/acre
Block and gravel drop inlet protection	Yes	Paved or Earthen	Applicable for heavy concentrated flows. Will not pond.
Gravel and wire drop inlet protection	No		Applicable for heavy concentrated flows. Will pond. Can withstand traffic.
Catch basin filters	Yes	Paved or Earthen	Frequent maintenance required.
Curb Inlet Protection			
Curb inlet protection with a wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Block and gravel curb inlet protection	Yes	Paved	Sturdy, but limited filtration.
Culvert Inlet Protection			
Culvert inlet sediment trap			18 month expected life.

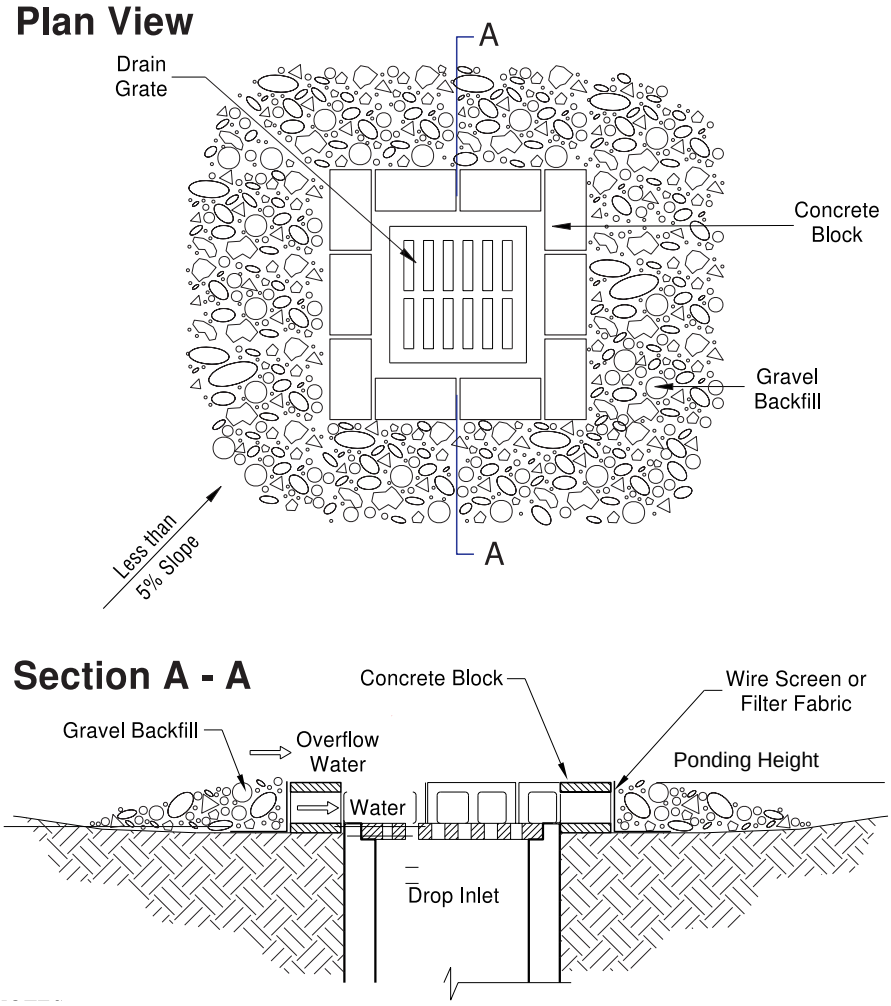
Design and Installation Specifications

Excavated Drop Inlet Protection - An excavated impoundment around the storm drain. Sediment settles out of the stormwater prior to entering the storm drain.

- Depth 1-2 ft as measured from the crest of the inlet structure.
- Side Slopes of excavation no steeper than 2:1.
- Minimum volume of excavation 35 cubic yards.
- Shape basin to fit site with longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water problems.
- Clear the area of all debris.
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- It may be necessary to build a temporary dike to the down slope side of the structure to prevent bypass flow.

Block and Gravel Filter - A barrier formed around the storm drain inlet with standard concrete blocks and gravel. See Figure 4.14.

- Height 1 to 2 feet above inlet.
- Recess the first row 2 inches into the ground for stability.
- Support subsequent courses by placing a 2x4 through the block opening.
- Do not use mortar.
- Lay some blocks in the bottom row on their side for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel just below the top of blocks on slopes of 2:1 or flatter.
- An alternative design is a gravel donut.
- Inlet slope of 3:1.
- Outlet slope of 2:1.
- 1-foot wide level stone area between the structure and the inlet.
- Inlet slope stones 3 inches in diameter or larger.
- Outlet slope use gravel ½- to ¾-inch at a minimum thickness of 1-foot.



Notes:
1. Drop inlet sediment barriers are to be used for small, nearly level drainage areas. (less than 5%)
2. Excavate a basin of sufficient size adjacent to the drop inlet.
3. The top of the structure (ponding height) must be well below the ground elevation downslope to prevent runoff from bypassing the inlet. A temporary dike may be necessary on the dowslope side of the structure.

Figure 4.14 – Block and Gravel Filter

Gravel and Wire Mesh Filter - A gravel barrier placed over the top of the inlet. This structure does not provide an overflow.

- Hardware cloth or comparable wire mesh with ½-inch openings.
- Coarse aggregate.
- Height 1-foot or more, 18 inches wider than inlet on all sides.
- Place wire mesh over the drop inlet so that the wire extends a minimum of 1-foot beyond each side of the inlet structure.
- If more than one strip of mesh is necessary, overlap the strips.
- Place coarse aggregate over the wire mesh.
- The depth of the gravel should be at least 12 inches over the entire inlet opening and extend at least 18 inches on all sides.

Catchbasin Filters - Inserts should be designed by the manufacturer for use at construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. The maintenance requirements can be reduced by combining a catchbasin filter with another type of inlet protection. This type of inlet protection provides flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way.

- 5 cubic feet of storage.
- Dewatering provisions.
- High-flow bypass that will not clog under normal use at a construction site.
- The catchbasin filter is inserted in the catchbasin just below the grating.

Curb Inlet Protection with Wooden Weir – Barrier formed around a curb inlet with a wooden frame and gravel.

- Wire mesh with ½-inch openings.
- Extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against wire/fabric.
- Place weight on frame anchors.

Block and Gravel Curb Inlet Protection – Barrier formed around an inlet with concrete blocks and gravel. See Figure 4.14.

- Wire mesh with ½-inch openings.
- Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
- Place a 2x4 stud through the outer holes of each spacer block to align the front blocks.
- Place blocks on their sides across the front of the inlet and abutting the spacer blocks.
- Place wire mesh over the outside vertical face.
- Pile coarse aggregate against the wire to the top of the barrier.

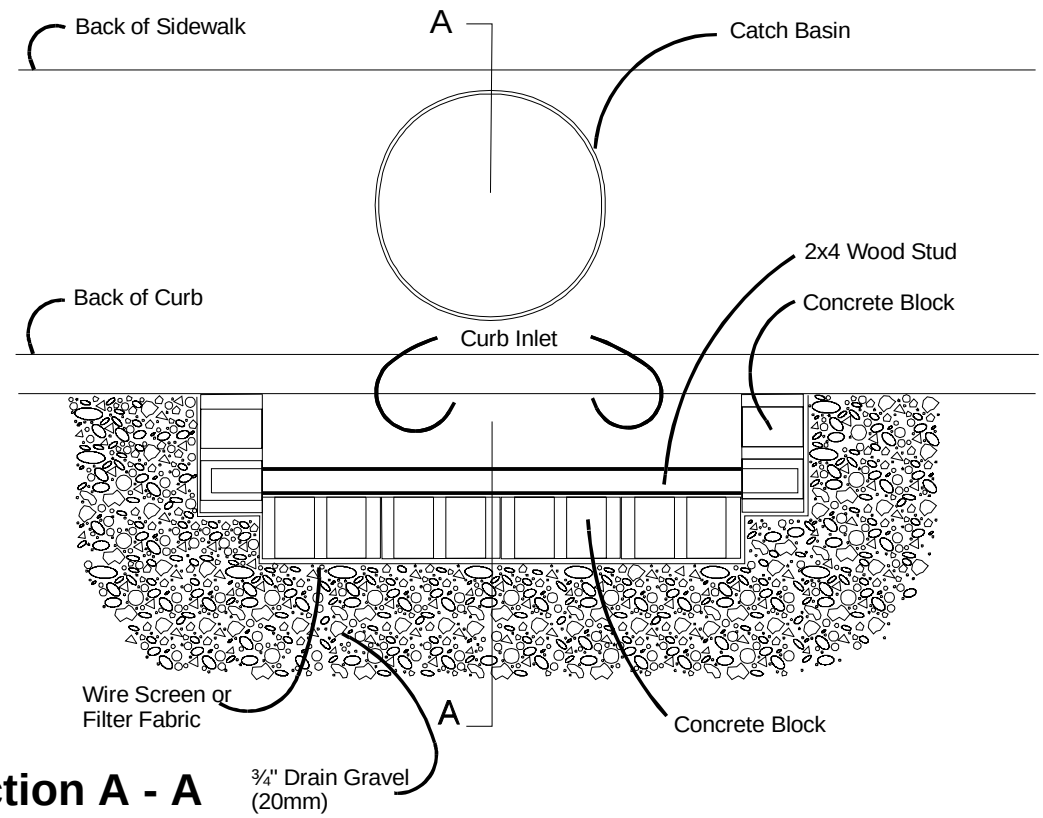
Curb and Gutter Sediment Barrier – Sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure 4.16.

- Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.
- Construct a horseshoe shaped sedimentation trap on the outside of the berm sized to sediment trap standards for protecting a culvert inlet.

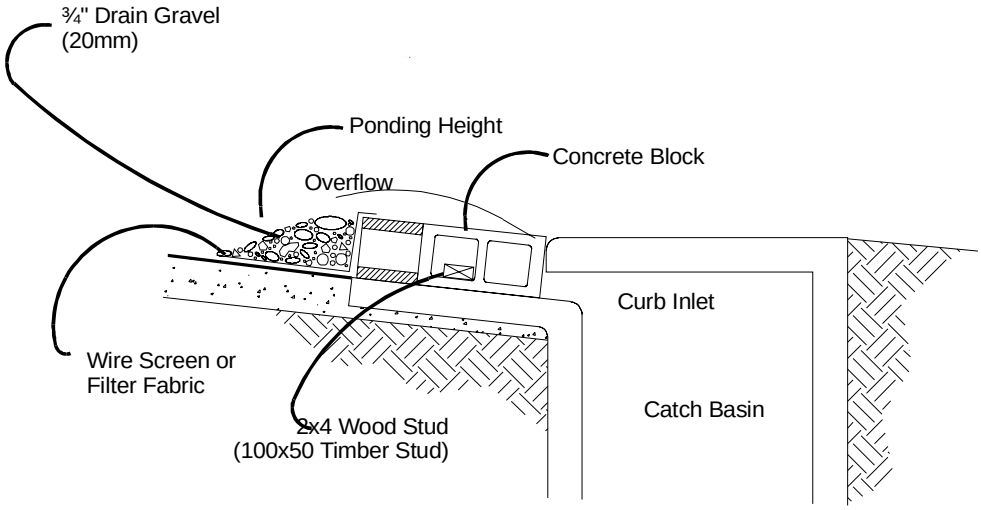
Maintenance Standards

- Catch basin filters should be inspected frequently, especially after storm events. If the insert becomes clogged, it should be cleaned or replaced.
- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.

Plan View



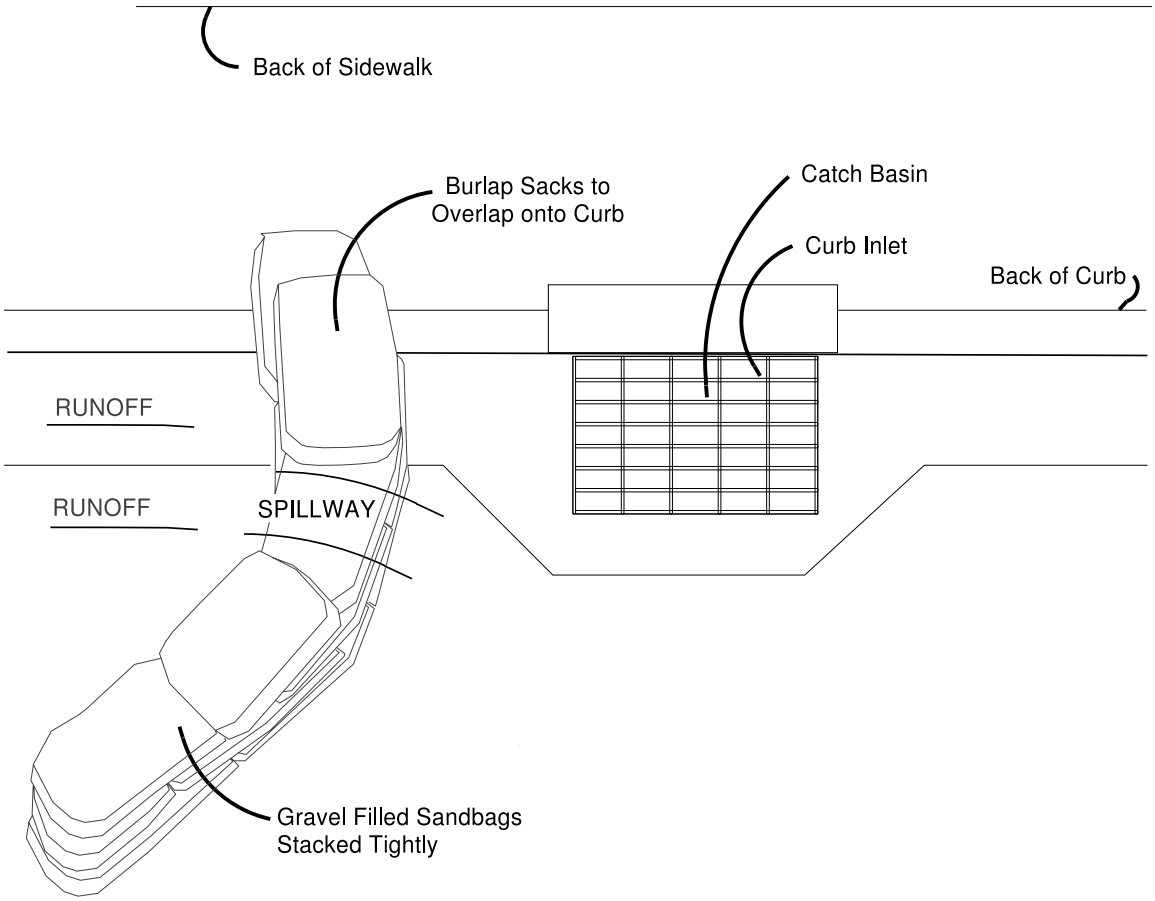
Section A - A



NOTES:
1. Use block and gravel type sediment barrier when curb inlet is located in gently sloping street segment, where water can pond and allow sediment to separate from runoff.
2. Barrier shall allow for overflow from severe storm event.
3. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Figure 4.15 – Block and Gravel Curb Inlet Protection

Plan View



NOTES:
1. Place curb type sediment barriers on gently sloping street segments, where water can pond and allow sediment to separate from runoff.
2. Sandbags of either burlap or woven `geotextile' fabric, are filled with gravel, layered and packed tightly.
3. Leave a one sandbag gap in the top row to provide a spillway for overflow.
4. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Figure 4.16 – Curb and Gutter Barrier

BMP C233: Silt Fence

Purpose

Use of a silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow. See Figure 4.19 for details on silt fence construction.

Conditions of Use

Silt fence may be used downslope of all disturbed areas.

- Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment pond. The only circumstance in which overland flow can be treated solely by a silt fence, rather than by a sediment pond, is when the area draining to the fence is one acre or less and flow rates are less than 0.5 cfs.
- Silt fences should not be constructed in streams or used in V-shaped ditches. They are not an adequate method of silt control for anything deeper than sheet or overland flow.

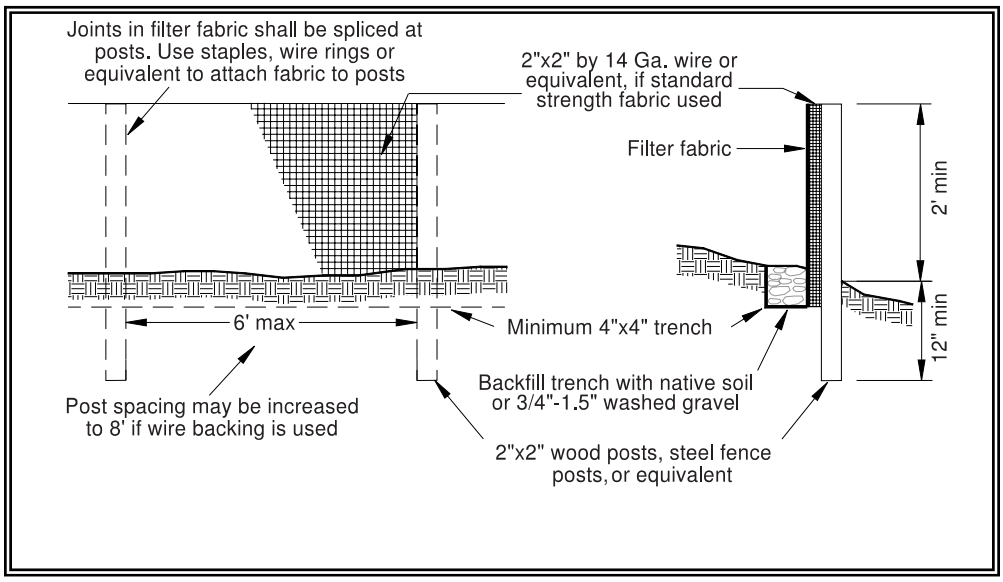


Figure 4.19 – Silt Fence

Design and Installation Specifications

- Drainage area of 1 acre or less or in combination with sediment basin in a larger site.
- Maximum slope steepness (normal (perpendicular) to fence line) 1:1.
- Maximum sheet or overland flow path length to the fence of 100 feet.
- No flows greater than 0.5 cfs.
- The geotextile used shall meet the following standards. All geotextile properties listed below are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in Table 4.10):

Table 4.10 Geotextile Standards	
Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for slit film wovens (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#100 sieve).
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. Minimum for extra strength fabric. 100 lbs minimum for standard strength fabric.
Grab Tensile Strength (ASTM D4632)	30% maximum
Ultraviolet Resistance (ASTM D4355)	70% minimum

- Standard strength fabrics shall be supported with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the fabric. Silt fence materials are available that have synthetic mesh backing attached.
- Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F. to 120°F.
- 100 percent biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed, if permitted by local regulations.
- Standard Notes for construction plans and specifications follow. Refer to Figure 4.19 for standard silt fence details.

  The contractor shall install and maintain temporary silt fences at the locations shown in the Plans. The silt fences shall be constructed in the areas of clearing, grading, or drainage prior to starting those activities. A silt fence shall not be considered temporary if the silt fence must function beyond the life of the contract. The silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.

  The minimum height of the top of silt fence shall be 2 feet and the maximum height shall be 2½ feet above the original ground surface.

  The geotextile shall be sewn together at the point of manufacture, or at an approved location as determined by the Engineer, to form geotextile lengths as required. All sewn seams shall be located at a support post. Alternatively, two sections of silt fence can be overlapped, provided the Contractor can demonstrate, to the satisfaction of the Engineer, that the overlap is long enough and that the adjacent fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.

The geotextile shall be attached on the up-slope side of the posts and support system with staples, wire, or in accordance with the manufacturer's recommendations. The geotextile shall be attached to the posts in a manner that reduces the potential for geotextile tearing at the staples, wire, or other connection device. Silt fence back-up support for the geotextile in the form of a wire or plastic mesh is dependent on the properties of the geotextile selected for use. If wire or plastic back-up mesh is used, the mesh shall be fastened securely to the up-slope of the posts with the geotextile being up-slope of the mesh back-up support.

The geotextile at the bottom of the fence shall be buried in a trench to a minimum depth of 4 inches below the ground surface. The trench shall be backfilled and the soil tamped in place over the buried portion of the geotextile, such that no flow can pass beneath the fence and scouring can not occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the trench a minimum of 3 inches.

The fence posts shall be placed or driven a minimum of 18 inches. A minimum depth of 12 inches is allowed if topsoil or other soft subgrade soil is not present and a minimum depth of 18 inches cannot be reached. Fence post depths shall be increased by 6 inches if the fence is located on slopes of 3:1 or steeper and the slope is perpendicular to the fence. If required post depths cannot be obtained, the posts shall be adequately secured by bracing or guying to prevent overturning of the fence due to sediment loading.

Silt fences shall be located on contour as much as possible, except at the ends of the fence, where the fence shall be turned uphill such that the silt fence captures the runoff water and prevents water from flowing around the end of the fence.

If the fence must cross contours, with the exception of the ends of the fence, gravel check dams placed perpendicular to the back of the fence shall be used to minimize concentrated flow and erosion along the back of the fence. The gravel check dams shall be approximately 1-foot deep at the back of the fence. It shall be continued perpendicular to the fence at the same elevation until the top of the check dam intercepts the ground surface behind the fence. The gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. The gravel check dams shall be located every 10 feet along the fence where the fence must cross contours. The slope of the fence line where contours must be crossed shall not be steeper than 3:1.

Wood, steel or equivalent posts shall be used. Wood posts shall have minimum dimensions of 2 inches by 2 inches by 3 feet minimum length, and shall be free of defects such as knots, splits, or gouges.

Steel posts shall consist of either size No. 6 rebar or larger, ASTM A 120 steel pipe with a minimum diameter of 1-inch, U, T, L, or C shape steel posts with a minimum weight of 1.35 lbs./ft. or other steel posts having equivalent strength and bending resistance to the post sizes listed. The spacing of the support posts shall be a maximum of 6 feet.

Fence back-up support, if used, shall consist of steel wire with a maximum mesh spacing of 2 inches, or a prefabricated polymeric mesh. The strength of the wire or polymeric mesh shall be equivalent to or greater than 180 lbs. grab tensile strength. The polymeric mesh must be as resistant to ultraviolet radiation as the geotextile it supports.

- Silt fence installation using the slicing method specification details follow. Refer to Figure 4.20 for slicing method details.

  The base of both end posts must be at least 2 to 4 inches above the top of the silt fence fabric on the middle posts for ditch checks to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.

  Install posts 3 to 4 feet apart in critical retention areas and 6 to 7 feet apart in standard applications.

  Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.

  Install posts with the nipples facing away from the silt fence fabric.

  Attach the fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. In addition, each tie should be positioned to hang on a post nipple when tightening to prevent sagging.

  Wrap approximately 6 inches of fabric around the end posts and secure with 3 ties.

  No more than 24 inches of a 36-inch fabric is allowed above ground level.

  The rope lock system must be used in all ditch check applications.

  The installation should be checked and corrected for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground if necessary.

  Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of four trips.

Maintenance Standards

- Any damage shall be repaired immediately.
- If concentrated flows are evident uphill of the fence, they must be intercepted and conveyed to a sediment pond.
- It is important to check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence or remove the trapped sediment.
- Sediment deposits shall either be removed when the deposit reaches approximately one-third the height of the silt fence, or a second silt fence shall be installed.
- If the filter fabric (geotextile) has deteriorated due to ultraviolet breakdown, it shall be replaced.

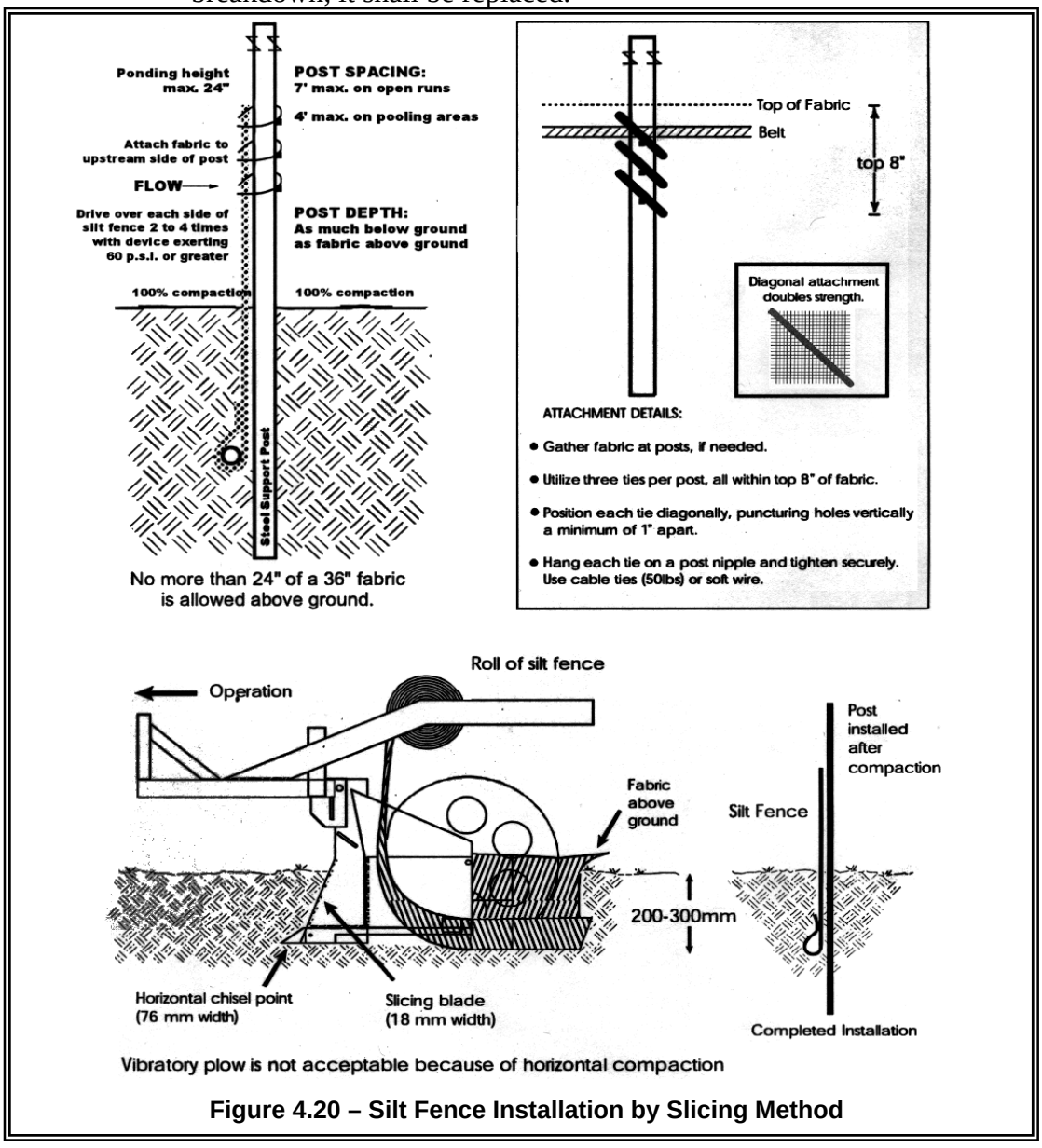


Figure 4.20 – Silt Fence Installation by Slicing Method

APPENDIX B

UNIVERSAL WASTE FACT SHEETS

This page intentionally left blank

The Universal Waste Rule for Batteries WAC 173-303-573(2)

Any business that generates dangerous waste must follow the dangerous waste rules, Chapter 173-303 WAC. In Washington State the Universal Waste Rule allows less burdensome management of the following wastes:

- Batteries *(#98.407.a)*
- Thermostats *(#98-407.b)*
- Lamps *(#98-407.c)*
- Mercury-containing equipment *(#98-407.b)*

Businesses have the choice of managing these wastes as universal waste (UW) or dangerous waste. UW requirements for storage, transportation and collection are less stringent.

Can I manage batteries at my business as Universal Waste?

All batteries that are dangerous waste can be managed as UW including:

- Alkaline
- Mercuric-oxide
- Alkaline-manganese
- Zinc carbon
- Zinc air
- Button cell mercuric-oxide
- Silver oxide
- Lithium
- Nickel-Cadmium (Ni-Cd)

Spent lead-acid batteries (typically, automobile batteries) can be managed as universal waste. However they are most often managed under the optional lead-acid battery exemption (WAC 173-303-520).

You can manage consumer products with difficult-to-remove batteries as universal waste. Miniature batteries can also be managed as universal waste. They are used in numerous products that require compact sources of electrical power, including toys, hearing aids, watches, calculators, and other portable devices. There is typically 0.1% to 2.0% mercury content in the formulations of most zinc air, alkaline manganese, and silver oxide miniature batteries.

How do I manage Universal Waste batteries?

Labeling and marking:

Clearly label or mark individual batteries or containers of UW batteries with one of the following phrases:

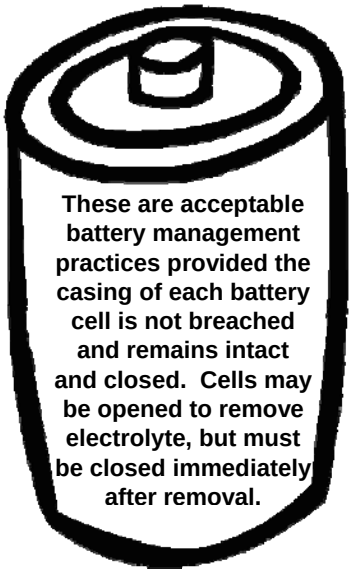
- *Universal Waste – Batteries*
- *Waste Batteries*
- *Used Batteries*

Accumulation and dating of universal waste batteries:
You can accumulate batteries for one year from the date they are generated. To document this, the collection container or individual UW battery is typically marked with the first date of accumulation. An extension to the one year accumulation limit is allowed if the facility needs more time to collect enough items to facilitate proper recovery, treatment, or disposal.

Prevent releases to the environment:
Store damaged or leaking batteries in closed containers to prevent releasing toxic materials to the environment. Batteries must be compatible with one another and with the container.

Handlers[1] may not dilute, dispose, or treat universal wastes:
The following routine battery management activities are not considered treatment:

- sorting batteries by type
- mixing battery types in one container
- discharging batteries
- regenerating used batteries
- disassembling battery packs,
- removing batteries from discarded consumer products
- removing electrolyte



Large Quantity Handlers of Universal Waste (LQHUW)
When a handler exceeds 11,000 pounds (or 2,200 pounds for lamps), they become an LQHUW and are subject to extra requirements, including:

- Notification to Ecology of LQHUW status, and which specific types of UW they manage.
- Tracking type and quantity of universal wastes received and shipped.
- Obtaining a RCRA Site Identification Number.

Transporting UW batteries:
You may self-transport UW batteries, complying with applicable U.S. Department of Transportation regulations. Refer to Ecology publication number 98-407 *The Universal Waste Rule* for details.

A dangerous waste generator has the choice of managing batteries as UW or under the more stringent dangerous waste requirements. In most cases UW management is much easier and the preferable alternative to dangerous waste management. Note that businesses that generate and manage dangerous wastes and UWs are considered both a dangerous waste generator and a UW handler. Regardless if you are a generator or a handler, you are liable for ensuring your waste is properly managed once it leaves your site.

[1] Handlers are either the original generators of the UW or businesses that receive and consolidate UW from other handlers before shipping to another handler or to a destination facility.

Where do I send them?

UW batteries may be sent to either another handler (acting as a collection point) or to a destination facility. Another handler could include any business that is already managing UW, government-sponsored collections, or hazardous waste management firms. Businesses that recycle or dispose of UW are called destination facilities. Ultimately, all UW must go to a destination facility. They are subject to dangerous waste regulations for recyclers and hazardous waste disposal facilities. A facility that only accumulates UW would not be a destination facility.

For a list of firms that offer waste management services, visit http://www.ecy.wa.gov/apps/hwtr/hwsd/default.htm.

Why are batteries hazardous?

Mercury, lead, cadmium and other heavy metals can leak from batteries and pose environmental risks when released to the environment through improper disposal practices. Because mercury is highly toxic to humans and wildlife, it is very important to properly manage batteries containing mercury. Persistent in the environment, mercury increases in concentration as it goes up the food chain. Miniature batteries are most likely to contain mercury.

Another concern with waste batteries is their potential to explode. Batteries stored in contact with one another can generate heat and hydrogen gas. If the storage container is not ventilated, it can explode. Also, some battery types may not be compatible and could cause unwanted reactions.

Not all batteries are recycled in the same way, so generators are encouraged to segregate their batteries by type. For instance, nickel cadmium batteries can be recycled to recover their metal content. A recycler may not accept them if they are mixed with alkaline or other batteries.

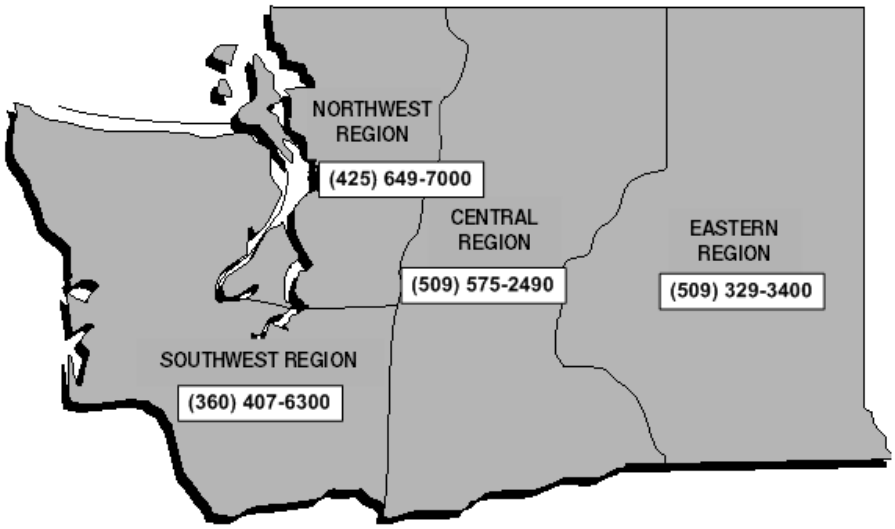
In the past, alkaline batteries designated for their mercury content and as a solid corrosive waste in Washington State. The mercury content in batteries has been decreasing due to changes in manufacturing, but alkaline batteries continue to designate as a solid corrosive waste. A generator may test batteries to determine if they are dangerous waste.

How do I manage household batteries?

Homeowners are not required to manage their batteries as UW, but are strongly encouraged to take them to a household hazardous waste collection facility if available. Another option for rechargeable batteries is to return them to the place of purchase, if the retail store participates in a battery return program. Many retailers participate in a take-back recycling program operated by the Rechargeable Battery Recycling Corporation (RBRC). To find a local participating store, go to the RBRC Web site at http://www.rbrc.org/consumer/index.html.

For More Information

Questions on this topic may be directed to your nearest regional office Dangerous Waste Specialist.



If you need this information in an alternate format, please call the Hazardous Waste and Toxics Reduction Program at 360-407-6700. If you are a person with a speech or hearing impairment, call 711, or 800-833-6388 for TTY.

The Universal Waste Rule for Lamps
WAC 173-303-573(5)

Any business that generates dangerous waste must follow the dangerous waste rules, Chapter 173-303 WAC. In Washington State the Universal Waste Rule allows less burdensome management of the following wastes:

- Batteries *(#98-407.a)*
- Thermostats *(#98-407.b)*
- Lamps *(#98-407.c)*
- Mercury-containing equipment *(#98-407.b)*

Businesses have the choice of managing these wastes as universal waste (UW) or dangerous waste. UW requirements for storage, transportation and collection are less stringent.

This publication focuses on the UW requirements for lamps. Publication number 98-407, *The Universal Waste Rule* provides more details on these requirements and the advantages of UW management.

What types of lamps are considered Universal Waste?

The types of lamps that may be Universal Waste include:

- Fluorescent
- High Intensity Discharge (HID) (e.g., mercury vapor, metal halide, high pressure sodium)
- Compact fluorescent
- Neon[1]
- Any other lamps that are dangerous waste

How can I tell if my lamps are dangerous waste?

The process of determining if a waste is hazardous is called designation. Through EPA test procedures, lamps have been shown to designate as dangerous waste because of their mercury and/or lead content. A generator has three choices when determining if their spent lamps are a dangerous waste:

1. Assume that their lamps are a dangerous waste;
2. Use manufacturer's information, MSDS and other available information to designate by knowledge;
3. Designate by sampling and testing.

[1] "Neon" lamp manufacturers sometimes use gases other than neon, and lamps have been manufactured that contained up to 600 milligrams of mercury per tube.

Certain "green tip" lamps pass the EPA test and are not dangerous waste. Ask your lamp manufacturer or supplier for product testing information that shows these particular lamps are not a dangerous waste.

Some local governments may have landfill bans on disposal of mercury-containing lamps or other mercury-containing items. Check with your local health department, solid waste agency, or landfill for specific requirements, as well as recycling or disposal options.

What are the requirements for Universal Waste management of lamps?

Manage Universal Waste lamps the same as the other Universal Wastes, except for a few specific handling requirements. Because glass bulbs are easily broken, Universal Waste rules require specific handling procedures. Universal waste management requirements for lamps include:

Accumulation start date:

Both used and unused lamps become waste on the date the handler decides to discard them.

Accumulation and dating of Universal Waste lamps:

You can only accumulate lamps for one year from the date they are generated. To document this, the collection container or individual UW lamp is typically marked with the first date of accumulation. An extension to the one year accumulation limit is allowed if the facility needs more time to collect enough items to facilitate proper recovery, treatment, or disposal.

Labeling and Marking:

Clearly label or mark individual lamps or containers with one of the following phrases:

- *Universal Waste – Lamps*
- *Waste Lamps*
- *Used Lamps*

Packaging:

Contain lamps in structurally sound containers such as cardboard boxes or fiber drums. In addition, keep containers closed when not adding lamps.

Clean up procedures:

Immediately clean up broken lamps and store debris in a closed container.

Large Quantity Handlers[2] of Universal Waste (LQHUW)

When a handler exceeds 11,000 pounds (or 2,200 pounds for lamps), they become an LQHUW and are subject to extra requirements, including:

- Notification to Ecology of LQHUW status, and which specific types of UW they manage.
- Tracking type and quantity of universal wastes received and shipped.
- Obtaining a RCRA Site Identification Number.

[2] Handlers are either the original generators of the UW or businesses that receive and consolidate UW from other handlers before shipping to another handler or to a destination facility.

Lamp crushing prohibited:
Lamps cannot be crushed under Universal Waste regulations. Lamp crushing is allowed as a dangerous waste treatment-by-generator activity, but not as a Universal Waste option.

Transporting Universal Waste lamps:
You may self-transport UW lamps, complying with applicable U.S. Department of Transportation regulations. Refer to Ecology publication number 98-407 "The Universal Waste Rule" for details.

Does the rule apply to me?

The following types of businesses may generate dangerous waste lamps and can take advantage of the Universal Waste regulations:

- Regulated generators[3] of dangerous waste (Medium Quantity and Large Quantity Generators)
- Businesses that generate or accumulate dangerous waste lamps in regulated quantities (this category may include commercial building/property owners that maintain the lighting for tenants)
- Businesses that provide collection and management services (e.g., lighting contractors)

A dangerous waste generator has the choice of managing lamps as UW or under the more stringent dangerous waste requirements. In most cases UW management is much easier and the preferable alternative to dangerous waste management. Note that businesses that generate and manage dangerous wastes and UWs are considered both a dangerous waste generator and a UW handler. Regardless if you are a generator or a handler, you are liable for ensuring your waste is properly managed once it leaves your site.

Where do I send them?

Universal wastes may be sent to either another handler (acting as a collection point) or to a destination facility. Another handler could include any business that is already managing UW, government-sponsored collections, or hazardous waste management firms. Businesses that recycle or dispose of UW are called destination facilities. Ultimately, all UW must go to a destination facility. They are subject to dangerous waste regulations for recyclers and hazardous waste disposal facilities. A facility that only accumulates UW would not be a destination facility.

For a list of firms that offer waste management services, visit http://www.ecy.wa.gov/apps/hwtr/hwsd/default.htm.

Why do we care about lamps?

[3] Regulated generators of dangerous waste are those that generate over 220 pounds of dangerous waste per month or batch (or 2.2 pounds of extremely hazardous waste), or accumulate greater than 2,200 pounds of dangerous waste (or 2.2 pounds of extremely hazardous waste) at any time. As a point of reference, 4-four-foot long, linear fluorescent tubes weigh approximately 2.2 pounds. It would take about 400 of those tubes to equal 220 pounds and approximately 4,000 tubes to equal 2,200 pounds.

Nationally, about 680 million lamps are disposed of annually, most to solid waste disposal facilities, including landfills and solid waste incinerators. Fluorescent lamps contain a small amount of mercury which is released when the lamp is broken. During waste handling and disposal, many lamps break, releasing mercury vapor and potentially exposing waste handlers to inhalation of those vapors. Waste incineration (not common in Washington State) of mercury-containing lamps also releases the mercury into the atmosphere. Mercury in the atmosphere is ultimately deposited back to the earth, rivers and lakes. From that point, mercury is then available to enter the food chain and eventually accumulates in fish.

The mercury content in newer fluorescent tubes ranges from 3.5 milligrams to 8 milligrams or more. Some older fluorescent tubes (pre-1999) contain up to 50 milligrams of mercury. HID lamps may contain up to 250 milligrams, depending on the lamp wattage.

Some lamps contain lead in the glass and lead solder in the base. Lead is a toxic metal that may leach from solid waste landfills into the ground water. Manufacturers are eliminating the lead by using non-leaded glass and solders in new lamps.

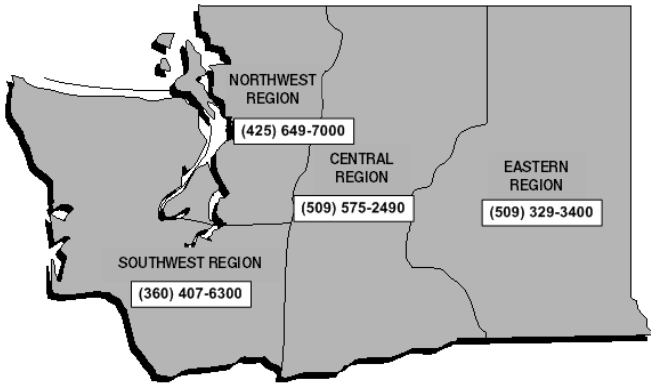
Although fluorescent and HID lamps contain toxic mercury and should be recycled, people are encouraged to continue using them because they use much less electricity and last much longer than other types of lighting. For this reason, fluorescents are a better long-term choice for the environment.

How do I manage lamps at home?

Homeowners are not required to manage their lamps as Universal Waste. They are strongly encouraged to take them to a local household hazardous waste collection facility or other appropriate recycling alternative, if available.

For More Information

Questions on this topic may be directed to your nearest regional office Dangerous Waste Specialist.



If you need this information in an alternate format, please call the Hazardous Waste and Toxics Reduction Program at 360-407-6700. If you are a person with a speech or hearing impairment, call 711, or 800-833-6388 for TTY.

Mercury-containing Equipment
(WAC 173-303-573(3-4))

This publication focuses on the Universal Waste (UW) requirements for mercury-containing equipment. Publication number 98-407, *The Universal Waste Rule* provides more details on these requirements and the advantages of UW management.

How is "mercury-containing equipment" defined?

Mercury-containing equipment is a broad category of UW including any device or part of a device that contains elemental mercury necessary for its operation. Mercury has been used in hundreds of devices at levels ranging from less than a gram up to several pounds. A few examples include:

- ► Thermometers
- ► Barometers
- ► Manometers
- ► Thermostats
- ► Tilt switches
- ► Flame sensors

Mercury-containing equipment does not include:

- Mercury waste generated as a by-product of manufacturing or waste treatment.
- Elemental mercury such as in vials or jewelry containing drops of mercury.
- Dental amalgam.
- Rubber flooring made with mercury.
- Chemical compounds containing mercury (e.g., pharmaceuticals, pesticides, paints, or lab chemicals).
- Intact devices or toys with removable mercury-containing batteries or lamps (batteries and lamps can be removed and handled according to their UW category).

A **mercury-containing thermostat** is defined as a temperature control device that contains metallic mercury in an ampule attached to a bi-metal sensing element. Thermostats are a type of mercury-containing equipment and are managed in the same way, although alternative labeling is permissible.

Accumulation start date

Both used and unused MCE become wastes on the date the handler decides to discard them.

WHY IT MATTERS

Any business that generates dangerous waste must follow the dangerous waste rules, Chapter 173-303 WAC. In Washington State, the Universal Waste Rule allows less burdensome management of these wastes:

- Batteries, *(98-407.a)*
- Mercury-containing equipment *(98-407.c)*
- Lamps *(98-407.c)*

Businesses have the choice of managing these wastes as universal waste or dangerous waste. Universal waste requirements for storage, transportation, and collection are less stringent.

Contact information

Rob Rieck
360-407-6751
Rori461@ecy.wa.gov

Special accommodations

To ask about the availability of this document in a version for the visually impaired, call the Hazardous Waste and Toxics Reduction Program at 360-407-6700. Persons with hearing loss, call 711 for Washington Relay Service. Persons with a speech disability, call 877-833-6341.

Labeling and marking MCE

Label or mark each device or container of devices with one of the following phrases:

- *Universal Waste – Mercury-containing equipment*
- *Waste Mercury-containing equipment*
- *Used Mercury-containing equipment*

Labeling and marking thermostats

As one option, you may label or mark single thermostats or a container of thermostats with one of the following phrases:

- *Universal Waste – Mercury thermostat(s)*
- *Waste Mercury thermostat(s)*
- *Used Mercury thermostat(s)*

Accumulation and dating

You can accumulate MCE for one year from the date they are generated. To document this, the collection container or individual UW device is typically marked with the first date a device is placed in it. An extension to the one-year accumulation limit is allowed if the facility needs more time to collect enough items to facilitate proper recovery, treatment, or disposal.

Performance standards for ampules

Ampules removed from thermostats and other MCE can also be managed as UW. Use a containment system (e.g., plastic tub under the work area) to prevent spills during removal. Store and transport ampules in closed containers and in a manner that avoids breakage.

Leaks

Place leaking ampules or other MCE in an air-tight container.

Mercury in open housing

MCE with mercury in an open housing (e.g., barometers) can be managed as UW following appropriate precautions. The open housing can be removed, sealed airtight and managed the same as ampules.

If not removed, the housing should be sealed prior to transport and the whole device placed in a closed container.

Large Quantity Handlers of Universal Waste (LQHUW)

When a handler exceeds 11,000 pounds (or 2,200 pounds for lamps), they become an LQHUW and are subject to extra requirements, including:

- Notification to Ecology of LQHUW status, and which specific types of UW they manage.
- Tracking type and quantity of universal wastes received and shipped.
- Obtaining a RCRA Site Identification Number.

Transporting UW mercury-containing equipment

You may self-transport UW mercury-containing equipment, complying with applicable U.S. Department of Transportation regulations. Refer to Ecology publication number 98-407 *The Universal Waste Rule* for details.

A dangerous waste generator has the choice of managing MCE as UW or under the more stringent dangerous waste requirements. In most cases UW management is easier and a preferable alternative to dangerous waste management. Note that businesses who generate and manage both dangerous wastes and UWs are considered dangerous waste generators and UW handlers. Regardless if you are a generator or a handler, you are liable for ensuring your waste is managed properly once it leaves your site.

Where do I send them?

Universal wastes may be sent to either another handler (acting as a collection point) or to a destination facility. Another handler could include any business that is already managing UW, government-sponsored collections, or hazardous waste management firms.

Businesses that recycle or dispose of UW are called destination facilities. Ultimately, all UW must go to a destination facility. They are subject to dangerous waste regulations for recyclers and hazardous waste disposal facilities. A facility that only accumulates UW would not be a destination facility.

For a list of firms that offer waste management services, visit www.ecy.wa.gov/apps/hwtr/hwsd/default.htm.

The major thermostat manufacturers set up the Thermostat Recycling Corporation (TRC) to provide recycling of thermostats at participating thermostat wholesale stores. Contractors are encouraged to return old thermostats to the store. Some stores will accept used thermostats from homeowners and other types of businesses. Participating stores can be located at http://www.thermostat-recycle.org/.

How do I manage household MCE?

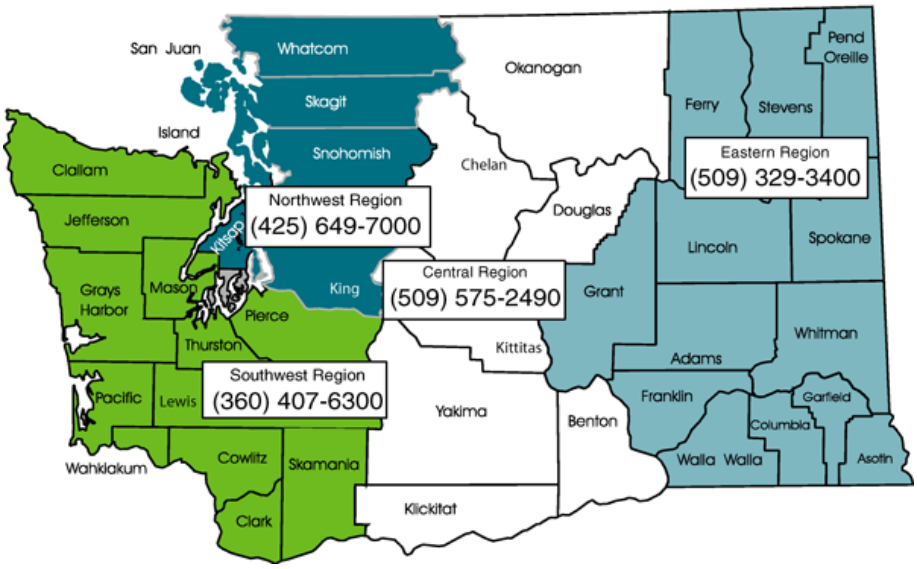
Homeowners are not required to manage their thermostats and MCE as UW, but are strongly encouraged to take them to a local household hazardous waste collection facility if available.

Why is MCE hazardous?

Mercury-containing devices can contain high levels of mercury that makes them a dangerous waste when discarded. Thermostats and thermometers are one of the largest sources of mercury in landfills. When thrown into the garbage, the ampule or glass can break, spilling the mercury. Some MCE can break while in use, spreading mercury droplets and contaminating the area. Because mercury is very toxic to humans and wildlife, it is important to prevent releases to the environment. To avoid future liability, replace mercury-containing devices with non-mercury alternatives.

Department of Ecology Regions

http://www.ecy.wa.gov/programs/hwtr



ATTACHMENT 4

STANDARD OPERATING PROCEDURES

This page intentionally left blank.

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

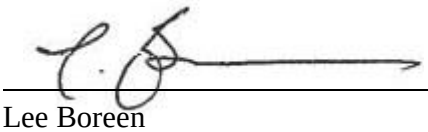
ISSUE AND USE OF RADIATION WORK PERMITS

NAVSTA PS-Tt-001

Approved By:

Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date



Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

This procedure describes the circumstances when a Radiation Work Permit (RWP) is required and addresses the requirements for planning, developing, issuing, using, modifying, and terminating RWPs. The RWP provides a complete document addressing existing radiological conditions, work scope, radiological limitations, specific protective requirements, as low as reasonably achievable (ALARA) considerations, and instructions to radiological support personnel. Adherence to this procedure will provide reasonable assurance that personnel exposures will be below specified limits, personnel will remain free of contamination, and contamination will not be spread beyond the designated contaminated area.

2.0 SCOPE

This procedure shall be implemented to initiate an RWP for the following jobs:
1. Personnel entry into a contaminated or potentially contaminated area.
2. Personnel entry into a radiation area.
3. Personnel entry into a radiologically controlled area.
4. Personnel entry into an area where air concentrations could exceed 10 percent of the derived air concentration (DAC).
5. At the discretion of the Radiation Safety Officer (RSO) or representative.

This procedure describes the radiological surveys required to generate an RWP and provides guidelines for specific protective measures required based upon the radiological conditions in the work area.

In addition to RWPs written to cover specific work tasks, general RWPs (GRWPs) may be created for tasks such as tours or surveys/remediation activities in areas in which a worker is not expected to receive 100 mrem annual total effective dose equivalent. In such cases, the GRWP should not span a time period of greater than 6 months. General RWPs do not have the requirements for an Access Log (Attachment 2).

3.0 MAINTENANCE

The RSO is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer - The RSO is responsible for implementation and compliance with this Standard Operating Procedure (SOP) during project operations and providing safety briefings to personnel working with radioactive materials. The RSO will conduct periodic reviews, via personal observation of activities carried out under RWPs and other job-specific guidance, to

ensure adherence to the requirements of these documents. In instances where the RWP or job-specific guidance documents are not being followed, the RSO or designee shall stop the work.

The RSO or designee shall review and approve RWPs generated by this procedure and ensure that RWPs generated per this procedure are maintained in project files.

Radiation Safety Officer Representative (RSOR) - The RSOR or designee shall be on-site during radiological operations. The RSOR is responsible for the assignment of personnel that will perform the tasks required by this SOP, for the implementation and monitoring of on-site radiological training, control of radioactive material, dosimetry coverage of radiological support personnel, and to ensure that personnel under their cognizance observe proper precautions. The RSOR is responsible for ensuring that RWPs are properly prepared and completed as required.

Radiological Task Supervisor - The Radiological Task Supervisor (RTS) shall be responsible for supervising personnel that will perform the tasks in accordance with the RWPs. The RTS will monitor work for compliance with RWPs, SOPs and applicable local, state, and federal statutes. The RTS is responsible for the maintenance of tools, equipment, and vehicles that are to be used on the site during work activities.

Radiological Control Technician - The Radiological Control Technician (RCT) shall be responsible for the performance of the requirements of this SOP and documentation of work performed, including interpretation and verification of data. The RCT shall ensure compliance with this and any other referenced procedure. RCTs may assist in training responsibilities as needed. The RCTs shall be aware of changing radiological conditions, which may require different levels of personal protective equipment or respiratory protection and be responsible for enforcing the provisions of the RWP and ALARA philosophy.

Radiological Support Personnel - Radiological support personnel are equipment operators and laborers performing field activities in support of survey activities. Radiological support personnel are required to read, understand, sign, and comply with the provisions of the RWP.

Site Health and Safety Specialist – For purposes of this procedure, the Site Health and Safety Specialist (SHSS) shall be responsible for reviewing draft RWPs to ensure that relevant non-radiological concerns are addressed.

5.0 DEFINITIONS AND ABBREVIATIONS

Airborne Radioactivity Area (ARA) - A room, enclosure, or area in which radioactive material is dispersed in the air in the form of dust, fumes, particulates, mists, vapors, or gases and where the concentration of the dispersed radioactive materials is in excess of:

- The derived air concentrations (DACs) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of CFR.

- Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

Contaminated Area (CA) - Any area where removable surface contamination levels exceed 20 percent of the contamination limits provided in Attachment 1 (Table 1).

General Radiation Work Permit (GRWP) – A Radiation Work Permit created for tasks such as tours or surveys/remediation activities in areas in which a worker is not expected to receive in excess of 100 mrem annual total effective dose equivalent. These tasks are typically ongoing, for routine tasks and require minimal anti-contamination personal protection equipment.

Non-Workers - Any persons entering an area covered by a work-specific RWP or a GRWP whose sole purpose is for observation or other tasks, not directly related to the work outlined in the RWP. Individuals that are escorted inside an area covered by a job-specific RWP are exempt from the requirements of this procedure. Non-Workers are also not required to log in and out on RWP Access Logs.

Radiation Area (RA) - Any area accessible to personnel in which there exists ionizing radiation at exposure rates such that an individual could receive a deep dose equivalent (DDE) in excess of 5 millirem (mrem) in 1 hour at 30 centimeters (cm) from the radiation source or from any surface that the radiation penetrates.

Radiologically Controlled Area (RCA) – An area containing radioactive materials (in excess of the levels provided in Table 1 of Standard Operating Procedure NAVSTA PS-Tt-007, *Radiologically Controlled Areas – Posting and Access Control*) to which access is controlled to protect individuals from exposure to contamination and ionizing radiation.

Specific Radiation Work Permit (SRWP) – A Radiation Work Permit created for tasks in areas in which a worker could reasonably receive in excess of 100 mrem annual total effective dose equivalent (based on current radiological surveys) and/or contamination areas and/or airborne radioactivity areas. These tasks are typically finite in duration (less than one month), for non-routine tasks and require additional anti-contamination personal protection equipment and/or monitoring.

Total Effective Dose Equivalent (TEDE) - TEDE is the sum of the DDE (external dose) and the committed effective dose equivalent (internal dose).

6.0 PROCEDURE DETAILS

6.1 GENERAL

6.1.1 CRITERIA FOR INITIATING RADIATION WORK PERMIT

An RWP is required when entering radiologically impacted areas (i.e., RCAs, RMAs, RAs, CAs, airborne radioactivity areas, underground RMAs).

6.1.2 PLANNING AND PREREQUISITES

6.1.2.1 Planning the RWP

The RSOR, or designee, initiates the RWP process by filling in the General Information section of the RWP. The accepted form to use for an RWP is included as Attachment 4 of this document. The RSOR, or designee, enters the effective date (date the RWP was initiated) and the expiration date that will correspond to the estimated completion date for the project.

The RSOR or RTS completes the Task section of the RWP. This includes an estimate of the number of personnel required for each task and the number of personnel-hours that will be spent inside an RCA. A detailed description is encouraged but not required and can be attached to the RWP. Work performed in areas with different radiological conditions should be listed as different tasks. This may not become apparent until after the surveys performed to support preparing the RWP are completed.

The RSOR or designee:

- Obtains and reviews any previous surveys performed in the work area.
- Obtains all information available on the identity, form, and quantities of radionuclides present in the work area.
- Reviews facility drawings, if available, to determine ventilation flows, component and equipment layouts, and building structures, which can be used for contamination barriers.

The RTS responsible for the work meets with the RSOR, or designee, to discuss the nature of the work to be performed, the specific components or equipment to be worked on, the positions the personnel may take to perform the work, the possibility of releasing radioactive contamination during the work activities, and the potential for changing radiation exposure rates as work progresses.

The RSOR, or designee, selects the necessary instrumentation, equipment and protective clothing to perform surveys in the work area. If contamination is expected in the work area, equipment to be taken into the work area may be wrapped to prevent contamination of equipment.

If anticipated contamination levels are above the limits given in Table 1 (Attachment 1) for classification of an area as a contaminated area, contamination controls will be established before entry into the area to prevent the spread of contamination upon exiting.

6.1.2.2 The RWP Pre-job Survey

Safety hazards that may be encountered during the work are evaluated (confined space entry, electric equipment or mechanical equipment requiring lock-out tags, falling objects, bumping hazards, slippery surfaces, fire hazards, etc.). An analysis of each hazard and the precautions to be taken shall be documented and provided to personnel prior to entry into the area.

The RCT collects radiation exposure rates in the area where the personnel will be positioned during work activities, as well as adjacent areas. A route to the work area is established. Readings are recorded on survey forms as specified in procedure NAVSTA PS-Tt-003, *Radiation and Contamination Surveys*.

Swipe samples are collected from the work area, adjacent areas, and along the route to the work area in sufficient quantity to adequately design work controls to maintain exposures ALARA. RCTs will rely on their professional experience or consultation with the RSOR, or designee, to determine what constitutes "sufficient quantity." Swipe samples and air samples collected in the area are then processed and recorded on survey forms, as specified in procedure NAVSTA PS-Tt-003, *Radiation and Contamination Surveys*.

The issuance of an RWP for work in an ARA will require air sampling to be done as part of the RWP. Air sampling is conducted in accordance with NAVSTA PS-Tt-005, *Air Sampling and Sample Analysis*.

An individual assigned by the RSOR (i.e., the RCT who surveyed the work area and obtained information from prior surveys, when available) records the exposure rates measured during the survey of work area on survey forms as specified in procedure NAVSTA PS-Tt-003, *Radiation and Contamination Surveys*.

6.2 PROCEDURE PROCESS

6.2.1 SPECIFYING WORKER AND WORKSITE REQUIREMENTS

Based on the data obtained from the pre-job survey and factoring in anticipated contamination conditions in the area, the RTS determines the quantities to specify in the Radiological Limits section of the RWP. Limits should be specified as an order of magnitude bound (i.e., whole-body exposure < 10 mrem/hour) that would not be expected to be exceeded under normal working conditions. Space is provided for clarifying remarks or other specific points of note. The radiological limits will govern the work to be done under the RWP. If, at any point during

the work, the limits are known to be exceeded, then work must cease and the RWP must be modified or a new RWP must be issued to reflect the current radiological conditions. A well-selected limit will be one general enough to avoid unnecessary stoppages of work while still protecting worker safety per the ALARA philosophy.

Next, the RTS or RSOR determines the types of protective clothing required to be used by personnel performing prescribed tasks, the respiratory protection requirements, dosimetry requirements, and monitoring requirements. The requirements are indicated under the protection requirements section of the RWP. Finally, any additional training requirements for personnel and the need for ALARA briefings or reviews are noted on the RWP.

Determinations of protection requirements are to be performed by the RTS or RSOR using their professional judgment and in accordance with industry standard practices and appropriate regulatory guidelines. Air monitoring is required if it is likely that airborne contamination may be present or created (i.e., during excavation and demolition) during work activities. Work activities will be stopped if the concentrations of airborne contaminants exceed 10 percent of the DAC.

6.2.2 SPECIAL INSTRUCTIONS

Special instructions associated with personal protective clothing, dosimetry, monitoring and inspection, respiratory protection, training, or ALARA are indicated in this section of the RWP.

6.2.3 REVIEW AND APPROVALS

The RSOR and SHSS, or designees, as a minimum, shall approve the RWP prior to the work starting. The RSOR shall review the sections of the draft RWP completed by the RCTS for completeness and accuracy. In cases where the RSOR has prepared the draft sections of the RWP prescribed for the RTS, instead of the RTS, then the RSO shall review and approve the RWP. The SHSS shall verify that relevant non-radiological safety considerations are addressed. When the non-radiological concerns of the SHSS have been adequately addressed, the RSOR will approve the RWP and forward to the RSO for review and approval.

RASO shall be notified if any of the following atypical worksite conditions are anticipated:

- An individual TEDE exceeding 500 mrem
- The collective TEDE for the job exceeding 1 rem
- Individual airborne exposures exceeding 10 DAC-hours in a 7-day period
- General area exposure rates exceeding 5 mrem/hour
- Contamination levels exceeding 10 times the limits requiring classification of an area as a CA

In cases where the RASO must be notified, the RSO, with concurrence from the RASO, must approve the RWP prior to work.

The check boxes in the approval section will be marked to indicate which of the approvers is required for each particular RWP. Any mandatory approver may suggest changes to the draft RWP prior to final approval.

6.2.4 USING THE RADIATION WORK PERMIT

A pre-job briefing is held with the individuals performing the work described in the RWP. The following topics are discussed in the pre-job briefing:

- Complete descriptions of the work tasks to be performed and method to minimize exposures to radiation and contamination while performing these work tasks.
- Discussions of the radiation, contamination, and airborne radioactive materials in the work area and situations which could result in increased levels of these components.
- Health and safety concerns which could be encountered during work activities.
- Emergency procedures and responsibilities.
- Discussions of the protective equipment requirements and the monitoring requirements.

In the case of an SRWP, the RSOR compiles the current year dose for the individuals performing RWP work to verify that the radiation exposure received during the work activities will not result in the individuals' dose exceeding the administrative limits specified in the Radiological Protection Plan. The individuals' current radiation exposures will be listed on Radiation Work Permit Authorization Log (Attachment 3).

Each individual entering the RWP work area is required to understand the RWP and sign the RWP Authorization Log, indicating that the individual understands the provisions of the RWP, is aware of his/her current year dose, and will comply with the RWP requirements.

An RWP that covers work to be performed at a field site or in a building shall have an Access Log (Attachment 2) appended to the RWP. RWPs that cover general work areas are not required to have an access log, but an access log may be appended to the RWP if desired.

In cases where an Access Log is used, the individual- logs the time that they entered the work area, along with the reading on the individuals Pocket Ion Chamber (PIC) or Direct Reading Dosimeter (DRD), if worn. The individual also indicates if the individual wore a respirator during the work activities. It should be noted that non-workers, as defined in Section 5.0, are not required to sign the Access Log.

When an individual, who signed in on an RWP Access Log, exits the work area, they must log the time that they leave the area and the individual's DRD reading, if worn. If the individual returns to the work area, another signature entry (and corresponding line entries) must be made on the RWP Access Log.

As previously noted, if the radiological limits listed on the RWP are exceeded at any point during a prescribed work task, then all work shall be stopped until the RWP can be modified to address the over-limit condition, or a new RWP is issued.

6.2.5 MODIFYING THE RADIATION WORK PERMIT

In the event of changes to the conditions or scope of the work that do not justify the generation of a new RWP, modifications to the RWP may be made by the RSOR, or designee with concurrence of the RSO. No more than two modifications can be made to an RWP before a new RWP must be issued. Modifications to the RWPs will be reviewed and approved in accordance with the initial requirements, as specified in Section 6.2.3.

To modify the RWP, each change is made with a single line cross out of the text or item. The RSOR or designee must initial and date adjacent to each change.

The RSOR or designee must communicate all changes to the individuals working under the RWP.

6.2.6 TERMINATING THE RADIATION WORK PERMIT

The RWP is terminated when the end date of the RWP is reached or can be terminated by one of the following reasons:

- The job has been completed.
- There is a significant change in the scope of work.
- There is a significant change in the radiological conditions.
- The RWP is revised.

When the RWP is terminated before the end date, a single line is drawn through the end date and a new end date is recorded in its place. The person terminating the RWP will initial adjacent to the change. Extension of the end date of the RWP must be done per the change procedure noted in the previous section. The RWP can be terminated by the RSOR, RSO, or designee. As part of the termination of an RWP, the Post-job Radiological Conditions and Closeout Review sections of the RWP shall be completed.

To complete the Post-job Radiological Conditions section, the RCT shall conduct a survey of the worksite governed by the RWP. This survey should be conducted in a manner similar to the pre-

job survey and should include determination of the current measurements for all quantities obtained in the pre-job survey. In addition, if personnel monitoring was in effect during work under the RWP and/or an individual was found to have contamination above the monitoring limits, then the appropriate checkbox should be marked.

At a minimum, the closeout review will be conducted by the RSOR. In cases where the RSO was required to be an approver due to atypical conditions listed in Section 6.2.3, then the RSO shall also perform the closeout review. As part of the closeout review, the reviewer(s) shall verify that associated records for the RWP are noted on the RWP form and that they are present in the project files. Reviewers shall also determine if there were any lessons learned that might be of value to future work to be performed on site. If so, then a "lessons learned" synopsis shall be written and communicated/incorporated to project personnel.

7.0 RECORDS

Radiation Work Permit Access Log

Radiation Work Permit Authorization Log

Radiation Work Permit

8.0 REFERENCES

Number	***Title***
NAVSTA PS-Tt-003	*Radiation and Contamination Surveys*
NAVSTA PS-Tt-005	*Air Sampling and Sample Analysis*
Regulatory Guide 1.86	*U.S. Atomic Energy Commission Termination of Operating Licenses for Nuclear Reactors*

9.0 ATTACHMENTS

Forms provided in this section illustrate the minimum requirements for their respective subject matter. Alternative documents may be used providing the information is presented in a clear and concise manner and the content meets or exceeds the information required to complete these documents.

Attachment 1 – Table 1 Contamination Limits Table

Attachment 2 – Radiation Work Permit Access Log

Attachment 3 – Radiation Work Permit Authorization Log

Attachment 4 – Radiation Work Permit

ATTACHMENT 1

TABLE 1 - CONTAMINATION LIMITS TABLE

	Surfaces			Soil		Sludge	
Radionuclide	Equipment, Waste (dpm/100 cm^2)[a]	Structures (dpm/100 cm^2)[b]	Residual Dose (mrem/y)[c]	Residential (pCi/g)[d]	Residual Dose (mrem/y)[c]	Residential (pCi/g)[d]	Residual Dose (mrem/y)[c]
Cesium-137	5,000	5,000	1.72	12.5	25	270.7	25
Radium-226	100	100	0.612	1.6	25	6.1	25
Strontium-90	1,000	1,000	0.685	6.2	25	17.3	25

Notes:

Criteria for other nuclides will be listed in TSPs, if needed.

[a] These limits are based on AEC Regulatory Guide 1.86 (1974). Limits for removable surface activity are 20 percent of these values.

[b] These limits are based on 25 mrem/y using RESRAD-Build Version 3.3 or Regulatory Guide 1.86, whichever is lower.

[c] The resulting dose is based on modeling using RESRAD-Build Version 3.3 or RESRAD Version 6.3.

[d] The off-site laboratory will ensure that the MDA meets the listed release criteria by increasing sample size or counting time as necessary. The MDA is defined as the lowest net response level, in counts, that can be seen with a fixed level of certainty, customarily 95 percent. The MDA is calculated per sample by considering background counts, amount of sample used, and counting time.

Abbreviations and Acronyms:

AEC – Atomic Energy Commission
cm^2 – square centimeter
dpm – disintegrations per minute
EPA – U.S. Environmental Protection Agency
MDA – minimum detectable activity
mrem/y – millirems per year
pCi/g – picocuries per gram
TSP – Task-specific Plan
.

ATTACHMENT 2 - RADIATION WORK PERMIT EXCLUSION ZONE ACCESS LOG

RWP NUMBER: _____ **REVISION:** _____ **DATE:** _____

WORK LOCATION:_____ **START DATE:**_____ **END DATE:** _____
(Field Area or Bldg #)

Printed Name	Signature	Emp ID # (Last 4 SSN)	Time In (1)	Time Out (1)	Time In (2)	Time Out (2)	Time In (3)	Time Out (3)	Time In (4)	Time Out (4)	Time In (5)	Time Out (5)	PIC/DRD Number	DRD Reading		Resp (√)
														In	Out	

ATTACHMENT 3 – RADIATION WORK PERMIT AUTHORIZATION LOG

RWP NUMBER: _____ **REVISION:** _____ **DATE:** _____

WORK LOCATION: _____ **START DATE:** _____ **END DATE:** _____

Worker Name	Employee ID Number	Current year TEDE (mrem)	*Signature	RCT Authorization	Date

* By my signature, I indicate that I have read, understand, and will comply with all requirements of this RWP.

ATTACHMENT 4 – RADIATION WORK PERMIT

Tetra Tech EC, Inc.

RSO USE ONLY	
Permit Number	
Effective Date	Expiration Date

RADIOLOGICAL WORK PERMIT

GENERAL INFORMATION (to be completed by the Requestor)				
Requested by (Name & Project)	Date	Phone No.	Site Mailing Address	
Work Location	Work Area	Building/Site	Extent	Room No.

Work Plan	Health & Safety Plan	Contract Number	Expected Start Date	Expected End Date

Tasks to be performed inside an RCA *(add attachment if necessary)*	Estimated No. Personnel	Estimated No. Personnel-hours

RADIOLOGICAL LIMITS (to be completed by the RCT)

☐ Anticipated radiological conditions ☐ See Attached Map

	Surface Contamination (dpm/100 cm sq)			**External Dose Rate (mrem/hr in work area)**	
	Direct	Swipe	LAS (Large Area Swipe)		
Alpha				Beta + gamma	
Beta/gamma				Neutron	
Tritium				Total (b + g + n)	

Airborne Radioactivity

Radionuclide(s) DAC ☐ Anticipated or ☐ Measured

Completed by	Name	Signature	ID Number	Date

ALARA/RADIOLOGICAL PROTECTION REQUIREMENTS (to be completed by RCT)

Protective Clothing Requirements

☐ None ☐ Rubber Overshoes ☐ Double Coveralls

☐ Lab Coat ☐ Skull Cap ☐ Hood ☐ Double Gloves ☐ Plastic Coverall

☐ Gloves ☐ Booties ☐ Single Coverall ☐ Double Booties ☐ Tape Openings

☐ Other: _____

Respiratory Requirements

☐ None ☐ Combination cartridge* ☐ Chemical cartridge*

☐ Powered Air Purifying Respirator ☐ Ventilation ☐ Air Line Respirator* ☐ SCBA*

☐ Negative Pressure Respirator ☐ Supplied air suit* ☐ Bubble Hood* **** Requires Health & Safety approval***

☐ Other: _____

Dosimetry Requirements

☐ None ☐ WB dosimeter ☐ Supplemental dosimeter

☐ TLD finger rings ☐ Special neutron dosimetry ☐ Pu access list ☐ Alarming dosimeter

☐ Bioassay sample ☐ Whole-body count ☐ Accident dosimeter ☐ Nasal swipes

☐ Other: _____

Monitoring Requirements

☐ None ☐ Notify RCT before job starts

☐ Intermittent coverage ☐ Personnel before leaving job ☐ Equipment and tools before removal

☐ Continuous coverage ☐ RCT monitor doffing of PCs ☐ Air monitoring

☐ Self-frisking ☐ Other: _____

Additional Training Requirements _____

☐ ALARA Pre-job briefing ☐ ALARA review (see attachments)

Completed by RCT Name Signature Employee ID Number Date

☐ Completed

SPECIAL INSTRUCTIONS (to be completed by the RCT)

Special Instructions:

Completed by RCT Name Signature ID Number Date

☐ Completed

APPROVALS

		Name	Signature	ID Number	Date
1. ☐	***RSOR***				
2. ☐	***RSO***				
3. ☐ ☐	***SHSS***	Names	Signatures	ID Numbers	Date

POST-JOB RADIOLOGICAL CONDITIONS (to be completed by the RCT)

Measured Radiological Conditions ***(Record all readings as highest / general area)*** ☐ See attached map

	Surface Contamination (dpm 100 sq cm)			External Dose Rate
	Direct	Swipe	LAS (large area swipe)	(mrem/hr in work area)
Alpha				Beta + gamma
Beta/gamma				Neutron
Tritium				Total (b + g + n)

Airborne Radioactivity

DAC _____ ☐ Estimated or

Isotope ☐ Measured

Survey of Personnel Leaving Job Site

☐ Personnel contaminated above applicable limits

(If yes, attach the Radiological Incident Report)

Completed by RCT	Name	Signature	ID Number	Date
☐ Completed				

REVIEW

Associated reports for this job ***(indicate the ones that apply):***

☐ CAM Results	☐ Nasal swipe data	☐ RWP acknowledgement log
☐ Job-specific air monitoring	☐ Bioassay sample(s)	☐ Dose tracking report
☐ Pre-job survey data	☐ Whole Body Count(s)	☐ Radiological occurrence/incident report
☐ Post-job survey data	☐ Wound count	☐ ALARA Pre-job briefing
☐ Finger ring data	☐ Skin contamination	☐ Formal ALARA review
☐ Special dosimetry results	☐ Personal clothing survey	☐
☐ Other: _____		

☐ Lessons Learned (If Yes, then briefly explain. Add attachment(s) if necessary)

Reviewed by RCT	Name	Signature	ID Number	Date
☐ Reviewed				

Reviewed by RSO (or designee)	Name	Signature	ID Number	Date

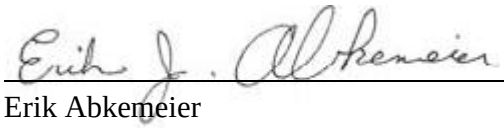
FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

PROJECT DOSIMETRY

NAVSTA PS-Tt-002

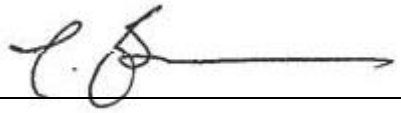
Approved By:



July 10, 2013

Erik Abkemeier
Radiation Safety Officer

Date



July 10, 2013

Lee Boreen
Project Manager

Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

This procedure provides specific guidelines for the control of project dosimetry, occupational radiation exposure records, and maintenance of a personnel exposure history for all Tetra Tech EC, Inc. (TtEC) full-time and temporary project personnel, subcontractors, visitors, and groups for whom monitoring is required.

2.0 SCOPE

Radiation monitoring shall be conducted when it is likely that any individual will exceed 10 percent of the annual limits specified in 10 Code of Federal Regulations (CFR) 20.

Subcontractors may use their procedures for conditions or activities not covered by this procedure following approval by TtEC.

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer - The RSO is responsible for oversight of project dosimetry in consultation with the Project Manager. The RSO is also responsible for assigning dose for derived air concentration (DAC)-hrs or bioassay results.

Radiological Safety Officer Representative– The Radiation Safety Officer Representative (RSOR) is responsible for the implementation of this procedure. This requires conducting periodic reviews of the adherence of personnel to the requirements of this procedure and ensuring that the technicians have appropriate knowledge, training, and experience to perform the requirements of this procedure.

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) is responsible for ensuring that the Radiological Control Technicians (RCTs) implement and use this procedure. The RTS will ensure that personnel under their cognizance observe proper precautions when using this procedure.

Radiological Control Technicians - RCTs are responsible for performing surveys and ensuring the proper use of monitoring devices by workers.

Personnel - All personnel are required to wear their issued dosimetry as required by the applicable Radiation Work Permit (RWP) and to maintain their exposure to radiation as low as reasonably achievable (ALARA).

5.0 DEFINITIONS AND ABBREVIATIONS

Bioassay - The determination of kinds, quantities or concentrations and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

Committed Dose Equivalent (CDE) - The dose equivalent to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent (CEDE) - The sum of the products of all organs or tissues with CDE and their respective weighting factors.

Control Badge/Dosimeter – A dosimeter, identical to those issued to personnel, that is used to monitor exposure in transit and in the storage location. Any dose received by a control badge is subtracted from dose assigned to dosimeters associated with that control badge.

Deep Dose Equivalent (DDE) – The dose equivalent of external whole-body exposure at a tissue depth of 1 centimeter (cm) [1,000 milligrams per square centimeter (mg/cm^2)]

Derived Air Concentration (DAC) - The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one annual limit intake (ALI). DAC values are given in Table 1, Column 3, of Appendix B of 10 CFR 20 (1-92).

.

Direct Reading Dosimeter (**DRD)** – A self-indicating, integrating radiation exposure measuring device such as a pocket ion chamber.

Dose - The deposition of energy in matter. Dose applies to energy deposited in material by any type of ionizing radiation.

Dose equivalent - The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dosimeter – A device, from a National Voluntary Laboratory Accreditation Program (NVLAP)-certified vendor, worn on the body to measure the radiation dose received by the exposed individual.

Lens Dose Equivalent (LDE) – The dose equivalent, from external exposure, to the lens of the eye taken at a tissue depth of 0.3 cm (300 mg/cm^2)

Monitoring (radiation monitoring, radiation protection monitoring) – the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

Quality Factor – The factor that is radiation-dependent and identifies the relative biological effectiveness of a radiation type and energy. The quality factor is multiplied times the dose to yield the dose equivalent.

Rad (Radiation Absorbed Dose) - The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (The SI unit for absorbed dose is the Gray [Gy] 1 Rad = 0.01 Gy).

Radiation Area (RA) – Any area accessible to personnel in which there exists ionizing radiation at exposure rates such that an individual could receive a DDE in excess of 5 millirem (mrem) in 1 hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

Radiologically Controlled Area (RCA) – An area containing radioactive materials (in excess of the levels provided in Table 1 of SOP NAVSTA PS-Tt-007, *Radiologically Controlled Areas – Posting and Access Control*) to which access is controlled to protect individuals from exposure to ionizing radiation.

Rem (Roentgen Equivalent Man) – The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (The SI unit for dose equivalent is Sv 1 rem=0.01 Sv).

Shallow Dose Equivalent (SDE) (also known as skin dose) – The dose equivalent, from external exposure, to the skin of the whole body or the skin of an extremity at a tissue depth of 0.007 cm (7 mg/cm^2).

Total Effective Dose Equivalent (TEDE) – The sum of the DDE (external dose) and the CEDE (internal dose).

6.0 PROCEDURE DETAILS

6.1 GENERAL

6.1.1 DISCUSSION

Personnel who could potentially receive 10 percent or more of the permissible legal limit for external radiation exposure are required by 10 CFR 20.1502 to be monitored for occupational exposure. In the interests of ALARA, TtEC personnel and TtEC subcontractors who work in an RCA will be issued and required to wear, at a minimum,

a whole body external dosimeter. Personnel required to work in areas with dose rates in excess of 5 mrem/hour, will be issued a direct reading dosimeter in addition to their whole body external dosimeter.

Prior to commencement of fieldwork, the RSOR and RSO will determine the appropriate radiation monitoring dosimetry required based on the radionuclides and activity present at the work area.

6.1.2 PLANNING AND PREREQUISITES

6.1.2.1 Personnel Training

Only personnel who have received appropriate training will be issued dosimetry.

6.1.2.2 Exposure Limits

Nuclear Regulatory Commission (NRC) radiation worker limits:

Whole Body (TEDE)	5 rem/calendar year (yr)
Eye Dose Equivalent	15 rem/yr
Skin Dose Equivalent	50 rem/yr
Organ Dose (CEDE)	50 rem/yr
Embryo/Fetus	0.5 rem/pregnancy

Former Naval Station Puget Sound (NAVSTA PS) Administrative control radiation worker limits:

Whole Body (TEDE)	0.5 rem/yr
Eye Dose Equivalent	1.5 rem/yr
Skin Dose Equivalent	5 rem/yr
Organ Dose (CEDE)	5 rem/yr
Embryo/Fetus	0.05 rem/pregnancy

The RSO, or designee, may approve, where appropriate, exposure above the administrative control limits.

NRC general public exposure limits:

100 mrem/calendar year not to exceed 2 mrem in an hour.

6.1.2.3 Dosimetry Storage

When not in use, the dosimetry shall be stored in a low-background area inside the project main office or in other designated storage locations. A control dosimeter shall be kept where the dosimeters are stored when they are not in use. Dosimeters that have not been issued shall also be kept in this storage location whenever possible. If the dosimeters that have not been issued are stored in a different location and/or there is more than one storage location for dosimeters when they are not being worn, each location shall have a control badge.

6.1.2.4 Cumulative Occupational Dose History

The RSO shall obtain a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure, that discloses the nature and the amount of any occupational dose that the individual may have received during the current year. This dose history will be recorded on NRC Form 4 (Attachment 1) or equivalent.

6.1.2.5 Occupational Dose Report

The RSO shall maintain records of doses received by individuals for whom monitoring was required by 10 CFR 20.1502, including records of doses received during planned special exposures, accidents, and emergency conditions. This dose record will be reported on NRC Form 5 (Attachment 2) or equivalent.

The RSO shall annually prepare a report of the doses received by individuals for whom monitoring was required by 10 CFR 20.1502 and provide this report to the individuals. This report will be provided on NRC Form 5 (Attachment 2) or equivalent.

6.2 PROCEDURE PROCESS

6.2.1 EXTERNAL DOSIMETRY

NVLAP-approved dosimeters are the permanent record of a radiation worker’s occupational exposure. TtEC personnel and TtEC subcontractors who work in an RCA will be issued and required to wear, at a minimum, a dosimeter.

The individual’s name, issue date, and date of return will be recorded on the Dosimetry Issue Log (Attachment 3) or equivalent.

Personnel issued dosimetry will wear the dosimetry whenever they are working in an RCA .

Personnel shall wear a dosimeter for no more than 3 months, or the duration of the project, whichever is shortest. The monitoring period may be shortened or extended at the discretion of the RSO.

Dosimeters that monitor whole-body DDE shall be worn on the front torso in the region of the torso expected to receive the highest dose. In cases where other areas of the body may receive a higher dose, the RSO shall evaluate and formally require (by specification on the RWP) that the whole-body dosimetry be worn at that body location.

Extremity dosimetry shall be issued when necessary as described by the site-specific RWP.

It is the responsibility of project personnel to return their dosimetry to the RSO at the end of each monitoring period or at the termination of employment.

Dosimetry and any control badges/dosimeters shall be returned in one shipment to the vendor for processing, at the end of each monitoring period.

6.2.2 DIRECT READING DOSIMETERS

Personnel working in an RCA may be issued a direct reading dosimeter (DRD). DRDs may either be issued for an individual or group depending on the type and duration of work to be performed. The RSO, or designee, will determine if it will be necessary to issue individual or group DRDs. If pocket ion chambers are used for general radiation work, they will have a range of response of zero to 200 millirem.

6.2.3 VISITORS/GROUP MONITORING

Visitors are any persons touring or visiting an RCA on an infrequent basis, are escorted while in the restricted area, and do not perform or supervise hands-on work.

A visitor may be escorted into a posted RCA without dosimetry, provided that:

- There will be no entries into radiation areas, surface contamination areas, or airborne contamination areas.
- They remain with an escort who has been issued dosimetry.

6.2.4 LOST, DAMAGED, AND QUESTIONABLE DOSIMETRY OR IMPROPERLY READING DRD

In the event of a lost, damaged, or questionable dosimeter or DRD or improperly reading DRD, the individual will exit the RCA immediately and notify the RSOR, or designee. A lost, damaged, or questionable dosimetry report (see Attachment 4) will be completed and filed in the individual's exposure file. The dose received while the individual was in an exposure situation must be estimated. The estimate of the dose

received by an individual may be made based on: 1) dose rates and time in the work area, 2) typical dose received on the type of job, or 3) the dose received by another person during the same type of work and stay time in the same area.

In the case of a lost, damaged, or improperly reading DRD, the RSO may deem it necessary to send the individual's personal dosimeter in for immediate processing. The dose determined shall be added to the dose record at the discretion of the RSO, or designee. The RSO, or designee, shall review, approve, and maintain all completed dose estimates.

In the event of multiple occurrences, the RSO shall be notified immediately.

6.2.5 INTERNAL DOSIMETRY

6.2.5.1 DAC-Hr Tracking

Air sampling results are used by the RSO to calculate DAC-hrs of exposure for an exposed worker. If an individual is exposed to airborne radioactivity that is > 1 DAC-hr but ≤ 10 DAC-hrs in any consecutive 7-day period, then the DAC-hr estimate is converted to dose equivalent at the rate of 2.5 mrem per DAC-hr for the most limiting isotope of concern. The RSO shall document all such calculations and a copy of this document shall be placed in the worker's exposure file. Notifications will be made to the Radiological Affairs Support Office (RASO).

6.2.5.2 Bioassay

A bioassay shall be performed whenever personnel have been, or are expected to be exposed to >10 DAC-hrs in any consecutive 7-day period. This should be based on air sampling data, accident conditions, external contamination, or other conditions that indicate an exposure of >10 DAC-hrs might have occurred.

If a worker returns a verified positive bioassay, the RSO shall assign an internal dose equivalent (CEDE or CDE as appropriate) to the worker's exposure file. The RSO shall use accepted and documented methods to calculate this dose. This may include health physics software, or technical reports by the National Council on Radiation Protection and Measurements (NCRP) and International Commission on Radiological Protection (ICRP).

6.2.5.3 Calculation of Total Dose

Whenever an internal dose is calculated or assigned, the RSO shall add this to the external DDE measured by the worker's dosimeter. This total dose (TEDE) shall be reported to the worker and filed in the worker's dosimetry file.

6.2.6 SHALLOW DOSE FROM SKIN CONTAMINATION

In the event of a skin or clothing contamination event, as described in NAVSTA PS-Tt-012, *Radiological Protective Clothing Selection, Monitoring, and Decontamination*, the RSO shall calculate a SDE for the worker. The RSO shall use accepted and documented methods to calculate this dose. This may include health physics software or technical reports by the NCRP and ICRP. This dose shall be reported to the worker and filed in the worker's dosimetry file.

6.2.7 DECLARATION OF PREGNANCY

In the event that an individual would like to declare a pregnancy, the RSO or designee shall provide the individual with a copy of NRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure*, and provide the individual with an opportunity to declare pregnancy by filling out and signing a Declaration of Pregnancy Form (Attachment 5).

7.0 RECORDS

The following records will be generated and retained in the permanent project file as a result of using this procedure:

- Cumulative Occupational Dose History (NRC Form 4)
- Occupational Dose Record (NRC Form 5)
- Dosimetry Issue Log
- Lost, Damaged, or Questionable Dosimetry Report
- Declaration of Pregnancy

8.0 REFERENCES

Number	***Title***
NAVSTA PS-Tt-007	*Radiologically Controlled Areas – Posting and Access Control*
NAVSTA PS-Tt-012	*Radiological Protective Clothing Selection, Monitoring, and Decontamination*

9.0 ATTACHMENTS

Attachment 1 – Cumulative Occupational Dose History (NRC Form 4)

Attachment 2 – Occupational Dose Record (NRC Form 5)

Attachment 3 – Dosimetry Issue Log

Attachment 4 – Lost, Damaged or Questionable Dosimetry Report

Attachment 5 – Declaration of Pregnancy Form

ATTACHMENT 1 – Cumulative Occupational Dose History (NRC Form 4)

PAGE ____ OF ____

NRC FORM 4
(6-2011)
10 CFR PART 20

U.S. NUCLEAR REGULATORY COMMISSION

CUMULATIVE OCCUPATIONAL DOSE HISTORY

APPROVED BY OMB NO.3150-0005 **EXPIRES: 03/31/2014**

Estimated burden per response to comply with this mandatory collection request: 30 minutes. This information is required to record an individual's lifetime occupational exposure to radiation to ensure that the cumulative exposure to radiation does not exceed regulatory limits. Send comments regarding burden estimate to the Information Services Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects.resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0005), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

1. NAME (LAST, FIRST, MIDDLE INITIAL)
2. IDENTIFICATION NUMBER
3. ID TYPE
4. SEX ☐ MALE ☐ FEMALE
5. DATE OF BIRTH (MM/DD/YYYY)

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)
7. LICENSEE NAME
8. LICENSE NUMBER
9. ☐ RECORD ☐ ESTIMATE ☐ NO RECORD
10. ☐ ROUTINE ☐ PSE
11. DDE
12. LDE
13. SDE, WB
14. SDE, ME
15. CEDE
16. CDE
17. TEDE
18. TODE

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)
7. LICENSEE NAME
8. LICENSE NUMBER
9. ☐ RECORD ☐ ESTIMATE ☐ NO RECORD
10. ☐ ROUTINE ☐ PSE
11. DDE
12. LDE
13. SDE, WB
14. SDE, ME
15. CEDE
16. CDE
17. TEDE
18. TODE

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)
7. LICENSEE NAME
8. LICENSE NUMBER
9. ☐ RECORD ☐ ESTIMATE ☐ NO RECORD
10. ☐ ROUTINE ☐ PSE
11. DDE
12. LDE
13. SDE, WB
14. SDE, ME
15. CEDE
16. CDE
17. TEDE
18. TODE

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)
7. LICENSEE NAME
8. LICENSE NUMBER
9. ☐ RECORD ☐ ESTIMATE ☐ NO RECORD
10. ☐ ROUTINE ☐ PSE
11. DDE
12. LDE
13. SDE, WB
14. SDE, ME
15. CEDE
16. CDE
17. TEDE
18. TODE

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)
7. LICENSEE NAME
8. LICENSE NUMBER
9. ☐ RECORD ☐ ESTIMATE ☐ NO RECORD
10. ☐ ROUTINE ☐ PSE
11. DDE
12. LDE
13. SDE, WB
14. SDE, ME
15. CEDE
16. CDE
17. TEDE
18. TODE

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)
7. LICENSEE NAME
8. LICENSE NUMBER
9. ☐ RECORD ☐ ESTIMATE ☐ NO RECORD
10. ☐ ROUTINE ☐ PSE
11. DDE
12. LDE
13. SDE, WB
14. SDE, ME
15. CEDE
16. CDE
17. TEDE
18. TODE

19. SIGNATURE OF MONITORED INDIVIDUAL
20. DATE SIGNED
21. CERTIFYING ORGANIZATION
22. SIGNATURE OF DESIGNEE
23. DATE SIGNED

NRC FORM 4 (6-2011)

ATTACHMENT 2 – Occupational Dose Record (NRC Form 5)

PAGE ____ OF ____

NRC FORM 5 (6-2011) 10 CFR PART 20 — **U.S. NUCLEAR REGULATORY COMMISSION**

APPROVED BY OMB NO.3150-0006 **EXPIRES: 06/30/2014**

Estimated burden per response to comply with this mandatory collection request: 20 minutes. This information is used to ensure that doses to individual do not exceed regulatory limits. This information is required to record/annually report individual occupational exposure to radiation to ensure that the exposure does not exceed regulatory limits. Send comments regarding burden estimate to the Information Services Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects.resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0006), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

OCCUPATIONAL DOSE RECORD FOR A MONITORING PERIOD

1. NAME (LAST, FIRST, MIDDLE INITIAL)	2. IDENTIFICATION NUMBER	3. ID TYPE	4. SEX ☐ MALE ☐ FEMALE	5. DATE OF BIRTH (MM/DD/YYYY)

6. MONITORING PERIOD (MM/DD/YYYY- MM/DD/YYYY)	7. LICENSEE NAME	8. LICENSE NUMBER(S)	9A. ☐ RECORD ☐ ESTIMATE	9B. ☐ ROUTINE ☐ PSE

INTAKES

10A. RADIONUCLIDE	10B. CLASS	10C. MODE	10D. INTAKE IN μCi

DOSES (in rem)

DEEP DOSE EQUIVALENT	(DDE)	11.
LENS (EYE) DOSE EQUIVALENT	(LDE)	12.
SHALLOW DOSE EQUIVALENT, WHOLE BODY	(SDE,WB)	13.
SHALLOW DOSE EQUIVALENT, MAX EXTREMITY	(SDE,ME)	14.
COMMITTED EFFECTIVE DOSE EQUIVALENT	(CEDE)	15.
COMMITTED DOSE EQUIVALENT, MAXIMALLY EXPOSED ORGAN	(CDE)	16.
TOTAL EFFECTIVE DOSE EQUIVALENT (ADD BLOCKS 11 AND 15)	**(TEDE)**	17.
TOTAL ORGAN DOSE EQUIVALENT MAX ORGAN (ADD BLOCKS 11 AND 16)	**(TODE)**	18.

19. COMMENTS

20. SIGNATURE - LICENSEE	21. DATE PREPARED

NRC FORM 5 (6-2011)

ATTACHMENT 3 – Dosimetry Issue Log

Project Name: _____

Location: _____

Dosimeter Series: _____

Monitoring Period Dosimeter No.	Issue Date	Return Date	Name

ATTACHMENT 4 – Lost, Damaged, or Questionable Dosimetry Report

ADMINISTRATIVE

REPORT DATE / TIME: _____

PROJECT NAME / NUMBER: _____

PROJECT MANAGER / CONTACT: _____

INDIVIDUAL'S NAME / SSN LAST 4: _____

DOSIMETER NUMBER / TYPE: _____

DATE / TIME OF INCIDENT: _____

LOCATION (IF KNOWN): _____

APPLICABLE RWP NUMBER: _____

DATE DOSIMETER WAS ISSUED: _____

DOSE CALCULATION

1. DOSE FROM DOSIMETER READINGS: (TOTAL FROM DATE ISSUED) THRU (DATE) = MREM

2. CURRENT DOSIMETER READING: (IF MORE THAN ONE DOSIMETER, USE HIGHEST) = _____ MREM

3. IF INDIVIDUAL WAS NOT WEARING A DOSIMETER, OR LOST HIS DOSIMETER, ASSIGN HIGHEST EXPOSURE RECEIVED BY WORKERS IN THE SAME AREA. IF NONE, USE DOSE RATE X TIME IN AREA FOR THE SAME PERIOD.

   DOSE RATE: _____ (MREM / HOUR) X TIME _____ (HOURS) = _____ MREM

   HIGHEST DOSIMETER READING _____ MREM = _____ MREM

4. TOTAL ESTIMATED EXPOSURE TO BE ASSIGNED: = _____ MREM

THE METHOD USED TO ESTIMATE MY EXPOSURE HAS BEEN EXPLAINED TO ME, AND THE ESTIMATED DOSE ASSIGNED TO MY RECORD IS ACCEPTABLE FOR THIS EVENT.

EMPLOYEE'S SIGNATURE: _____ *DATE:* ____ / ____ / ____

DOSE RECORD AUTHORIZATION

DOSE ESTIMATE CALCULATED BY: _____ DATE: ____ / ____ / ____

DOSE ESTIMATE REVIEWED BY: (RSO) _____ DATE: ____ / ____ / ____

DOSE ESTIMATE POSTED BY: _____ DATE: ____ / ____ / ____

ATTACHMENT 5 - DECLARATION OF PREGNANCY FORM

In accordance with 10 CFR 20.1208, I am voluntarily declaring that I am pregnant, for the purposes of lowering the dose received by my embryo/fetus. I realize that work restrictions may be imposed to ensure that the embryo/.fetus does not receive a dose in excess of that given in 10 CFR 20.1208 (500 mrem, or 0.005 Sv, during the entire gestation period). I also realize that supplemental dosimetry may be supplied to me, along with periodic reports of the dose received by my embryo/fetus.

Estimated date of conception_____

_____ _____

Printed name of worker

_____ _____

Signature of worker Date

Submission of this form will in no way affect the benefits, seniority, or potential for promotion of the person signing this form.

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

RADIATION AND CONTAMINATION SURVEYS

NAVSTA PS-Tt-003

Approved By:

Erik Abkemeier — July 10, 2013

Erik Abkemeier
Radiation Safety Officer

Date

Lee Boreen — July 10, 2013

Lee Boreen
Project Manager

Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to specify methods and requirements for radiological surveys and documentation of acquired data.

Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results. This guidance for control of radiation exposures provided in this procedure is in accordance with the as low as reasonably achievable (ALARA) philosophy.

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to perform radiation and contamination surveys at the Former Naval Station Puget Sound (NAVSTA PS).

2.0 SCOPE

This procedure shall be implemented by TtEC staff and subcontractor personnel when conducting radiation or contamination surveys.

Subcontractors may use their procedures for conditions or activities not covered by this procedure following approval by TtEC and the Radiological Affairs Support Office (RASO).

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer - The RSO is responsible for the overall implementation and compliance with this procedure during all project operations. The RSO shall conduct periodic reviews, via personal observation of personnel conducting radiation and contamination surveys, to ensure adherence to the requirements of this procedure.

The RSO is responsible for the training of personnel working with radioactive materials. The RSO shall ensure that personnel are adhering to the requirements of this procedure. The RSO shall review and approve documentation generated by this procedure as well as the results of all surveys.

Radiation Safety Officer Representative (RSOR) - The Radiation Safety Officer Representative (RSOR) is responsible for ensuring that personnel performing the tasks required by this procedure are properly assigned. The RSOR is responsible for ensuring that personnel conducting radiation and contamination surveys are familiar with the requirements of this SOP and have access to a copy of the Radiation Work Permits (RWPs). The RSOR can review the results of surveys in place of the RSO when necessary.

Radiological Task Supervisor - The RTS is responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible for the control of radioactive material, coverage of radiation workers, and to ensure that personnel under their cognizance observe proper precautions. Survey documentation will be reviewed by the Radiological Task Supervisor (RTS), or designee.

Radiological Control Technician - The Radiological Control Technician (RCT) shall be responsible for the performance of the requirements of this procedure and documentation of work performed. The RCT shall ensure compliance with this and any other referenced procedure.

5.0 DEFINITIONS AND ABBREVIATIONS

Activity - The rate of disintegration (transformation) or decay of radioactive material. The units of activity for the purpose of this procedure are disintegrations per minute (dpm) for loose and fixed surface contamination, picocuries per gram (pCi/g) for soil, or microcuries per milliliter (μCi/mL) for airborne contamination.

Contamination - Deposition of radioactive material in any place it is not desired. Contamination may be due to the presence of alpha particle, beta particle, or gamma ray emitting radionuclides.

Exposure Rate - The amount of radiation (exposure) delivered at a given point per unit time. Typical units are microroentgen per hour (μR/hr).

Fixed Contamination - Radioactive contamination that is not readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe or masslin.

Minimum Detectable Activity (MDA) - For purposes of this procedure, MDA for removable radioactive contamination is defined as the smallest amount of sample activity that will yield a net count with a 95 percent confidence level based upon the background count rate of the laboratory counting instrument used.

Minimum Detectable Concentration (MDC) - For purposes of this procedure, MDC is the *a priori* activity level that a specific instrument and technique can be expected to detect 95 percent of the time for portable survey instruments.

Radiation Work Permit (RWP) - A document generated in accordance with NAVSTA PS-Tt-001 to provide:

- A description and scope of the work to be performed
- The existing radiological conditions in the work area
- The radiological limits of applicability for the RWP, if radiation levels exceed limits then a new RWP or a modification to the existing RWP must be made
- The protective measures to be employed during the work to protect the worker(s)
- The period of time the RWP is valid
- Special instructions to workers and RCTs during the course of work
- The proper approvals required to begin work

Radiologically Controlled Area (RCA) – An area containing radioactive materials (in excess of the levels provided in Table 1 of Standard Operating Procedure NAVSTA PS-Tt-007, *Radiologically Controlled Areas – Posting and Access Control*) to which access is controlled to protect individuals from exposure to contamination and ionizing radiation.

Removable Surface Contamination - Radioactive contamination that is readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe or masslin.

Uncontrolled Area - An uncontrolled area is any area where access is not controlled for radiological purposes.

6.0 PROCEDURE DETAILS

6.1 GENERAL

Radiation surveys are performed to identify radiation areas, measure the exposure rate, and assess the intensity and shape of those areas to determine control requirements at the worksite.

Contamination surveys are conducted to detect loose surface contamination and fixed contamination. Loose surface contamination is normally detected indirectly by a swipe sample or wipe performed on the item or surface of interest. Fixed contamination levels

are measured directly.

Survey results, locations, and any unusual conditions shall be documented and described on Attachments 1 and 2, Radiation/Contamination Survey Form and Radiation/Contamination Survey Supplement, respectively.

When performing surveys, express the readings as the actual number observed. Do not report "<MDA" or "<Bkg." When background corrections are made, results may be expressed as negative numbers as applicable.

6.1.1 DISCUSSION

Radiation and contamination surveys shall be performed on an as-needed basis. The need for performing a survey is identified by, but not limited to the following conditions:

- An RWP is needed to perform an approved job.
- A condition exists where radiological data are needed.
- An investigation is required due to abnormal conditions or indications.
- An ongoing job requires a survey to update radiological postings and/or an RWP.
- As required to support *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM; NUREG-1575) based survey activities.

6.1.2 PLANNING AND PREREQUISITES

Instruments used to perform radiation and contamination surveys shall be operated in accordance with their operation procedure. Steps to be completed during the planning phase include the following:

- Obtain and review any site-specific survey plans [such as a Task-specific Plan (TSP), work instruction, and time-critical removal action (TCRA) Work Plan] and previous surveys performed in the area.
- Obtain appropriate survey instruments and prepare the instruments for use.
- Obtain the necessary forms, swipes, and protective clothing that will be used during the survey.

Prior to entering an area to perform a survey, each radiation detection instrument shall be:

- Battery Checked.
- Checked for obvious physical damage.
- Quantitatively response-checked daily, prior to use.
- Checked to ensure that the instrument calibration is current.

If any of the above conditions are unsatisfactory, the instrument shall be tagged out of service and not used.

6.2 PROCEDURE PROCESS

6.2.1 EXPOSURE SURVEYS

When entering posted or suspected high radiation areas, or unknown areas, the instrument range selector switch (if applicable) shall be selected to the highest range and moved down through the lower ranges until the meter indicates on scale.

Always survey a sufficient number of locations to determine average and maximum general area and contact radiation levels.

A Ludlum Model-19 or equivalent should be used for performing exposure rate surveys for gamma radiation. The instrument should be operated in accordance with the manufacturer supplied operations manual and any applicable requirements from work specific documents (i.e., work instructions or TSPs). Care should be taken to ensure that the instrument has been allowed to stabilize between individual measurements.

When performing general area exposure rate surveys, the RCT should:

- Attempt to determine the source of radiation fields.
- Record the highest level as the general area exposure rate.
- Perform contact exposure rate measurements with the detector within 1 inch of the surface to be surveyed.
- Perform surveys at approximately 1 meter (waist level) from surface to establish posting requirements for the area.
- Verify the exposure rates of known hot spots.

6.2.2 REMOVABLE CONTAMINATION SURVEYS

6.2.2.1 Removable Contamination Swipe

The following guidance shall be used unless an approved site-specific survey/work instruction directs otherwise. Specific survey instructions will be prepared and given in work specific documents (i.e., work instructions or TSPs) for radioisotopes requiring unusual sampling techniques, such as tritium (^{3}H).

6.2.2.2 Swipe Surveys

1. Label or number swipes, as necessary, to identify each swipe.
2. Wipe the swipes over approximately 100 square centimeters (cm^2) (16 square inches) of the surface to be sampled.
3. Apply moderate pressure.

4. Exercise care on rough surfaces so as not to tear the swipes.
5. Exercise care on wet surfaces so as not to degrade the swipes. Ensure that surfaces are not submerged in water and that cloth swipes or similar are used on wet/damp surfaces.

When surveying an area:

1. Obtain swipes from sample points, which are representative of the average and maximum contamination levels in the area, as identified during preliminary surveys. These areas could include:
    a. Areas of high traffic
    b. On and under benches or tables
    c. Beneath piping and components
    d. On accessible wall surfaces
    e. On piping and significant components
    f. Near drains, sumps, and low spots
2. Swipe floor and component surfaces, which display evidence of (potentially) contaminated water leakage.
3. Ensure contamination is not spread to clean areas when obtaining swipes.

When surveying equipment:

1. Obtain swipes on large surfaces.
2. Obtain swipes in cracks or crevices where contamination may have settled.
3. Obtain swipes on openings to internal surfaces.
4. Handle swipes in a manner that will prevent cross-contamination such as by placing each swipe in a separate envelope.

6.2.2.3 Counting Swipes

Low-background gas proportional counters should be used whenever practical. Typically a Protean WPC 1050 and/or a Tennelec Series 5 XLB gas-flow proportional alpha/beta radiation counter will be employed to count swipes. As a backup to the gas-flow proportional counters a Ludlum Model 2929/3030 scaler with a Model 43-10-1 ZnS(Ag) scintillation probe (or equivalent) may be used.

Swipes will be counted in the field with a portable instrument. If high levels are identified, the counting lab will be notified.

1. Count the swipes in accordance with the operating procedure for the instrument.

2. Record swipe results in dpm/100 cm².
3. Store/archive used swipes as radioactive material until disposal is approved by the RASO.

6.2.2.4 Removable Contamination Surveys Using Large-area Wipes (LAWs)

Large-area contamination surveys using LAWs are appropriate for monitoring the radiological cleanliness of non-contaminated areas or equipment, to track area decontamination progress, or for initially verifying that surfaces are free from contamination.

There are no specific requirements concerning the amount of area to be wiped when performing LAWs. The area wiped should be determined based on the use of the survey data and the dust loading of the LAW material.

6.2.2.5 Performing LAWs

Use masslin, oil-impregnated cloths, or equivalent media to perform LAWs. Select an appropriate collection material and method based upon the survey conditions such as wet surfaces, rough surfaces, heavily soiled area and oily and greasy surfaces.

1. Label or number the cloths, as necessary, to assist in determining the location of the sample.
2. Determine the size of the area to be sampled based on the results of the survey.
3. Wipe the collection media over the surface using moderate pressure by hand, with a masslin mop, or other approved techniques.

6.2.2.6 Evaluating LAWs

1. Allow wet swipe to dry prior to counting.
2. Scan the swipe with an appropriate field instrument (2360/43-89 or equivalent), in an area with a low background.
3. Hold the detector within ½ inch or less above the swipe and move the detector over the swipe at a maximum rate of 1 inch per second.
4. If any indication of an increased count rate is noted, pause to allow the meter reading to stabilize.
5. If the swipe reading is indistinguishable from background, consider the surveyed surface to be free from contamination. If the LAW reading is greater, conduct further surveys, using swipes over a 100 cm² area, to isolate the boundaries of the contamination.
6. Dispose of used LAW media as radioactive waste.

6.2.3 SURVEYS FOR FIXED ALPHA/BETA CONTAMINATION

Fixed contamination surveys are used to obtain indications of fixed contamination levels on surface areas, pieces of equipment, or tools for characterization and/or release surveys. Fixed contamination surveys are also performed to assess if residual contamination is present greater than the release criteria for the radionuclide(s) of concern.

A Ludlum Model-2360/43-68 or 43-37 series floor monitor or equivalent should be used for performing fixed contamination surveys for alpha and beta radiation.

6.2.3.1 Scan Surveys

1. When surveying for fixed alpha/beta contamination, the probe should be held within 1/4 inch or less from the surface being surveyed. The movement rate of the detector probe should be 1 inch per second or slower.
2. Whenever practical, 100 percent of accessible areas being surveyed should be direct scan surveyed, unless the applicable work planning document indicates otherwise.
3. Scan ranges are documented as the range from the lowest measurement to the highest measurement observed.

6.2.3.2 Static Surveys

1. Count time for conducting static measurements will be dependent upon the isotope of concern and the MDA for the instrument being used.
2. Static measurements should be performed at regions showing the highest indicated reading during the scan survey or as required by a work specific document (i.e., TSP or work instruction) or frequently enough to ensure the detection of residual activity.
3. When taking a static measurement for fixed alpha/beta contamination, the probe should be held within 1/4 inch or less from the surface being surveyed.
4. Results should be reported in units of net counts per minute (cpm) above background or dpm/100 cm^2.

The following formula should be used for converting direct probe readings from cpm to dpm/100 cm^2:

$$A_S = \frac{R_{S+B} - R_B}{\varepsilon_i \varepsilon_s \frac{W_A}{100\,cm^2}}$$

Where:

A_S = total surface activity (dpm/100 cm^2)
R_{S+B} = the gross count rate of the measurement in cpm,
R_B = the background count rate in cpm
ε_i = the instrument efficiency (counts per particle)
ε_S = the contaminated surface efficiency (particles per disintegration)
W_A = the physical area of the detector window (cm^2)

In the absence of experimentally determined surface efficiencies, ISO-7503-1 and NUREG-1507 provide conservative recommendations for surface efficiencies. ISO-7503-1recommends a surface efficiency of 0.25 for alpha emitters. NUREG-1507 provides surface efficiencies based on studies performed primarily at Oak Ridge Institute for Science and Education (ORISE). At the former Naval Station Puget Sound, a surface efficiency of 0.25 will be used for alpha/beta emitters.

6.2.4 GAMMA SURVEYS

A Ludlum Model-2350-1/44-10 or equivalent should be used for gamma radiation surveys.

A single detector or an array of detectors may be used to perform gamma scans.

6.2.4.1 Scan Surveys

1. Set the audio response switch to the “on” position.
2. If a single detector is used, traverse a path at a maximum speed of approximately 0.5 meters per second and slowly move the detector assembly in a serpentine (S-shaped) pattern, while maintaining the detector approximately 10 centimeters (cm) (4 inches) from the area being surveyed.
3. If a detector array is used, it will be pushed or pulled in a straight line with the detector centers positioned approximately 30 cm apart.
4. Scan ranges should be recorded from the lowest reading to the highest reading noted.
5. If data logging is being performed, the scan data will be collected at the time interval necessary to obtain the measurements required for the survey.
6. Locations of radiation levels greater than 3 standard deviations above background shall be marked and identified for further investigations.
7. Measurement results are recorded in cpm.

6.2.4.2 Static Surveys

1. Static gamma measurements require positioning the detector assembly approximately 10 cm (4 inches) above the surface and completing a stationary 60-second survey.
2. Static measurements should be performed as required in the applicable work planning document or frequently enough to ensure the detection of residual activity.
3. Measurement results are recorded in cpm.

6.2.5 ROUTINE RADIOLOGICAL SURVEYS

6.2.5.1 Frequency Requirements for Routine Surveys

Appropriate routine radiological surveys shall be performed at the following frequencies unless directed otherwise by the applicable work planning document or the RSO.

Exposure Rate Surveys

Surveys should be performed as frequently as necessary to ensure that radiological postings accurately reflect actual conditions during activities that have the potential to change exposure rates. Additionally, radiation surveys should be performed under the following circumstances:

- Upon initial entry into potential radiation areas after extended periods of closure.
- Daily, in the vicinity of contamination concentration points on operating high-efficiency particulate air (HEPA)-filtered ventilation units.
- Weekly, in occupied office spaces located inside radiologically controlled areas.
- Weekly, or upon entry if entries are less frequent than weekly, inside radiation areas and radioactive material storage areas.
- Weekly, along radiation area boundaries to ensure that the radiation areas do not extend beyond the posted boundaries.
- Monthly, around the Radiation Screening Yard(s) Radiologically Controlled Areas (RCAs).
- Quarterly, around inactive RCAs .

Contamination Surveys

- Daily when in use, or once per shift in high-use situations at contamination control points, radiological change areas, or step-off pads.
- Daily, in count rooms and laboratories that are used to analyze potentially contaminated samples.
- Daily, in office spaces located inside radiologically controlled areas.
- Daily, in lunchrooms, eating areas, locker rooms, and shower areas adjacent to radiologically controlled areas.
- Weekly, for all designated lunchrooms and offices for the project.
- Weekly, or upon entry if entries are less frequent, in the areas where radioactive materials are handled or stored.
- Weekly, or upon entry if entries are less frequent, in posted contamination areas.

6.2.5.2 Identifying and Scheduling Routine Radiological Surveys

The RSO, or designee, shall identify and schedule routine surveys as required by the radiological conditions and work activities.

Routine survey schedules shall be developed using a standard system for designating surveys as follows:

Frequency of survey:

Daily	D
Weekly	W
Monthly	M
Quarterly	Q
Semiannually	S
Annually	A
Upon Entry	U

Routine survey schedules shall be submitted to, and approved by, the RSO or designee.

Routine survey tracking forms should be prepared using the approved routine survey schedules.

Changes to any routine survey schedule shall be submitted to, and approved by, the RSO or designee.

6.2.5.3 Survey Log

Completion of surveys shall be documented using the assigned survey log (see Attachment 3) for the project. This is not limited to initial surveys but includes routine surveys. Each survey shall be assigned a unique tracking number consistent with the practices of the project.

6.2.5.4 Performance of Routine Surveys

RCTs shall perform routine surveys in accordance with the RWP and the other applicable procedures.

Upon completion of a routine survey, the RCT shall initial the appropriate Survey Log.

6.2.5.5 Periodic Evaluation of Routine Surveys

Routine survey schedules (see Attachment 4) shall be reviewed and updated periodically to ensure that all areas within the project boundaries are receiving appropriate routine survey coverage.

Changes of conditions within the project area will be reported to the RSO or designee, and may require a modification of the routine radiological survey schedule and/or RWP.

6.2.5.6 Management Notification

The RSO shall be notified, in writing by the RSOR, of any failure to complete a routine survey as scheduled. The missed survey will be completed as soon as possible after the discovery that it was missed.

7.0 RECORDS

Radiation/Contamination Survey Form
Radiation/Contamination Survey Supplement
Survey Log
Routine Survey Schedule

8.0 REFERENCES

Number	***Title***
10 CFR 20	*Standards for Protection Against Radiation*
ISO-7503-1	*Evaluation of Surface Contamination*
NUREG-1507	*Minimum Detectable Concentration/Activities for Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*
NUREG-1575	*Multi-Agency Radiation Survey and Site Investigation Manual*
NAVSTA PS-Tt-001	*Issue and Use of Radiation Work Permits*

9.0 ATTACHMENTS

Forms provided in this section illustrate the minimum requirements for their respective subject matter. Alternative documents or electronic data logging may be used providing the information is presented in a clear and concise manner and the content meets or exceeds the information required to complete these documents.

Attachment 1 – Radiation/Contamination Survey Form

Attachment 2 – Radiation/Contamination Survey Supplement

Attachment 3 – Survey Log

Attachment 4 – Routine Survey Schedule

ATTACHMENT 1 – RADIATION/CONTAMINATION SURVEY FORM

DATE: TIME:	INSTRUMENTATION USED					
SURVEY NUMBER:	**Model Inst/Det.**	**Serial Number**	**Calibration Due Date**	**% Efficiency**	**MDC/MDA (dpm/100cm^2)**	**Background (dpm/100cm^2)**
LOCATION:						
SURVEYOR:						
REVIEWED BY:						
RSO/RTM:						
Isotopes of Concern:						
Description or drawing:						

Routine (Daily / Weekly / Monthly) ☐ Non-routine ☐	All radiation readings in µr/hr unless otherwise noted. Ⓐ….denotes swipe location or fixed α/β readings. #…….denotes G/A radiation readings. #/#…denotes contact / 1 meter radiation readings. *……denotes highest radiation reading on contact. Δ……...denotes static location.

ATTACHMENT 2 - RADIATION/CONTAMINATION SURVEY SUPPLEMENT

SURVEY NUMBER:								
SURVEYOR:				LOCATION:				
Location	**Exposure Rate (μR/hr)**		**Fixed + Removable**			**Removable**		**Comments**
	Contact	**1 Meter**	**Gamma (cpm)**	**Alpha dpm/probe**	**Beta/Gamma dpm/probe**	**Alpha dpm/100cm^2**	**Beta/Gamma dpm/100cm^2**	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
Reviewer			Date/Time:			RSO/RSOR		Date/Time:

ATTACHMENT 3 – SURVEY LOG

Project: **Location:**

Survey Number Project	#	Year	**Date**	**Survey Description**	**Surveyor** (Init.)

Reviewed/Approved By: _____ /

RSO/RSOR Date

ATTACHMENT 4 – ROUTINE SURVEY SCHEDULE

Survey Description	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init
	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
	#	#	#	#	#	#	#	#	#	#	#	#
	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init
	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
	#	#	#	#	#	#	#	#	#	#	#	#
	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init
	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
	#	#	#	#	#	#	#	#	#	#	#	#
	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init
	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
	#	#	#	#	#	#	#	#	#	#	#	#
	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init	Surveyor Init
	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
	#	#	#	#	#	#	#	#	#	#	#	#

Prepared/Submitted By: ____________________ / ________
Technician Date

Reviewed/Approved By: ____________________ / ________
RSO/Manager Date

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

PREPARATION OF PORTABLE RADIATION AND CONTAMINATION SURVEY METERS AND INSTRUMENTS FOR FIELD USE

NAVSTA PS-Tt-004

Approved By:

Erik J. Abkemeier	July 10, 2013
Erik Abkemeier Radiation Safety Officer	Date
	July 10, 2013
Lee Boreen Project Manager	Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

This procedure is used to specify the general requirements for preparing portable radiation and contamination survey meters and instruments for use at field locations. The procedures presented below will be supplemented by the specific instrument operation manuals, Tetra Tech EC, Inc. (TtEC)-approved subcontractor procedures and specific work documents (i.e. Task-specific Plans (TSPs), work instructions, and other Work Plan documents).

2.0 SCOPE

This procedure will be used by TtEC personnel and its subcontractors. This procedure is intended to provide general instructions for preparing radiation and contamination survey meters and instruments for field operations.

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer – The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the radiation and contamination survey meters and instruments. The RSO will assist in the interpretation of results obtained during surveys.

Radiation Safety Officer Representative -The RSOR will also be responsible for performing periodic surveillance of the use and maintenance of instruments and ensuring that the instruments are calibrated at specified intervals, ensuring that records pertaining to the instrument are maintained on file throughout the duration of the project and copies retained in the permanent project file, and reviewing documentation generated by the use of this procedure.

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) is responsible for ensuring that all personnel assigned the task of operating radiation and contamination survey meters and instruments are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys. The RTS is responsible for ensuring that a copy of this procedure is available at the job site. The RTS will also be responsible for ensuring that Radiological Control Technicians (RCTs) are qualified by training and experience to perform the requirements of this procedure, notifying the RSO of any unsafe or unusual conditions observed during operation of the instrument, and implementation of this procedure. The RTS is

responsible for ensuring that RCTs implement and use this procedure. The RTS will ensure that personnel under their cognizance observe proper precautions when using this procedure.

Radiological Control Technician – The RCT is responsible for being qualified by training and experience to perform the requirements of this procedure, notifying the RTS of any unsafe or unusual conditions observed during operation of the instrument, and implementation of this procedure.

5.0 DEFINITIONS AND ABBREVIATIONS

Acceptance Range – A range of values that describes an acceptable instrument check result. An acceptance range is typically determined by adding $\pm$ 20 percent or $\pm 2\sigma$ to the expected value.

Calibration Sticker – A label affixed to a properly calibrated instrument. The calibration sticker shall be applied by the calibration facility. The calibration sticker should indicate the date through which the calibration is valid.

Chi-Square Test – A probability density function that gives the distribution of the sum of the squares of a number of independent random variables each with a normal distribution with zero mean and unit variance, that has the property that the sum of two or more random variables with such a distribution also has one, and that is widely used in testing statistical hypotheses especially about the theoretical and observed values of a quantity and about population variances and standard deviations. This test is used to evaluate the operation of an instrument, generally upon return from calibration.

Check Log – A form or series of forms which are used to document that an instrument was checked prior to usage in the field. Check logs can consist of multiple pages and must contain at least one page identifying the instrument. At least one page must also specify the parameters (source, geometry, etc.) used for the daily check. Space shall be provided to document the daily tests in the log. The log should be designed so as to clearly associate the required verifications with the signature or initials of the individual performing the check and date of each check.

Instrument Efficiency – A measure of the response (counts) obtained with a particular instrument/probe combination when exposed to a known fluence of radioactive particles. Instrument efficiency has units of counts per disintegration..

6.0 PROCEDURE DETAILS

6.1 CALIBRATION

Instrument calibrations shall be performed using measuring and test equipment and National Institute of Standards and Technology (NIST) traceable sources. Calibrations will be performed at an accredited calibration facility. Calibration will be performed in accordance with the equipment manufacturers' manuals or a subcontractor's TtEC-approved procedure. Properly calibrated instruments shall be marked with a calibration sticker and include an accompanying calibration certificate.

Calibration shall be performed annually or on a schedule consistent with the manufacturer's recommendation if more restrictive. In addition to the routine frequency of performance, calibration shall be performed under the following conditions:

- Prior to placing a new instrument into service.
- After any major repair or alteration to the instrument or detector.

6.2 GENERAL CONSIDERATIONS

Upon receipt of survey equipment from an offsite vendor, and prior to shipment to an offsite vendor, the survey equipment shall be surveyed for alpha/beta fixed and loose contamination in accordance with *NAVSTA PS-Tt-009, Release of Materials and Equipment from Radiologically Controlled Areas*. If any contamination limits are exceeded, notify the RTS immediately.

Determination of instrument background, chi-square testing and instrument efficiency should be conducted in a controlled environment. This typically will consist of a secured office or lab area located in a non-impacted area and which is known to be free of contamination. Testing jigs or apparatus may be employed as necessary to ensure that consistent, reproducible geometries are used, particularly during repeated measurements.

In the event that any instrument and detector combination fails a chi-square test or daily operation check or has exceeded its annual calibration date without RSO approval, the instrument shall be put in an "out of service" condition by placing an "out of service" tag or equivalent on the instrument and detector combination, and securing in a separate area such that the instrument and detector combination cannot be issued for use. The RTS shall be notified immediately when any survey instrumentation has been placed "out of service".

Any instrument and detector combinations that have not had a daily operation check performed because daily plans do not include their use shall be secured in an area to prevent their use until operation checks have been performed.

Table 1 gives suggested geometries to use for the most common instrument types to be used at the former Naval Station Puget Sound (NAVSTA PS). Alternate geometries can be used provided that they are more appropriate for the intended usage of the instrument.

TABLE 1

SUGGESTED GEOMETRIES FOR BACKGROUND MEASUREMENTS AND SOURCE CHECKS

Measurement	Instrument/Detector Combinations	Probe Location
Exposure Rate	Ludlum Model 19 MicroR Meter or equivalent with integral NaI 1"x1" detector	contact[a]
Gamma	Ludlum Model 2221, 2350-1 or 2360 with Ludlum Model 44-10 or equivalent detector	4 inches above ground surface/source
Beta/Gamma	Ludlum Model 3 portable survey meter with Ludlum Model 44-9 G-M probe or equivalent	¼ inch above ground surface/source
Alpha/Beta	Ludlum Model 2350-1, 2360 or equivalent portable survey meter with Ludlum Model 43-37, 43-68, 43-89 or equivalent detector	¼ inch from surface/source

Notes:

[a] Field readings with exposure rate instruments are conducted at 1 meter per the Base-wide Radiological Work Plan; background determination, chi-square test and operational checks are typically performed at a more convenient distance. Geometry should be documented as appropriate on the relevant data forms and logs.

G-M – Geiger-Muller

6.3 DETERMINATION OF INSTRUMENT BACKGROUND

The determination of an instrument specific background is an optional procedure which may be employed at the discretion of the RTS. There is no regulatory requirement that necessitates the determination of background for each instrument. Instrument background determination is typically performed in a controlled environment and usually consists of a series of repeated background measurements that are statistically analyzed to obtain an expected range of valid background values. The established instrument background range can be used as a means of performing daily operation checks.

Instrument background determinations, when necessary, are considered valid for as long as the instrument has been properly maintained per the requirements of this procedure. If instrument backgrounds are required, a new background determination should be performed following each calibration.

When determining instrument background, this procedure shall be followed; however, any specific instructions for background determination in governing work-specific documents shall have precedence.

When required, background determinations will be documented on Attachment A or equivalent or as specified in the work-specific procedures. The form should include the following information at a minimum:

- Identification information (i.e. model and serial numbers) for the instrument and detector
- Conditions used for determination (geometry, radiation type, operating voltage, etc.)
- Date and time of determination
- Identification and signature or initials of technician
- Identification and signature of reviewer (typically the RTS)

The end result of a background determination should be to obtain an acceptance range for subsequent background checks.

6.4 CHI-SQUARE TEST

When chi-square tests are required by work-specific documents, this procedure shall be followed; however, any specific instructions for chi-square testing in governing work specific documents shall have precedence. When required, chi-square tests shall be performed annually (± 15 days), following calibration, or if there is reason to suspect that the instrument calibration may no longer be valid (i.e. inability to obtain a valid range of chi-square values). Chi square testing is not required to be performed on exposure rate instruments (e.g., Ludlum Model 19 or RO-20) or personnel contamination “frisking” instrument/detector combinations (e.g., Ludlum Model 3 or 177 with 44-9) unless specified in work-specific documents.

Chi-square tests shall be performed with NIST traceable sources with isotopic content appropriate to the detector being evaluated and the anticipated contaminants in the survey area. The source should be of sufficient activity to yield a counting rate of 1000 to 50,000 counts per minute (cpm).

When required, chi-squared tests should be documented in Attachment B or equivalent or as specified in the work-specific documents. The form should include the following information at a minimum:

- Identification information (i.e. model and serial numbers) for the instrument and detector
- Conditions used for the test (geometry, radiation type, operating voltage, etc.)
- Source ID number
- Date and time of determination
- Identification and signature or initials of technician
- Identification and signature of reviewer (typically the RTS)

The chi-square test procedure will produce a chi-squared value (χ^2) which should be between 10.11 and 30.14. Failure to obtain a chi-squared value in this range indicates a problem with either the instrument or the methodology used to perform the chi-square test and requires further investigation. The RTS should be notified of the failure to assist in planning a course of action.

6.5 INSTRUMENT EFFICIENCY FOR PORTABLE INSTRUMENTS

The instrument efficiency (ε_i) is the ratio between the net count rate (in cpm) of the instrument and the surface emission rate of the efficiency check source for a specified geometry. The surface emission rate is the 2π particle fluence that is affected by both the attenuation and backscatter of the radiation emitted from the efficiency check source.

The following equation is used to calculate the instrument efficiency in counts per particle:

$$\varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi}\left(W_A / S_A\right)}$$

Where,

R_{S+B} = the gross count rate of the efficiency check source, measured in cpm
R_B = the background count rate in cpm
$q_{2\pi}$ = the 2π surface emission rate of the calibration source (NIST traceable)
W_A = the active area of the probe window in square centimeters (cm^2)
S_A = the area of the source in cm^2

Note: This equation assumes that the dimensions of the efficiency check source are sufficient to cover the window of the instrument detector. If the dimensions of the efficiency check source are smaller than the detector's window, set W_A equal to the dimensions of the efficiency source (i.e., set the quotient of W_A and S_A equal to 1).

Instrument efficiency shall be determined for all instruments and radiation and contamination survey meters that are to be used for alpha and beta surveys prior to use for field operations. Instrument efficiency is dependent upon energy of the incident radiation. Multiple energy-specific instrument efficiencies may be determined when isotopes with significantly varying energies are analyzed.

The equipment manufacturer's procedures shall be followed to determine the instrument efficiency for those instruments for which it is required. In instances where governing work-specific documents specify a means or expanded scope of inclusion for instrument efficiency determination, they shall have precedence.

All instrument efficiency determinations should be documented in calibration certificates provided from the manufacturer or an approved vendor or as specified in the work-specific documents. The form should include the following information at a minimum:

- Identification information (i.e. model and serial numbers) for the instrument and detector
- Conditions used for determination (geometry, radiation type, operating voltage, etc.)
- Source-specific information (ID number, surface emission rate, area),
- Detector window area
- Date and time of determination
- Identification and signature or initials of technician
- Identification and signature of reviewer (typically the RTM)

The resulting instrument efficiency should be reported in units of counts per disintegration.

6.6 OPERATION CHECK

An operation check for each instrument should be performed at the beginning of each work day that a particular instrument is used. The operations check should include the following checks at a minimum:

- Check that instrument calibration is still valid (date on sticker not yet passed)
- Check the instrument (including the probe) for physical defects (knobs, displays, cables, connectors, mylar windows, backlights, speakers, etc.)
- Check of instrument battery (per manufacturers' instructions)
- Source check (should give consistently reproducible results with same source)

Instructions for performing operation checks for specific instrument and detectors are included in Attachment C of this procedure. Failure of any of the above checks shall result in the instrument being removed from active service until the condition can be addressed. The RTS should be notified of any instrument failing an operations check for reasons other than failure of a battery check. In cases of battery check failure, the battery should be replaced and the check repeated.

The specified checks should each be performed every day and documented on a new line of the check log. A separate check log shall be maintained for each instrument type. The check log shall contain the following information at a minimum:

- Identification information (i.e., model and serial numbers) for the instrument and detector
- Conditions used for the check (geometry, radiation type, etc.)
- Source ID number
- Verification of current calibration
- Verification of physical condition
- Verification of battery check
- Verification that source check is in acceptance range
- Date of operational check
- Signature or initials of technician
- Identification and signature of reviewer (typically the RTS)

Of the required information given above, only the verifications, date and signature or initials need to be completed on a daily basis. The remaining information can be completed once and kept in the check log with the additional pages for daily checks, provided that none of the information changes. If the information changes, then a new check log should be started.

A sticker annotating that daily operation checks have been completed satisfactorily shall be affixed to each instrument. The sticker shall contain the following information at a minimum:

- Initials of technician
- Date of operational check

6.7 MAINTENANCE

Instruments shall be stored in areas, which prevent damage by movement, accumulation of moisture or dust. Detector covers shall be used for storage when practical.

Instrument maintenance (except external adjustments and cable or mylar window replacements) shall be performed by the manufacturer or an approved vendor..

7.0 RECORDS

Records that result from this procedure may include forms that document background determinations, chi-square tests, instrument efficiency, instrument calibration and check logs. Record forms shall be obtained from the attachments of this procedure or equivalent electronic versions or specified in work-specific procedures.

8.0 REFERENCES

Number	***Title***
DCN: RMAC-0809-0011-XXX1	*Radiological Work Plan*

9.0 ATTACHMENTS

Attachment A – Instrument/Detector Background Form

Attachment B – Chi Square Form

Attachment C – Instrument and Detector Operational Check Procedures

ATTACHMENT A – INSTRUMENT/DETECTOR BACKGROUND FORM

Instrument/Detector Background Form

		Former Naval Station Puget Sound				
Instrument Model:					Instrument Serial No.	
Cal due date					Data Type	
Detector Model:					Detector Serial No.:	
Today's Date:					Data Collected by:	

Count Number	Background
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
Total	
Mean Count:	
Standard Deviation:	
Mean + 3 σ Value:	

Comments:

Mean +20%	
Mean -20%	

Calculations Completed by:	Date:
Reviewed by:	Date:

Attachment A

ATTACHMENT B – CHI SQUARE FORM

Chi Square Form

	Former Naval Station Puget Sound					
Instrument Model:				Instrument Serial No.		
Cal due date				Data Type		C_B
Detector Model:				Detector Serial No.:		
Today's Date:				Data Collected by:		
Source ID:	Activity	dpm				
Radionuclide:	CPM	CPM				
Count Number Background	(Gross) C_G	(Net) C_i		$(C_i - \bar{c})$	$(C_i - \bar{c})^2$	+20%
1						-20%
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
Total				SUM		$\Sigma(C_i - \bar{c})^2$
Mean Count: $\bar{c}$						
Chi Squared Value (C^2):		10.11 - 30.14	Standard Deviation:			
+ 2 σ Value:	- 2 σ Value:					
Calculations Completed by:					Date:	
Reviewed by:					Date:	

Attachment B

ATTACHMENT C – INSTRUMENT AND DETECTOR OPERATIONAL CHECK PROCEDURES

Operational Checks for Portable Radiation and Contamination Survey Meters and Instruments

1.0 Pre Operational Checks for Ludlum 2350-1 with 44-10 Detector or FIDLER

1.1 Battery Check

1.1.1 Keystroke SVD1 which will display the current battery voltage. When the battery voltage reads 4.4 volts or less the message LOW replaces the voltage reading. Replace batteries.

1.2 Instrument Check

1.2.1 Connect one end of the cable provided to the detector by firmly pushing the connectors together while twisting clockwise ¼ turn until it latches. Repeat the process in the same manner with the other end of the cable and the instrument.

1.2.2 Insure that the instrument high voltage is at the proper setting for the detector in use.

1.2.3 Check for proper background reading (Typically 4-10 kcpm). Document on Source Check Log for Model 2350 (Form 1).

1.3 Model 44-10 Gamma Scintillator Detector Response Check

1.3.1 Expose the detector to a Cs 137 check source at a distance of 4 inches using a jig and verify that the instrument indicates within ± 20% of the check source reading obtained during the last calibration. Document on Source Check Log for Model 2350 (Form 1). For a FIDLER detector, expose the check source using an Am-241 source and verify that the instrument indicates within ± 20% of the check source reading obtained during the last calibration. Document on Source Check Log for Model 2350 (Form 1).

Attachment C

2.0 Pre Operational Checks for Ludlum Model 3 with 44-9 detector

2.1 Battery Check

2.1.1 Move the range multiplier switch to the BAT position.

2.1.2 Ensure that the meter needle deflects to the BATTERY TEST position on the meter scale.

2.1.3 If no meter response is observed, check that the batteries are correctly installed and replace if necessary.

2.2 Instrument Check

2.2.1 Connect one end of the Ludlum 44-9 detector cable to the detector by firmly pushing the connectors together while twisting clockwise ¼ turn. Repeat the process in the same manner with the other end of the cable and the instrument.

2.2.2 Place the instrument range switch to the X100 position.

2.2.3 Place the AUD ON-OFF switch to the ON position.

2.2.4 Expose the Ludlum 44-9 detector to a Sr-90 check source. The speaker should emit "clicks" relative to the rate of counts detected.

2.2.5 Test the detector cable by bending or flexing either end of the cable and checking for an increase in counts being detected. Replace the cable if increases in count rate are observed.

2.2.6 Check the meter reset function by depressing the "RES" pushbutton switch and ensuring the meter needle drops to "0".

2.3 Detector Response Check

2.3.1 Check for a proper background reading which typically should be in the range of 25-50 cpm at 8-15 uR/hr. Document on Source Check Log for Friskers (Form 2).

2.3.2 Place a Sr-90 check source into the source holder.

2.3.3 Place the model 44-9 detector into the source jig at ¼" from the detector and verify the instrument indicates within +/- 20% of the check source reading supplied from the last calibration. Document on Source Check Log for Friskers (Form 2).

Attachment C

3.0 Pre Instrument Operational Checks for RO-20

3.1 Circuit Checks

3.1.1 Operate the LIGHT SWITCH, located on the upper assembly the top right middle of the instrument, in both directions and observe that the lamps operate.

3.1.2 Turn the nine position FUNCTION SWITCH, located on the upper assembly at the base of the instrument, to the CHECK BATTERY 1 position (C cell battery). The meter should read in the green BATTERY CHECK arc. Replace C cell batteries if meter needle is not within the green arc.

3.1.3 Turn the nine position FUNCTION SWITCH to the CHECK BATTERY 2 position (Lithium cells). The meter should read in the green BATTERY CHECK arc. Replace lithium batteries if meter needle is not within the green arc.

3.1.4 Turn the nine position FUNCTION SWITCH to the ZERO position. Check that the meter reads zero. If not, set the meter reading to zero with the ZERO knob.

3.2 Desiccant Check

3.2.1 Remove the upper assembly from the lower case by unfastening the front and rear latches and lifting the instrument from the case.

3.2.2 Inspect the desiccant pack. If the desiccant appears clear or pink in color, remove old desiccant pack and replace with new desiccant pack. **Note:** It is very important that the inside of the chamber assembly be kept dry to avoid leakage current due to moisture. If the instrument becomes erratic due to moisture, cycle the instrument between room temperature and 140° **F** three or four times to flush the chamber air across the new desiccant.

3.3 Detector Response Check

3.3.1 Place a 10 uCi Cs-137 source into the source positioning holder.

3.3.2 Place the RO-20 meter with the beta window closed into the source positioning holder positioning the center of the meter face approximately 1/8 inch from the source.

3.3.3 Place the function switch to the 50 mR/h scale range. The meter needle should be reading approximately 4.0 on the meter face. Document on Source Check Log for Model RO-20 (Form 3). Remove the meter from service if the response is not within a tolerance of +/- 20%.

Attachment C

4.0 Pre Operational Checks for a Ludlum Model 19 MicroR Meter

4.1 Battery Check

4.1.1 Turn the RANGE SWITCH to the "25" position.

4.1.2 Depress the BAT pushbutton switch to ensure that the meter needle falls within the "Bat Ok" marks. If needle response is not in the band, replace the batteries.

4.2 Instrument Check

4.2.1 Switch the "AUD ON/OFF" switch to the "ON" position and confirm that the external speaker produces an audible click for each event detected.

4.2.2 Check the meter reset function by depressing the "reset" pushbutton and ensuring the meter needle drops to "0".

4.2.3 Depress the "LAMP" switch. Ensure that the meter face illuminates when the switch is depressed.

4.3 Response Check

4.3.1 Turn the Range Selector switch to the "25" position. Check for proper background reading. A typical reading would be 4-15 uR/hr.

4.3.2 Turn the Range Selector switch to the "5000" position. Place a 1.0 uCi Cs-137 check source approximately ½ " from the forward face of the instrument centering the source within the indentation marks on the instrument case. Verify that the instrument reading is within +/- 20% of the check source value obtained during the last calibration. Document on Source Check Log for Model 19 (Form 4).

Attachment C

5.0 Pre Operational Checks for a Ludlum Model 2360 with 43-68 detector

5.1 Battery Check

5.1.1 Turn the six position ROTARY SWITCH, located in the center of the instrument, to the "BAT" position, the meter pointer should deflect above the left vertical mark on the "BAT OK" line.

5.1.2 Replace the batteries if pointer does not response appropriately.

5.2 Detector Flush

5.2.1 Connect detector output P-10 gas line to output flow meter.

5.2.2 Connect detector input and gas lines from main supply through the regulator and input flow meter.

5.2.3 Turn main supply on and flush detector at 100 cc/min for 15 minutes.

5.2.4 Set gas flow to 30-50 cc/min following the flush period.

5.2.5 Check output flow meter, insure detector leakage is less than 5 cc/min.

5.3 Detector Response Checks

5.3.1 Measure background of detector operating in the alpha only plateau region, meter should display 3 counts per minute (cpm) or less.

5.3.2 Expose the detector to a known quantity certified Tc-99 source used when the instrument was chi-square tested upon receipt from the latest calibration. Ensure reading is within +/- 20% of mean value determined at that time. Document on Source Check Log for Model 2360 (Form 5).

5.3.3 Expose the detector to a known quantity certified Th-230 source used when the instrument was chi-square tested upon receipt from the latest calibration. Ensure reading is within +/- 20% of mean value determined at that time. Document on Source Check Log for Model 2360 (Form 5).

Attachment C

6.0 Pre Operational Checks of 2360 with 43-37 or 43-37-1 gas flow proportional detector

6.1 Battery Check

6.1.1 Turn the six position ROTARY SWITCH, located in the center of the instrument, to the "BAT" position, the meter pointer should deflect above the left vertical mark on the "BAT OK" line.

6.1.2 Replace the batteries if pointer does not response appropriately.

6.2 Detector Flush

6.2.1 Connect detector output P-10 gas line to output flow meter.

6.2.2 Connect detector input and gas lines from main supply through the regulator and input flow meter.

6.2.3 Turn main supply on and flush model 43-37 detector at 100 cc/min for 30 minutes, model 43-37-1 for 45 minutes.

6.2.4 Set gas flow to 30-50 cc/min following the flush period.

6.2.5 Check output flow meter, insure detector leakage is less than 5 cc/min.

6.3 Detector Response Checks

6.3.1 Measure background of detector operating in the alpha only plateau region, meter should display 10 counts per minute (cpm) or less.

6.3.2 Expose the detector to a known quantity certified Tc-99 source used when the instrument was chi-square tested upon receipt from the latest calibration. Ensure reading is within ± 20% of mean value determined at that time. Document on Source Check Log for Model 2360 (Form 5).

6.3.3 Expose the detector to a known quantity certified Th-230 source used when the instrument was chi-square tested upon receipt from the latest calibration. Ensure reading is within ± 20% of mean value determined at that time. Document on Source Check Log for Model 2360 (Form 5).

6.3.4 Check each section of the detector face for statistically uniform response. Ensure that each section is reading within ± 10% of the average of the reading. If the count is not statistically uniform, check for light leaks in the window and repeat flush procedure. Note: There is an expected performance degradation along the sides of the probe and within an inch of the standoffs. Document on Source Check Log for Model 2360 (Form 5).

Attachment C

7.0 Pre Operational Checks for Model 177 Alarming Ratemeter with 44-9 Detector

7.1 Battery Check

7.1.1 Turn the power switch to the ON position.

7.1.2 Depress the BAT TEST button.

7.1.3 Check that the meter reads above the BAT TEST indication. If the battery does not check, the instrument will operate on AC line power only. Replace the internal GEL-CELL battery.

7.2 Detector Response Check

7.2.1 Connect 44-9 probe to the instrument.

7.2.2 Place a Sr-90 source into the source holder. Place the model 44-9 detector into the source jig at ¼" from the detector and verify the instrument indicates within +/- 20% of the check source reading supplied from the last calibration. Document on Source Check Log for Friskers (Form 6).

7.3 Alarm Point Check

7.3.1 Set the instrument to the appropriate range with the RANGE selector switch.

7.3.2 Set the alarm point by pressing the ALARM TEST switch and adjust ALARM SET for the desired alarm point. The meter displays the alarm set point when the ALARM TEST switch is depressed. Recheck the alarm set point after locking the ALARM SET control.

7.3.3 Using a Sr-90 check source, increase the count rate to exceed the alarm threshold. The alarm lamp and audible alarm signal should activate.

7.3.4 Depress the RESET button. The meter needle should drive to zero and the alarm circuit should de-energize, shutting off both the visual and audible alarms.

7.4 High Voltage Setting Check

7.4.1 Depress the HV TEST button and ensure that the high voltage is properly set for 900 volts.

Attachment C

8.0 Pre Operational Checks for a Ludlum Model 2360 with 43-89 or 43-93 detector

8.1 Battery Check

8.1.1 Turn the six position ROTARY SWITCH, located in the center of the instrument, to the "BAT" position, the meter pointer should deflect above the left vertical mark on the "BAT OK" line.

8.1.2 Replace the batteries if pointer does not response appropriately.

8.2 Detector Response Checks

8.2.1 Measure background of detector for alpha only, meter should display 3 counts per minute (cpm) or less.

8.2.2 Expose the detector to a known quantity certified Tc-99 source used when the instrument was chi-square tested upon receipt from the latest calibration. Ensure reading is within +/- 20% of mean value determined at that time. Document on Source Check Log for Model 2360 (Form 5).

8.2.3 Expose the detector to a known quantity certified Th-230 source used when the instrument was chi-square tested upon receipt from the latest calibration. Ensure reading is within +/- 20% of mean value determined at that time. Document on Source Check Log for Model 2360 (Form 5).

Attachment C

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

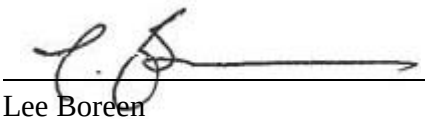
AIR SAMPLING AND SAMPLE ANALYSIS

NAVSTA PS-Tt-005

Approved By:

Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date



Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors at former Naval Station Puget Sound (NAVSTA PS) to perform air sampling and document the results. Results will be used to determine what respiratory protection, if any, is required for the work area.

Note that this procedure is strictly for air sampling for worker protection. The Washington State Department of Health approved Radioactive Air Emissions Plan complying with the requirements of WAC 246-247-110 Appendix A, and included in Remedial Action Work Plan as an attachment, is implemented as a separate air sampling and analysis plan to ensure protection of the general public from airborne emissions.

Air sample analysis for worker protection will be performed at the on-site radiological laboratory, by trained personnel using a Ludlum Model 2929 Alpha/Beta Counter (or equivalent) in accordance with the operator manual. Further discussion of sample analysis is not within the scope of this procedure.

2.0 SCOPE

This procedure will be used for all TtEC and subcontractor radiological air sampling activities supporting NAVSTA PS field projects, regardless of the organization performing the work. Results will be used to determine respiratory protection requirements and assign dose to workers from inhalation and/or ingestion when necessary.

3.0 MAINTENANCE

The Radiological Safety Officer (RSO) is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer – The RSO is responsible for the overall implementation and compliance with this procedure during all project operations. The RSO shall conduct periodic reviews, via personal observation of personnel performing air sampling and the analysis of resulting samples. The RSO shall ensure that personnel are adhering to the requirements of this procedure. The RSO shall review and approve documentation generated by this procedure.

Radiation Safety Officer Representative – The Radiation Safety Officer Representative (RSOR) is responsible for ensuring that the conditions of this procedure are complied with during all project operations including periodic reviews of adherence to the requirements of this procedure, ensuring that Radiological Control Technicians (RCTs) are qualified by training and experience to perform the requirements of this procedure, and conducting reviews of air sample data to verify effectiveness of engineering controls and the respirator program.

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) shall be responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible to ensure that RCTs implement and use this procedure. The RTS will ensure personnel under their cognizance observe proper precautions when using this procedure.

Radiological Control Technician – The RCT shall be responsible for the performance of the requirements of this procedure and documentation of work performed. The RCT shall ensure compliance with this and any other referenced procedure.

5.0 DEFINITIONS AND ABBREVIATIONS

Airborne Radioactivity Area – A room, enclosure, or area in which airborne radioactive material, dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases, exist in concentrations:

- In excess of the derived air concentrations (DACs) specified in the Code of Federal Regulations (CFR), Title 10 Part 20, Appendix B; or
- To such a degree that an individual present in the area without respiratory protection could exceed, during the hours that the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-HR.

Annual Limit on Intake (ALI) – The annual limit on intake (ALI) is the derived limit for the quantity of radioactive material taken into the body of a worker by inhalation or ingestion in a year.

Breathing Zone – That region adjacent to the worker's mouth and nostrils from which air is drawn into the lungs while he/she performs his/her assigned work. Air taken from this region will represent the air the worker is breathing while he/she works. The samples collected to assess breathing zone concentrations are normally collected from an area within 12 inches of the face.

Derived Air Concentration (DAC) – DAC is the concentration of a given radionuclide (as specified in 10 CFR 20, Appendix B) in air which, if breathed by the "reference man"

for a working year (40 hours per week for 50 weeks) under the conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one ALI.

DAC-HR – The product of the concentration of radioactive material in air (expressed as a multiple of the DAC for each nuclide) and the time of exposure to that nuclide, in hours. Two-thousand DAC-HRs represents one ALI.

Grab Sample – A random, single sample taken over a short period of time (dependent upon flow rate) and based upon the minimum volume required.

High-volume Air Sample – Air sample taken at an air flow rate of 10 cubic feet per minute (cfm) [283.2 liters per minute (lpm)] to 30 cfm (849.6 lpm).

Lapel Sampler – A battery-operated portable air sampler with a sample collector fastened near the breathing zone.

Low-volume Air Sample – Air sample taken at an air flow rate of 1 cfm (28.32 lpm) to 5 cfm (141.6 lpm).

Particle – An aggregate of molecules forming a solid or liquid ranging in size from a few molecular diameters to some tenths of millimeters (several hundred microns).

Representative – Having the same quality and characteristics of the entire volume from which a sample is drawn.

Sample – A representative portion of an atmosphere of interest, or one or more separated constituents from a representative portion of an atmosphere.

6.0 PROCEDURE DETAILS

Air samples will be taken in areas with the potential to exceed ten (10) percent of the DAC for any radionuclide.

Ambient air monitoring equipment shall be placed in locations representative of the airborne contamination in the work location.

Data obtained from air monitoring shall be used for assessing the control of airborne radioactivity in the workplace and to evaluate the dose equivalent to radiation workers from internal sources.

Process or other engineering controls (e.g., containment or ventilation) shall be used, to the extent practicable, to control the concentration of radioactive material in air.

Air samplers shall be operated in accordance with the manufacturers' operation and calibration procedures.

Filters of different air samples shall be placed in a separate envelope, polybag, or other suitable container to ensure that there is no possibility of cross-contamination.

During collection and handling of air samples, caution must be used to prevent the samples from being contaminated by other sources of radioactive material.

6.1 PRECAUTIONS

Avoid unnecessary contamination of air sampling equipment through the use of plastic coverings and care in handling. Do not cover the air intakes or exhausts on air samplers.

Avoid unnecessary exposure when conducting air monitoring surveys by using as low as reasonably achievable (ALARA) practices.

Air samplers used in confined spaces may ignite explosive gases. Extreme care shall be exercised, including prior sampling of the atmosphere for explosive gas and oxygen content.

Samples should be taken in such a manner as not to contaminate the sample filter with materials that are not airborne or by sucking up loose contamination from surfaces near the sampling head. Caution should be used to minimize producing airborne material by the exhaust of the sampler.

When air sample results exceed 10 percent of the DAC value, report this information to the RSOR immediately. Also, consideration should be given to isotopic analysis and area access restriction/posting in accordance with NAVSTA PS-Tt-007, *Radiological Restricted Areas - Posting and Access Control*.

6.2 TYPE OF AIR SAMPLES

6.2.1 GENERAL AREA AIR SAMPLES

General area air samples provide data representative of the work area for determining if the area should be controlled as an airborne radioactivity area. Samples are normally taken over a short period of time ranging from an hour up to one or more days. This type of sample is:

- Taken on a routine basis at predetermined times and locations, as specified by the Radiation Work Permit (RWP), Task-specific Plan (TSP), or other work document

- Uses a low-volume air sampler
- Consists of a minimum of 100 cubic feet (ft^3) (2,832 liters) of air passed through the sample filter
- Collected at between 3 and 6 feet above the floor level, in the vicinity of the workers performing the fieldwork
- Analyzed for alpha and beta activity at the on-site radiological counting laboratory

6.2.2 GRAB SAMPLES

Grab air samples are taken to evaluate the concentration of airborne radioactive radionuclides during the relatively short sampling period. This type of sample is useful for estimating the instantaneous or peak concentration of airborne contamination. This type of sample is:

- Taken as needed during radiological work coverage at the discretion of the RCT, or as directed by the RSO or RTM
- Uses a high-volume air sampler
- Consists of a minimum of 100 ft^3 (2,832 liters) of air passed through the sample filter
- Collected in the vicinity of the workers performing the fieldwork
- Analyzed for alpha and beta activity at the on-site radiological counting laboratory

6.2.3 BREATHING ZONE AIR SAMPLES

Breathing zone air samples provide data representative of the concentration of airborne radioactive material that a worker would be breathing during a particular task. This type of sample:

- Is used during the work activities with widely varying airborne contamination concentrations across the work area
- Uses a small portable air sampler with sample head attached on the worker's collar
- The sample head is usually positioned within 12 inches of the worker's face
- Consists of a minimum of 50 ft^3 (1,416 liters) of air passed through the sample filter

- Is analyzed for alpha and beta activity at the on-site radiological counting laboratory

6.3 AIR SAMPLING PROCEDURES

6.3.1 GENERAL

Sample types, number, locations and volumes will be collected as specified in an RWP, TSP or other work document.

Samples will be surveyed with a portable alpha/beta survey meter before placing in envelope or baggie. If the survey indicates the presence of contamination that exceeds background, appropriate steps will be taken to determine source of contamination and secure the area.

Samples will be sent to the on-site laboratory to be analyzed, as a minimum, for gross alpha and beta-gamma and determination (if any) of the DAC.

If sample analysis indicates airborne contamination, which exceeds 10 percent of a DAC, appropriate steps will be taken to determine source of contamination and secure the area, notify the RSO and RSOR. The RSO will notify Radiological Affairs Support Office (RASO) upon validation of the air sample analysis.

The Air Sample Identification Record (Attachment 1) and Personal Air Monitoring Log (Attachment 2) provide examples of air sampling record sheets. Equivalent or electronic forms, which provide at a minimum the information on these forms, may be used.

Air samples will be preserved and archived after analysis.

6.3.2 GENERAL AREA AIR SAMPLING

1. Determine the requirements for air sampling prior to initiating any work activities. This may be done by reviewing the Work Plan, RWP, discussion with the RSO, RSOR, RTS, and / or workers assigned to the task.
2. Test the functionality of the air sampling equipment prior to entering the work area. Check for current dates on calibration tags and recent calibration of the sampler flow meter. Any equipment not functioning properly, or with calibrations out of date will not be used. Notify the RSOR of any equipment that does not function properly.
3. Gather essential supplies before entering the work area. This may include:
    - Extension cords
    - Air sample filters

- Tongs (if necessary)
- Additional gloves
- Air sample envelopes
- Pen or marker
- Backup air sample equipment

4. Record the following information on the air sample envelope:
    - Sample identification number
    - Date
    - Location
    - Air sampler identification number
    - Start time
5. Place the air sampler on a stable surface 3 to 6 feet from the ground, in the vicinity of the workers performing the field activities.
6. Place an unused sample filter into the sample holder using care not to contaminate the filter with material on the tongs or gloves used to hold the filter while placing it into the holder. If the sampler has been in the contaminated area for some time, it is good practice to clean any visible debris or dust from around the sampler filter holder housing before placing the unused filter into the holder.
7. Operate the air sampler for the predetermined time. Verify the sampler flow rate, if a flow meter is provided on the sampler. Record any deviation from the predetermined flow rate.
8. If not provided with an automatic shut-off timer, turn the air sampler off as soon as practical after the predetermined sampling time has elapsed.
9. Prior to removing the sample from the holder, survey the sample using a hand-held alpha and beta contamination survey meter. Note the activity observed on the outside of the sample envelope.
10. If the sample survey indicates the presence of radioactive contamination and the area is not already controlled as an airborne radiation area, stop work, notify the RSOR, and implement appropriate controls, including postings. Record sample information on the sample envelope, place the sample in the envelope and immediately send to the onsite laboratory for immediate analysis and percent DAC determination.
11. Using caution not to knock debris or dust from the sample filter holder housing onto the air sample, remove the air sample from the holder using clean gloved hands or clean tongs.
12. Place the sample into the sample envelope using caution not to scrape or remove contamination from the surface of the sample.

13. Record the following information on the air sample envelope*:*
    - Stop time
    - Sample volume
    - Sample pump flow rate
14. Send the sample to the on-site counting laboratory for analysis and percent DAC determination.
15. On Attachment 1, Air Sample Identification Record (or equivalent including electronic)*,* note the sample analysis information provided by the laboratory as soon as the data is available, including:
    - Alpha count results [microCuries per milliliters (µCi/mL)]
    - Beta count results (µCi/mL)
    - Percent DAC
16. Complete Attachment 1 by transcribing the information from the sample envelope to Attachment 1 and initialing.
17. Report any higher than normal, higher than expected, greater than 10 percent of the DAC, or trending upward results to the RSO and RSOR immediately.

6.3.3 BREATHING ZONE AIR SAMPLING

The following steps will be taken for breathing zone air sampling:

1. Determine the requirements for breathing zone air sampling prior to initiating any work activities. This may be done by reviewing the Work Plan, RWP, discussion with the RSO, RSOR, RTS, and / or workers assigned to the task.
2. Assemble the individual breathing zone air sampler sets. Make sure that all hoses are firmly seated in the hose connectors found on the sample head and sample pump. Make sure that the sample head is not cracked or damaged in any way. Set any damaged or unusable equipment aside and notify the RSOR and RSO.
3. Note the relative size of the individual to whom the sampler will be issued. It may be necessary to replace the standard length belt with a longer belt, or chain two belts together to achieve the required length. Make sure that the belt buckle is not damaged and will function properly to restrain the sampler around the worker. Set any damaged or unusable equipment aside and notify the RSOR and RSO.

4. Test the functionality of the air sampling equipment prior to entering the work area. Check for current dates on calibration tags and recent calibration of the sampler flow meter. Any equipment not functioning properly, or with calibrations out of date will not be used. Notify the RSOR of any equipment that does not function properly.

   ***Note*:** Only use a sample pump containing a battery that is known to be fully charged.

5. Insert a new, unused sample filter paper into the sample head and tighten the sample head. Take care not to damage the filter paper or the sample head during this operation.

6. Prior to issuing any equipment to a worker, instruct the worker to:

   - Refrain from touching or tampering with the pump or the sample head;
   - Leave the work area if the sampler fails and note the stop time;
   - Contact the RCT for assistance when leaving the work area and at completion of work.

7. Prior to issuing any equipment to a worker, enter the following information on Attachment 2, Personal Air Monitoring Log:

   - Wearers' Name
   - Sampler ID number
   - Date

8. Attach the personal breathing zone air sampler to the worker. Make sure that the belt is tight, but not uncomfortable.

9. Attach the sample head to the worker. Make sure that the sample head is clipped securely to the worker's lapel or other piece of clothing close to the worker's face. Make sure that opening in the end of the sample head is unobstructed.

10. Check the hose connecting the sample head to the sample pump. Make sure that the hose is not kinked, crimped, or folded. Make sure that the hose is not in a position where it may become kinked, crimped, or folded during work. Make sure that it will not interfere with routine work. If any of these conditions are found, reorient the hose. It may be necessary to find alternate places to position the sample head or sample pump so the hose is unobstructed.

11. Upon arrival at the work location, turn the pump ON. Note the START TIME and flow rate on Attachment 2, Personal Air Monitoring Log.

    ***Note*:** Make sure to note whether flow rate is in units of cfm or lpm.

12. Every time a worker leaves the work area, turn the sample pump OFF and note the stop time. Upon re-entering the work area, turn the sample pump back ON and make a new notation of the re-start time.

13. At the end of the sampling period (end of the task, or end of the shift), turn the pump OFF and note the stop time on Attachment 2, Personal Air Monitoring Log.
14. Calculate the total time that the sample pump was operating by adding together the operating periods of time.
15. Calculate the total sample volume by multiplying the operating time by sampler flow rate. The result may be in units of cfm or lpm.
16. Record the total sample volume on Attachment 2, Personal Air Monitoring Log. Note the appropriate units (cfm or lpm) on Attachment *2,* Personal Air Monitoring Log.
17. Select a clean, unused sample envelope. Label the envelope with the following information:
    - Sample ID number
    - Date
    - Location
    - Worker name
    - Total sample volume (use the appropriate units – cfm or lpm)
18. Open the sample holder using caution not to remove or add to the contamination on the sample.
19. Prior to removing the sample from the holder, survey the sample using a hand-held alpha and beta contamination survey meter. Note the activity observed on the outside of the sample envelope.
20. If the sample survey indicates the presence of radioactive contamination, and the area is not already controlled as an airborne radiation area, stop work, notify the RSOR, and implement appropriate controls, including postings.
21. Using caution not to knock debris or dust from the sample filter holder housing onto the air sample, remove the air sample from the holder using clean gloved hands or clean tongs.
22. Place the sample into the sample envelope using caution not to scrape or remove contamination from the surface of the sample.
23. Confirm that the information on the sample envelope matches the information in Attachment 2, Personal Air Monitoring Log.
24. Immediately send the sample to the counting laboratory for analysis and percent DAC determination.
25. On Attachment 2, Personal Air Monitoring Log, note the sample analysis information provided by the laboratory as soon as the data is available, including:
    - Alpha count results (µCi/ml)
    - Beta count results (µCi/ml)

- Percent DAC

26. Complete the Attachment 2, Personal Air Monitoring Log.
27. Report any higher than normal, higher than expected, or trending upward results to the RSO and RSOR immediately.

6.3.4 DOCUMENTATION

Air samples shall be documented using either an Air Sample Identification Record or Personal Air Monitoring Log (or equivalent).

7.0 REFERENCES

Number	*Title*
NAVSTA PS-Tt-007	*Radiologically Restricted Areas – Posting and Access Control*

8.0 ATTACHMENTS

Attachment 1 – Air Sample Identification Record

Attachment 2 – Personal Air Monitoring Log

ATTACHMENT 1

AIR SAMPLE IDENTIFICATION RECORD

Project/Location:_____ Page ____ of ____

Sample ID	Date	Location	Start Time	Stop Time	Air Sampler ID	Sample Volume	Count Results α (μCi/ml)	Count Results β (μCi/ml)	%DAC	Counter ID

DAC derived air concentration
μCi/ml microcurie per milliliter
ID identification number
α alpha
β beta

ATTACHMENT 2

PERSONAL AIR MONITORING LOG

Name of Wearer	Sampler ID #	Date	Time On / Time Off	Flow Rate cfm /lpm	Total Volume ft^3 / Liters	Activity α (µCi/ml)	Activity β (µCi/ml)	Percent DAC

cfm	cubic feet per minute	lpm	liters per minute
DAC	derived air concentration	µCi/ml	microcurie per milliliter
Ft^3	cubic feet	α	alpha
ID	identification number	β	beta

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

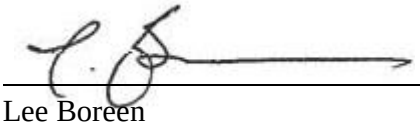
SAMPLING PROCEDURES
FOR RADIOLOGICAL SURVEYS

NAVSTA PS-Tt-006

Approved By:

Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date



Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

1.0 PURPOSE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors at the former Naval Station Puget Sound (NAVSTA PS) to perform swipe sampling and sampling of various types of media including soil, sediment, solid material (such as concrete, brick, porcelain, wood), and water. This procedure also details sample packaging and transporting samples to the laboratory.

2.0 SCOPE

This procedure shall be implemented by TtEC staff and subcontractor personnel when collecting samples on field projects related to radiological surveys at NAVSTA PS.

3.0 MAINTENANCE

The Program Chemist is designated as the procedure owner and is responsible for updating this procedure. Final approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

The following personnel (or their qualified designee) will be directly involved with the sampling procedures discussed herein.

Program Chemist - The Program Chemist is responsible for updating this procedure as necessary. In addition, the Program Chemist will coordinate with the Radiation Safety Officer Representative (RSOR) to ensure that samples are collected in conjunction with this procedure.

Radiation Safety Officer Representative (RSOR) – The RSOR is responsible for ensuring that the conditions of this procedure are complied with during project sampling operations. The RSOR shall ensure, by periodic personal observation, that samples are collected appropriately and chain-of-custody (COC) is controlled as described in this procedure. The RSOR will also ensure that Radiological Control Technicians (RCTs) are qualified by training and experience to perform the requirements of this procedure and ensure that personnel under their cognizance observe proper precautions. The RSOR will make a copy of this procedure available to the RCTs.

Radiation Safety Officer – The Radiation Safety Officer (RSO) is responsible for training personnel working with radioactive material. The RSO is responsible for the overall implementation and compliance with this procedure during all project operations. The RSO shall conduct periodic reviews, via personal observation of conducting radiation and contamination surveys, to ensure adherence to the requirements of this procedure.

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) shall be responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible for the control of radioactive material samples, supervision of RCT's performing the requirements of this procedure, and to ensure that personnel under their cognizance observe proper precautions.

Radiological Control Technician – The Radiological Control Technician (RCT) shall be responsible for the performance of the radiological survey requirements of this procedure and documentation of work performed. The RCT shall ensure compliance with this and any other referenced procedure.

Soil or Sediment Sample Collector – The Soil or Sediment Sample Collector shall be responsible for collecting soil samples, and shall ensure that the soil samples collected within a Radiologically Controlled Area (RCA) (if applicable) are radiologically surveyed by an RCT prior to removing from the RCA. Note that the Soil Sample Collector may be an RCT.

5.0 DEFINITIONS AND ABBREVIATIONS

Swipe Samples – Swipe samples are materials, which after being wiped over a surface, are analyzed to determine the presence of removable radioactivity on the surface area that was wiped.

Soil Samples – Soil samples are defined as soil collected for analytical purposes. Soil samples will be collected from the top 15 centimeters (cm) of the surface, unless otherwise noted in the applicable work-planning document [e.g. a Task-specific Plan (TSP), Work Instruction or Work Plan].

Sediment Samples – Sediment samples are defined as a collection of clay, silt, sand, and/or gravel deposited by water, wind, or glaciers used for analytical purposes.

Solid Material Samples – Solid material samples are defined as pieces of concrete, brick, porcelain, wood, or any other hard material collected for analytical purposes from buildings or surrounding areas. The samples could include accumulations from ventilation systems or drain systems.

Liquid Samples – Liquid samples are defined as liquid collected for analytical purposes from sinks, drain piping, sewer systems, rinsate, groundwater, leachate, liquid investigation-derived waste, and low-point accumulation areas inside of buildings, sumps, and excavation pits.

6.0 SAMPLING PROCEDURE DETAILS

6.1 GENERAL PROCEDURES

Field instruments used for measurements required by this procedure shall be checked with standards and verified to have current calibration.

Anytime this procedure is in effect, the RSOR (or qualified designee) should ensure, by periodic personal observation, that samples are appropriately collected and controlled.

Surface scan surveys are to be performed at each location before initiating sampling. This will identify the presence of gross contamination, which will require that samples and equipment be treated as radioactive and handled in accordance with applicable license requirements. Samples will be recorded on COC documentation.

6.2 SAMPLING PROCEDURE PROCESS

Sample activities will be recorded in the field logbook as directed by the Sampling and Analysis Plan (SAP). Sampling personnel will don a new pair of disposable nitrile gloves immediately before collecting samples at each location.

6.2.1 SWIPE SAMPLING

Swipe samples will be obtained in accordance with NAVSTA PS-Tt-003, *Radiation and Contamination Surveys*. Swipe samples will be documented in the sample logbook as applicable. Sample COC records shall be completed in accordance with the SAP.

6.2.2 SOIL SAMPLING

Because standard surface soil contamination criteria for radionuclides are applicable to the average concentration in the upper 15 cm of soil, the sampling protocol described here is based on obtaining a sample of this upper 15 cm. Special situations, such as sampling at depths greater than 15 cm, evaluating trends or airborne deposition, determining near-surface contamination profiles, and measuring non-radiological contaminants, may require special sampling procedures. These special situations will be evaluated and incorporated into TSPs as the need arises.

Samples will be collected with a hand-auger, hollow-stem auger, split-spoon sampler, disposable scoop, or equivalent. The soil removed for sampling must be sufficient to yield a sample of sufficient volume for the sample container being used. Soil samples will be collected and handled as follows:

1. Loosen the soil at the selected sampling location to a depth of approximately 15 cm, using a clean trowel or other digging instrument.

2. Remove large rocks, vegetation and foreign objects. In some cases, however, these objects may be the source of the contamination and may be collected as separate samples for characterization.
3. Place as much soil as practical into a 250-milliliter (mL)-wide mouth plastic bottle or plastic 500-mL Marinelli container.
4. If sample containers are not readily available, samples may be collected in a plastic bag for subsequent transport to the laboratory for sample preparation.
5. Tape the cap of the container in place or seal the ziplock plastic bag.
6. Label the sample container in accordance with the SAP.
7. Document all samples collected in the sample logbook as applicable. Sample COC records shall be completed in accordance with the SAP.
8. Transport samples to the laboratory for analysis as soon as possible after sample collection. Sample packaging and shipment procedures for transporting samples to an off-site laboratory are described in Section 6.3 of this procedure.
9. Clean or decontaminated tools will be used at each sampling location. Sampling tools will be decontaminated as described in the SAP.

6.2.3 SEDIMENT SAMPLING

Several methods are available to collect sediment samples. The tools used will be appropriate to the circumstances and may include use of trowels, augers, or other hand tools. Sediment sampling will be conducted as follows:

1. A hand-auger, trowel or similar device will be used to access each sampling location. The sample collection tool will be selected based on physical limitations accessing the sample location.
2. Place as much material as practical into a 250-mL-wide mouth plastic bottle or plastic 500-mL Marinelli container.
3. Follow steps 4 through 9 of Section 6.2.2 to complete sample collection.

6.2.4 SOLID MATERIAL SAMPLING

Several methods are available to collect solid material samples. To collect samples, solid materials may need to be broken into smaller pieces. Solid materials will be collected as follows:

1. Break up the material into small enough pieces to fill a 250-mL-wide mouth plastic bottle or plastic 500-mL Marinelli container.
2. Follow steps 4 through 9 of Section 6.2.2 to complete sample collection.

6.2.4.1 Pipe and Drain Line Sampling

Pipe and drain line sampling is conducted to assess residual radioactivity that may be inside of drain lines or materials within sanitary sewer and storm drain systems.

1. Since the type of material found inside drain lines varies, there is no specific method identified to collect these samples. Samples may be collected using a plumber's snake, swabs, scraper, trowel, etc.
2. As much material as possible should be collected and placed into a 250-mL-wide mouth plastic bottle or plastic 500-mL Marinelli container
3. Follow steps 4 through 9 of Section 6.2.2 to complete sample collection.

6.2.4.2 Ventilation Sampling

Ventilation sampling will be performed to identify if the system is impacted and assess the residual radioactivity that may be present.

1. If visible dust is present inside the ventilation system, use a masslin cloth to accumulate the material into a pile. (If no visible dust is present, collect a swipe sample as discussed in NAVSTA PS-Tt-003, *Radiation and Contamination Surveys*.)
2. Using a flat utensil, such as a piece of paper or scraper, carefully place as much material as possible into a 250-mL-wide mouth plastic bottle or plastic 500-mL Marinelli container.
3. Follow steps 4 through 9 of Section 6.2.2 to complete sample collection.

6.2.5 WATER SAMPLING

Water samples will be collected as follows:

1. Collect water using any of the following sampling equipment: disposable bailer, pump, coliwassa-type tube sampler, or equivalent. Care will be taken to avoid collection of bottom sediment or vegetation.
2. Fill completely a 250-mL-wide mouth plastic bottle, plastic 500-mL Marinelli container or two liter plastic bottles.
3. Follow steps 5 through 9 of Section 6.2.2 to complete sample collection.

6.3 SAMPLE PACKAGING AND TRANSPORT

Samples shall be sent for off-site analysis as described in the SAP and applicable work planning documents. A COC will be generated by the RSOR or designee for samples designated for off-site laboratory analysis. Samples designated for transport off site will be packaged in accordance with applicable Department of Transportation (DOT) and

International Air Transport Association (IATA) procedures. At a minimum, sample containers will be placed in a box, cooler, or similar container for shipment and packaged with bubble wrap or other materials as necessary to prevent container breakage.

For samples transported by an off-site laboratory courier, two custody seals will be taped across the lid of the box or cooler: one seal in the front and one seal in the back. The appropriate section(s) of the COC will be completed by the assigned courier. The box/cooler and the top two copies (white and pink) of the COC will then be released to the courier for transportation to the laboratory.

For samples shipped via a commercial carrier, the COC will include the airbill number, and the "Received By" box will be labeled with the commercial courier's name. The top two copies (white and pink) of the COC will be sealed in a resealable bag and then taped to the inside of the sample cooler lid or placed inside the box. The yellow copy of the COC will be maintained on-site and the manila copy will be submitted to the TtEC project chemist. A duplicate of the manila copy may also be kept in the TtEC project file on site. The box/cooler will be taped shut with strapping tape as necessary. Two custody seals will be taped across the lid: one seal in the front and one seal in the back. The pouch for the airbill will be placed on the box/cooler and secured with clear tape. The airbill will be completed for priority overnight delivery and placed in the pouch. If multiple boxes/coolers are being shipped, then the original airbill will be placed on the box/cooler with the COC, and copies of the airbill will be placed on the other boxes/coolers. The number of packages should be included on each airbill (1 of 2, 2 of 2). Saturday deliveries should be coordinated in advance with the designated off-site laboratory and placement of "Saturday Delivery" stickers on each box and/or cooler to be shipped should be confirmed with the commercial courier prior to release. Prepared packages will also be surveyed prior to shipment.

7.0 RECORDS

Sample collection records will include field logbooks and COCs. These records will be completed and maintained in accordance with the SAP.

8.0 REFERENCES

Number	***Title***
NAVSTA PS-Tt-003	*Radiation and Contamination Surveys*

9.0 ATTACHMENTS

None.

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

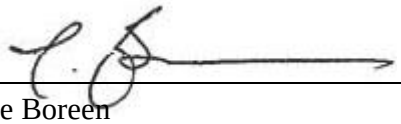
RADIOLOGICALLY CONTROLLED AREAS - POSTING AND ACCESS CONTROL

NAVSTA PS-Tt-007

Approved By:

Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date



Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

The purpose of this procedure is to specify methods and requirements for consistent posting and control of radiologically restricted areas. This procedure is intended to satisfy the posting requirements of 10 Code of Federal Regulations (CFR) 20, Standards for Protection Against Radiation.

2.0 SCOPE

This procedure identifies the types of postings necessary and requirements to clearly identify radiological conditions in a specific area or location within an area. It also specifies the requirements for access into and egress from radiologically controlled areas. This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to control entry and egress from radiologically controlled areas (RCAs) at former Naval Station Puget Sound facilities.

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer – The RSO is responsible for monitoring compliance with this procedure.

Radiological Safety Officer Representative (RSOR) – The Radiation Safety Officer Representative (RSOR) is responsible for ensuring that all RadiologicalControl Technicians (RCTs) are adequately trained to verify the adequacy of area postings and the radiological controls within an area. The RSOR is responsible for ensuring that a copy of this procedure is available at the jobsite and that field technicians follow this procedure. The RSOR is responsible for installing radiological postings and notifying the RSO when an area is initially posted or when area posting is changed.

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) shall be responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible for ensuring that RCTs implement and use this procedure. The RTS will ensure that personnel under their cognizance observe proper precautions when using this procedure.

Radiological Control Technicians – The RCT shall be responsible for the performance of the requirements of this procedure and documentation of work performed. The RCT shall ensure compliance with this and any other referenced procedure.

5.0 DEFINITIONS AND ABBREVIATIONS

Airborne Radioactivity Area – A room, enclosure or area in which radioactive material is dispersed in air in the form of dusts, fumes, particulates, mists, vapors, or gases, and the concentration of the dispersed radioactive materials is in excess of:

- The derived air concentrations (DACs) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of CFR.
- Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

Annual Limit on Intake (ALI) – The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a 1-year period. ALI is the smaller value of intake of a given radionuclide by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 sievert [Sv]) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table 1, Columns 1 and 2 of Appendix B of 10 CFR 20.) One ALI is equivalent to 2,000 DAC-hrs.

As Low As Reasonably Achievable (ALARA) – An approach to radiation protection for the control and management of exposure (both individual and collective) to the workforce and the general public; thus ensuring a level of exposure as low as social, technical, economic, practical, and public policy considerations permit. The ALARA program is structured to increase worker awareness of exposure reduction techniques and the associated benefits of that reduction.

Contaminated Area – Any area where removable surface contamination levels exceed 20 percent of the contamination limits provided in Table 1 (Attachment 1).

Derived Air Concentration (DAC) – The concentration of a given radionuclide in air which, if breathed for a working year of 2,000 hours under conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table 1, Column 3, of Appendix B of 10 CFR 20 (1-92), Standards for Protection Against Radiation.

Fixed Contamination –Surface contamination exceeding the contamination limits provided in Table 1 (Attachment 1) that cannot be readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe, or masslin.

Radiation Area – Any area accessible to personnel in which there exists ionizing radiation at exposure rates such that an individual could receive a deep dose equivalent (DDE) in excess of 5 millirem (mrem) in 1 hour at 30 centimeters (cm) from the radiation source or from any surface that the radiation penetrates.

Radiation Work Permit (RWP) – A document generated, in accordance with NAVSTA PS-Tt-001, *Issue and Use of Radiation Work Permits*, to provide specific requirements for radiological activities.

Radioactive Materials Area (RMA) – Any designated area where radioactive materials are stored or used. Posting of an RMA is not required if the radioactive material is stored inside a radiation area, contaminated area or airborne radioactivity area.

Radiologically Controlled Area (RCA) – An area containing radioactive materials (in excess of the levels provided in Table 1) to which access is controlled to protect individuals from exposure to ionizing radiation.

Underground Radioactive Materials Area (URMA) –An underground area that is known to contain radioactive materials such as pipelines, tanks, cribs, covered ponds, covered ditches, catch basins, inactive burial grounds and sites of known, covered spills.

6.0 PROCEDURE DETAILS

6.1 GENERAL

This procedure will address establishing and posting:

- RCAs
- RMAs
- Radiation areas
- Contaminated areas
- Airborne radioactivity areas
- Underground RMAs

6.1.1 PRECAUTIONS

Personnel working in a RCA shall:

- Comply with all radiation protection instructions and postings.
- Refrain from eating, drinking, smoking or chewing while in a RCA.
- Perform jobs or tasks in such a manner that minimizes the creation or spread of contamination.
- Ensure that tools and equipment are surveyed prior to removing the items from a RCA.
- Refrain from loitering in radiation areas.
- Wear dosimetry in a manner required by the RWP.
- Perform a personal contamination survey upon exit from a RCA.
- Immediately report the loss, damage or unexpected exposure of dosimetry to the RSOR.
- Notify the RTS of any wounds, sores or rashes before entering any area where contamination exists.
- Exit immediately if a wound occurs in a RCA, notify the RCT and seek first aid.
- Follow any additional requirements dictated by the RSO, RSOR, RTS or RCT.

6.1.2 SIGNAGE

All posted areas will be designated an RCA. Additional restricted areas (such as a CA, RA, RMA, ARA) may be posted within an RCA, as necessary, to identify additional precautions that may be required.

Signs identifying radiological hazards shall be posted on all entrances and accessible sides of the barrier surrounding the identified RCA. Signs identifying radiological hazards shall be firmly attached to the barrier or entrances with materials that will withstand the effects of adverse weather and normal use conditions. If signs with the exact wording are not readily available, alternative phrases may be used as long as the same requirements are clearly communicated by the posting. Signs will be identified in English and Spanish.

6.1.3 SURVEYS

Radiation and contamination surveys for establishing and maintaining RCAs shall be

performed in accordance with NAVSTA PS-Tt-003, *Radiation and Contamination Surveys.*

6.2 PROCEDURE PROCESS

6.2.1 ESTABLISHING AND POSTING RADIOLOGICALLY CONTROLLED AREAS

RCAs shall be designated by clearly and conspicuously posting all entrances and all other accessible sides of the area with a sign bearing the following:

The sign will also list requirements for entering the RCA. To enter a RCA, a person must meet all posted requirements.

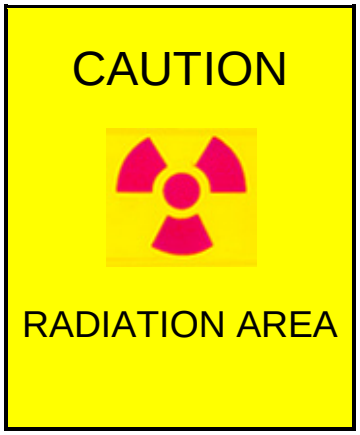
6.2.2 POSTING REQUIREMENTS FOR RADIOACTIVE MATERIALS AREAS

Radiation protection personnel shall post any area or room in which radioactive materials are stored with a sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIALS AREA."

When posting a room, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the radioactive material shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction. If signs with these exact words are not readily available, alternative phrases may be used as long as the same requirements are clearly communicated by the posting.

6.2.3 Establishing and Posting Radiation Areas

Radiation protection personnel shall post radiation areas with signs bearing the radiation symbol and the words “CAUTION, RADIATION AREA.”



If an entire room or most of a room is at or above the 5milliroentgen per hour (mR/hr) level, a sign should be placed on each entrance door to the room. If the area to be

posted is not a room, the area at or above the 5 mR/hr level shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction. If a posting is placed on a door in a manner that would prevent the posting from being observed if the door is propped open, an additional posting shall be placed in the doorway.

A single entry/exit point shall be established to access the radiation area. Access into radiation areas shall be limited to radiation workers wearing dosimetry that are signed-in on an approved RWP.

6.2.4 ESTABLISHING AND POSTING CONTAMINATED AREAS

6.2.4.1 Removable Surface Contamination

Radiation protection personnel shall post any contaminated area with a sign or signs bearing the radiation symbol and the words “CAUTION, CONTAMINATED AREA.”

When posting a room, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the contamination shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction.

A single entry/exit point shall be established to access the contaminated area. A step-off pad is placed at the entry/exit point that provides a defined boundary between contaminated and non-contaminated areas. Each contaminated area that is to be entered shall have a step-off pad maintained in an uncontaminated condition located at the access/egress point.

Contaminated areas, which require personnel access on a daily basis, should have a frisking station located as close to the access/egress point as is reasonably possible, taking background radiation levels and work processes into consideration. All personnel exiting a contaminated area shall perform personnel contamination monitoring in accordance with the applicable RWP.

6.2.4.2 Fixed Contamination

If the area of contamination is within a RCA, the boundaries of the contaminated area will be delineated in such a way to identify it for future characterization.

If the area of contamination is not within a RCA, then the area will be posted as a contaminated area, as described in Section 6.2.4.1.

6.2.5 Establishing and Posting Airborne Radioactivity Areas

TtEC policy is to minimize the amount of radioactive materials taken into a worker's body. In order to accomplish this, Airborne Radioactivity Areas are posted at 10 percent DAC, as specified in Table 1, Column 3 of Appendix B of 10 CFR 20. Maintaining the airborne activity below these limits will eliminate any posting requirements.

To verify that the limits for airborne radioactivity are not exceeded, air sampling will be performed continuously during each work activity. The results of the air samples are compared with the limits above to verify that the limits are not exceeded. If the limits are exceeded, immediately contact the RTM or designee.

Radiation protection personnel shall post any Airborne Radioactivity Area or room with a sign or signs bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIOACTIVITY AREA."

When posting a room, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the airborne radioactivity shall be bounded by signs fastened to stanchions, posts or other sturdy structures. The signs will be positioned such that they are conspicuous when the area is approached from any accessible direction.

6.2.6 ESTABLISHING AND POSTING UNDERGROUND RADIOACTIVE MATERIALS AREAS

The entrance to any area (normally outside areas) shall be posted to indicate the presence of identified underground items that are known to contain radioactive materials such as pipelines, tanks, cribs, covered ponds, covered ditches, catch basins, inactive burial grounds and sites of known, covered, spills.

The entrances to the areas shall be clearly and conspicuously posted:

Underground radioactive material areas shall also be posted “Authorized Personnel, RWP Required for Entry.” If signs with these exact words are not readily available, alternative phrases may be used as long as the same requirements are clearly communicated by the posting.

7.0 RECORDS

Documentation generated by the implementation of this procedure shall consist of recording the date and location of any radiologically controlled, radioactive material, radiation, contaminated or airborne radioactivity areas established in the project logbook. Include a sketch of the area and area boundary on survey forms.

8.0 REFERENCES

Number	*Title*
NAVSTA PS-Tt-001	*Issue and Use of Radiation Work Permits*
NAVSTA PS-Tt-003	*Radiation and Contamination Surveys*
NRC Reg. Guide 1.86	*Termination of Operating Licenses for Nuclear Reactors*

9.0 ATTACHMENTS

Table 1

TABLE 1

CONTAMINATION LIMITS TABLE

	Surfaces			Soil		Sludge	
Radionuclide	Equipment, Waste (dpm/100 cm^2)[a]	Structures (dpm/100 cm^2)[b]	Residual Dose (mrem/y)[c]	Residential (pCi/g)[d]	Residual Dose (mrem/y)[c]	Residential (pCi/g)[d]	Residual Dose (mrem/y)[c]
Cesium-137	5,000	5,000	1.72	12.5	25	270.7	25
Radium-226	100	100	0.612	1.6	25	6.1	25
Strontium-90	1,000	1,000	0.685	6.2	25	17.3	25

Notes:

Criteria for other nuclides will be listed in TSPs, if needed.

[a] These limits are based on AEC Regulatory Guide 1.86 (1974). Limits for removable surface activity are 20 percent of these values.

[b] These limits are based on 25 mrem/y using RESRAD-Build Version 3.3 or Regulatory Guide 1.86, whichever is lower.

[c] The resulting dose is based on modeling using RESRAD-Build Version 3.3 or RESRAD Version 6.3.

[d] The off-site laboratory will ensure that the MDA as specified in the Sampling and Analysis Plan meets the listed release criteria by increasing sample size or counting time as necessary. The MDA is defined as the lowest net response level, in counts, that can be seen with a fixed level of certainty, customarily 95 percent. The MDA is calculated per sample by considering background counts, amount of sample used, and counting time.

Abbreviations and Acronyms:

AEC – Atomic Energy Commission
cm^2 – square centimeter
dpm – disintegrations per minute
EPA – U.S. Environmental Protection Agency
MDA – minimum detectable activity
mrem/y – millirems per year
pCi/g – picocuries per gram
TSP – Task-specific Plan

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

CONTROL OF RADIOACTIVE MATERIAL

NAVSTA PS-Tt-008

Approved By:

Erik J. Abkemeier

Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date

Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

The purpose of this procedure is to specify methods and requirements for tracking and controlling radioactive material (RAM) collected or generated during survey, characterization and remediation activities at the former Naval Station Puget Sound (NAVSTA PS) by Tetra Tech EC, Inc. (TtEC) and its subcontractors.

Through the use of the guidance in this procedure, TtEC and its subcontractors shall meet or exceed the requirements for their respective NRC radioactive materials licenses (RMLs).

2.0 SCOPE

This procedure governs control of RAM on site and shall be implemented by TtEC staff and subcontractor personnel when handling RAM at NAVSTA PS. The requirements given in this procedure are limited to RAM collected or generated during survey, characterization and remediation activities at NAVSTA PS.

Procedures for the preparation and labeling of RAM for shipment are beyond the scope of this document. Packaging, labeling, and shipment of RAM shall be conducted in accordance with the requirements of 49 Code of Federal Regulations (CFR) and other applicable regulations.

Radioactive waste will be packaged in an appropriate container. The waste containers will be maintained under TtEC's RML, until disposed of via the Navy's Low-level Radioactive Waste program.

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer – The RSO is responsible for updating the base wide radioactive waste inventory (RWI) of RAM waste maintained at NAVSTA PS. The RSO is also responsible for ensuring that subcontractors are implementing this procedure.

Radiation Safety Officer Representative (RSOR) – The Radiation Safety Officer Representative (RSOR) is responsible for ensuring that all personnel assigned the tasks of control and tracking of RAM are familiar with this procedure, adequately trained in the use of this procedure and have access to a copy of this procedure. The RSOR is responsible for ensuring that the conditions of this procedure are complied with during all project operations. Additionally, the RSOR is responsible for ensuring that Radiological Control Technicians (RCTs) are qualified by training and experience to

perform this procedure and for training RCTs in the performance of this procedure. The RSOR is also responsible for maintaining an inventory of their samples maintained at NAVSTA PS.

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) shall be responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible for ensuring that RCTs implement and use this procedure. The RTS will ensure that personnel under their cognizance observe proper precautions when using this procedure.

Radiological Control Technician – The RCT shall be responsible for the performance of the requirements of this procedure and documentation of work performed. The RCT shall ensure compliance with this and any other referenced procedure.

5.0 DEFINITIONS AND ABBREVIATIONS

Container – Any package or barrier which is used to enclose RAM so that it can be easily handled and contained. Examples of containers include drums, roll-off boxes, conex boxes, fiber, metal, wooden or cardboard boxes, plastic or glass jars, metal cans, bags (ziplock or open top), plastic sheeting or any other package that meets the requirements of this definition.

Control - In relation to handling of RAM, control is defined as having physical custody, being in the immediate vicinity of, or in line-of sight of the RAM. Control also refers to being responsible for the securing of RAM to prevent unauthorized access.

Mixed Waste – Waste that contains a hazardous waste component and a RAM component.

Radioactive Material (RAM) – For purpose of activities at NAVSTA PS, RAM is defined as any material (e.g. soil, demolition debris, etc.), solid samples or swipes, or equipment (tools, instruments, etc.), that has a radioactive component (fixed or removable) at or above the levels specified in Table 6-1.

Radioactive Materials Area (RMA) – Any designated area where RAM is stored or used. Posting of an RMA is not required if the RAM is stored inside a posted, radiation area, contaminated area or airborne radioactivity area.

Radiologically Controlled Area (RCA) – An area containing RAM (in excess of the levels provided in Table 6-1) to which access is controlled to protect individuals from exposure to ionizing radiation.

Samples – Aliquots (portions) of material deposited on or placed within a container for the purposes of transferring and performing a quantitative or qualitative analysis of that material.

6.0 PROCEDURE DETAILS

6.1 CLASSIFICATION AND IDENTIFICATION OF RADIOACTIVE MATERIAL

6.1.1 RADIOACTIVE MATERIAL LIMITS

Table 6-1 identifies the limits of contamination and/or activity for defining RAM at NAVSTA PS.

TABLE 6-1

CONTAMINATION LIMITS TABLE

	Surfaces			Soil		Sludge	
Radionuclide	Equipment, Waste (dpm/100 cm^2)[a]	Structures (dpm/100 cm^2)[b]	Residual Dose (mrem/y)[c]	Residential (pCi/g)[d]	Residual Dose (mrem/y)[c]	Residential (pCi/g)[d]	Residual Dose (mrem/y)[c]
Cesium-137	5,000	5,000	1.72	12.5	25	270.7	25
Radium-226	100	100	0.612	1.6	25	6.1	25
Strontium-90	1,000	1,000	0.685	6.2	25	17.3	25

Notes:

Criteria for other nuclides will be listed in TSPs, if needed.

[a] These limits are based on AEC Regulatory Guide 1.86 (1974). Limits for removable surface activity are 20 percent of these values.

[b] These limits are based on 25 mrem/y using RESRAD-Build Version 3.3 or Regulatory Guide 1.86, whichever is lower.

[c] The resulting dose is based on modeling using RESRAD-Build Version 3.3 or RESRAD Version 6.3.

[d] The off-site laboratory will ensure that the MDA meets the Sampling and Analysis Plan listed release criteria by increasing sample size or counting time as necessary. The MDA is defined as the lowest net response level, in counts, that can be seen with a fixed level of certainty, customarily 95 percent. The MDA is calculated per sample by considering background counts, amount of sample used, and counting time.

Abbreviations and Acronyms:

AEC – Atomic Energy Commission
cm^2 – square centimeter
dpm – disintegrations per minute
EPA – U.S. Environmental Protection Agency
MDA – minimum detectable activity
mrem/y – millirems per year
pCi/g – picocuries per gram
TSP – Task-specific Plan

6.1.2 IDENTIFICATION OF RADIOACTIVE MATERIAL

Determination of whether or not to classify material or equipment as RAM waste is accomplished by surveying and/or sampling the material or equipment. In the absence of survey data, material originating from impacted areas or RCAs shall be classified as

RAM and handled accordingly until proven otherwise by instrument survey or laboratory analysis.

6.1.3 MIXED WASTE

Mixed waste may be encountered or generated during remediation or decontamination activities at NAVSTA PS. If the radiological and chemical components in the waste can be easily separated by physical means, this shall be done to allow for each component to be handled separately. Work to be performed at NAVSTA PS shall be conducted to minimize mixed waste. Chemicals used for chemical decontamination activities shall be selected to minimize the creation of mixed waste. When it is impossible to segregate hazardous and radioactive components of materials or equipment designated for disposal, then the item(s) must be handled as a mixed waste. Applicable precautions and guidance for handling both RAM and hazardous material must be used for mixed wastes.

6.2 STORAGE OF RADIOACTIVE MATERIAL

Radioactive material must be stored in a posted area as specified below to communicate the material hazard present to personnel that may encounter the material. Posting will be done in accordance with NAVSTA PS-Tt-007, *Radiologically Restricted Areas – Posting and Access Control*. RAM waste shall be containerized, whenever possible, or otherwise protected and stored in pre-authorized areas determined concurrently by the Radiological Affairs Support Office (RASO) and the Remedial Project Manager. Control must be maintained over all RAM to minimize personnel exposure and the spread of contamination. Requirements for containerizing, posting, and control of RAM are given below.

6.2.1 CONTAINERIZING

To the greatest extent possible, RAM waste should be containerized for storage. To facilitate containerization, equipment that can be disassembled should be broken down into the smallest number of components practical. Sharp edges or projections should be blunted, taped or otherwise secured to ensure that the package will maintain integrity during subsequent handling operations.

If object size does not allow for disassembly and containerization is not possible, then a plastic covering can be used to minimize the potential for the spread of contamination.

For bulk items, such as soil stockpiles, where containerization is not practicable, the materials will be placed on an impervious material and covered to prevent the spread of the material.

Items that exceed 100 times the limits in Table 6-1 should be packaged such that two barriers exist (i.e., double-wrapped or bagged inside a rigid container).

6.2.2 POSTING

Posting will be done in accordance NAVSTA PS-Tt-007, *Radiologically Restricted Areas - Posting and Access Control*

RAM waste that is stored in a building requires that the entrances to the building be posted as a RCA, and a cordoned off area within the building posted as the RMA. If RAM waste is stored in stockpiles or in large containers that are stored outdoors, the stockpiles or containers shall be located within an RCA. The immediate area around the stockpile or containers will be cordoned off and posted as an RMA.

6.2.3 CONTROL

The control of RAM shall be performed in accordance with the provisions of 10 CFR 20, Standards for Protection Against Radiation; NAVSTA PS-Tt-007, *Radiologically Restricted Areas – Posting and Access Control,* NAVSTA PS-Tt-009, *Release of Materials and Equipment from Radiologically Controlled Areas*, NAVSTA PS-Tt-010, *Decontamination of Equipment and Tools*.

Radioactive material should be consolidated in common RMAs to the greatest extent possible to simplify the implementation of adequate materials control. Control of RMAs will include security measures (i.e., locks, fencing, packaging, etc.) to preclude unauthorized access to or removal of RAM. Access shall also be controlled to prevent non-radiation workers from gaining entry to RMAs. RMAs will be inspected at least once a week by an RCT. RCTs shall note the physical status of RMAs noting:

- Locked/secure status
- Labeling/posting
- Condition of containers

6.3 RADIOACTIVE WASTE INVENTORY MANAGEMENT

A radioactive waste inventory (RWI) program will be used to track RAM waste generated during survey and remediation activities. The program includes the provision for regular inventory checks. The specific requirements for inventory management are given in the following sections.

6.3.1 CONTAINER/STOCKPILE INVENTORY

A running inventory of materials in a container will be kept on the container. Stockpile inventories will be kept in the TtEC site trailer. Inventories of material in a container or stockpile will be kept on the Stockpile/Container Inventory Log Sheet, or equivalent, (Attachment 1). The log sheet will be updated as material is added to containers or stockpiles.

6.3.2 REPORTING

TtEC shall receive weekly inventory updates from its subcontractors updating the amount of RAM waste maintained by them. These reports should indicate that the location and status for all RAM waste has been verified and accounted for. In addition, the reports will include the following information for new RAM waste:

- Point of origin
- Storage location
- Removal Date
- Waste description
- Isotope and activity (If known)
- Other hazardous constituents (If known)
- Quantity or volume
- Waste packaging dates
- Any additional comments

TtEC will maintain a master RWI of all RAM waste at NAVSTA PS. The RWI for the project will be updated weekly by the RSOR.

6.4 DISPOSITION OF RADIOACTIVE MATERIAL

Disposition of RAM collected during remediation, surveys, or generated through site activities will either be disposal or reduction in volume by decontamination. The considerations for these two activities are discussed below.

6.4.1 DECONTAMINATION

In some instances, it may be possible to reduce the volume of RAM by decontaminating items contaminated with RAM to levels at which the item no longer needs to be classified as RAM. The guidance for determining if decontamination is appropriate and for actually performing decontamination is given in NAVSTA PS-Tt-010, *Decontamination of Equipment and Tools*.

Any former RAM that has been decontaminated to levels below those requiring classification as RAM shall have any RAM labels removed or otherwise defaced such that the wording and radiation symbol are no longer legible. Additionally, the status of any inventoried RAM that has been decontaminated shall be updated on the associated data sheets and in the RWI to indicate that it is no longer an actively tracked RWI item.

6.4.2 DISPOSAL

Unwanted RAM will be disposed of as LLRW. Preparation of material for disposal and actual disposal shall be conducted under the approved procedures of a licensed waste broker through the Navy Low-Level Radioactive Waste Disposal Program. The status of RAM waste that has been disposed of and removed from the site shall be updated on

inventory data sheets and in the RWI to indicate that the item is no longer in storage on site.

7.0 RECORDS

Weekly waste inventory reports will be retained as records. Additionally, an electronic RWI containing a master list of all RAM waste on site shall be maintained as part of the project files.

8.0 REFERENCES

Number	***Title***
AEC Regulatory Guide 1.86	*Termination of Operating Licenses for Nuclear Reactors*
10 CFR 20	*Standards for Protection Against Radiation*
NAVSTA PS-Tt-007	*Radiologically Restricted Areas – Posting and Access Control*
NAVSTA PS-Tt-009	*Release of Materials and Equipment from Radiologically Controlled Areas*
NAVSTA PS-Tt-010	*Decontamination of Equipment and Tools*

9.0 ATTACHMENTS

Attachment 1 – Stockpile/Container Inventory Log Sheet

Attachment 2 – Radioactive Waste Inventory Log Sheet

ATTACHMENT 1

STOCKPILE/CONTAINER INVENTORY LOG SHEET

Drum ID # Page of

Description of Item	Item ID #	Date	Time (24 hr)	Contact Dose Rate - µR/hr	Initials

ATTACHMENT 2

RADIOACTIVE WASTE INVENTORY LOG SHEET

Point of Origin	Storage Location	Collection Date	Target Removal Date	Waste Description	Isotope and Activity Content	Other Hazardous/Regulated Constituents	Quantity or Volume	Waste Packaging Date(s)	Waste Shipping Date(s)	Additional Information

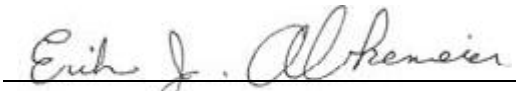
FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

RELEASE OF MATERIALS AND EQUIPMENT FROM RADIOLOGICALLY CONTROLLED AREAS

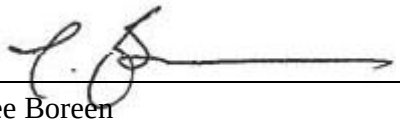
NAVSTA PS-Tt-009

Approved By:



Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date



Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

The purpose of this procedure is to specify the radiological survey requirements for releasing materials and equipment from radiologically controlled areas (RCAs).

2.0 SCOPE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to release materials from RCAs.

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) is designated the procedure owner and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer – The RSO is responsible for the overall implementation and compliance with this procedure during all project operations. The RSO will assist in the interpretation of results obtained during surveys. The RSO shall conduct periodic reviews to ensure adherence to the requirements of this procedure.

The RSO is responsible for the training of personnel performing work detailed by this procedure.

Radiological Safety Officer Representative – The Radiological Safety Officer Representative (RSOR) is responsible for ensuring that all personnel assigned the task of performing surveys in support of unconditionally releasing materials from controlled areas are familiar with this procedure, trained in the use of this procedure, and have access to a copy of this procedure. The RSOR is responsible for ensuring Radiological Task Supervisors (RTSs) are implementing this procedure for work performed under their cognizance. The RSOR ensures that the Radiological Control Technicians (RCTs) performing activities governed by this procedure are implementing this procedure. The RSOR will review survey data and approve the unconditional release of materials and equipment from RCAs. The RSOR will notify the RSO of any unsafe or unusual conditions observed during performance of this procedure.

Radiological Task Supervisor – The RTS is responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible for the control of radioactive material, coverage of radiation workers, and to ensure that personnel under their cognizance observe proper precautions. The RTS is responsible for notifying the RSOR of any unsafe or unusual conditions observed during performance and implementation of this procedure.

Radiological Control Technician – The RCT is responsible for the performance of the requirements of this procedure and documentation of work performed. The RCT shall ensure compliance with this and any other referenced procedure. The RCT is responsible for notifying the RTS of unsafe or unusual conditions.

5.0 DEFINITIONS AND ABBREVIATIONS

Contamination – Deposition of radioactive material in any place it is not desired. Contamination may be due to the presence of alpha particle, beta particle or gamma ray emitting radionuclides.

Fixed Surface Contamination – Radioactive contamination that is not readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe or masslinn.

Radiologically Controlled Area (RCA) – An area containing radioactive materials (in excess of the levels provided in Table 1 of Standard Operating Procedure NAVSTA PS-Tt-007, *Radiologically Controlled Areas – Posting and Access Control*) to which access is controlled to protect individuals from exposure to contamination and ionizing radiation.

Release for Unrestricted Use – The authorization to remove or reuse equipment and/or material from a RCA. Such authorization will be based on review of survey data confirming that the material and/or equipment being released does not exhibit radiation levels exceeding those in Table 5-1.

Removable Surface Contamination – Radioactive contamination that is readily removed from a surface by applying light to moderate pressure when wiping with a paper or cloth disk swipe or masslinn.

6.0 PROCEDURE DETAILS

6.1 GENERAL

Materials and equipment will be released from RCAs based on surveys for fixed and removable contamination. Surveys for fixed and removable surface contamination shall

be conducted and documented in accordance with NAVSTA PS-Tt-003, *Radiation and Contamination Surveys.*

6.2 LIMITATIONS

This procedure shall not be used for personnel surveys. Personnel will be surveyed in accordance with NAVSTA PS-Tt-012, *Personnel Protective Equipment, Monitoring, And Decontamination.*

6.3 RELEASE PROCEDURE

6.3.1 MATERIAL HISTORY

Upon receipt of an item presented for release from RCAs, the history of the item should be determined. This determination should include if possible:

- The current and past use of the item.
- The location(s) in which the item was used or stored.
- If the item was in an area where radioactive material was used or stored.

This history will be used, if applicable, to evaluate the potential for contamination to be present on inaccessible surfaces of the item.

6.3.2 CONTAMINATION SURVEYS

All accessible surfaces will be surveyed for removable and fixed surface contamination in accordance with NAVSTA PS-Tt-003, *Radiation and Contamination Surveys.*

Swipes will be taken on all accessible surfaces of the material and equipment. Swipes collected for removable surface contamination shall be analyzed with a Ludlum Model 2929 scaler with a Model 43-10-1 ZnS(Ag) scintillation probe (or equivalent).

Scan surveys will be conducted on all accessible surfaces of the material or equipment. Whenever practical, 100 percent of the accessible area will be scanned for alpha, beta, and gamma.

Following scan surveys, static survey measurements will be collected. The number of static surveys will be determined by:

- The size and history of the item
- Preliminary results of the swipe and scan surveys
- If an increase in the audible and/or digital/analog count rate was detected
- If during the survey, the RCT determines that there may be fixed activity present

6.3.3 INACCESSIBLE SURFACES

If items have inaccessible surfaces that may have been exposed to contamination, or if it is unknown if they have been exposed to contamination, the items should be disassembled as completely as possible to facilitate release surveys. Items with inaccessible surfaces will not be released from an RCA, unless evaluated and documented by the RSO or designee in conjunction with RASO.

6.3.4 RELEASE OF MATERIAL AND EQUIPMENT

The following steps shall be taken for release of material and equipment:

1. If the results of the swipe, scan and static surveys do not exceed the limits of Table 5-1 then the material may be released for unrestricted use.
2. If the swipe, scan or static survey results indicate contamination, which exceeds the limits of Table 5-1, the material shall be secured and managed in accordance with NAVSTA PS- Tt-008, *Control of Radioactive Material*. Material that cannot be released for unrestricted use will be evaluated for decontamination in accordance with NAVSTA PS-Tt-010, *Decontamination of Equipment and Tools,* or packaged for disposal.
3. Results of the swipe, scan and static surveys shall be documented in accordance with NAVSTA PS-Tt-003, *Radiation and Contamination Surveys*.
4. If the equipment and/or materials are being returned to a vendor or removed from the former Naval Station Puget Sound, a completed Attachment 1 – Unconditional Release of Equipment or Materials Form – or copy of the Radiation/Contamination Survey and Supplement form (Attachments 1 and 2 from NAVSTA PS-Tt-003, *Radiation and Contamination Surveys)* with the statement “Equipment or materials have been surveyed and found to be within acceptable surface contamination levels for unconditional release as required by AEC Guide 1.86” written or stamped on the Radiation/Contamination Survey Form or equivalent will accompany the equipment and/or material.

TABLE 5-1

RELEASE LIMITS FOR MATERIALS AND EQUIPMENT

Radiation Type	Release Limits[1] (Fixed) (dpm per 100 cm^2)	Release Limits[1] (Removable) (dpm per 100 cm^2)
Alpha (α) Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	20
Beta (β-) Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	200
Beta-Gamma (β-γ) Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	1,000

Notes:

[1] These limits are based on AEC Regulatory Guide 1.86 (AEC, 1974)

Abbreviations and Acronyms:
AEC – Atomic Energy Commission
cm^2 – square centimeters
dpm – disintegrations per minute

7.0 REFERENCES

Number	***Title***
AEC Regulatory Guide 1.86	*Termination of Operating Licenses for Nuclear Reactors*
NAVSTA PS-Tt-003	*Radiation and Contamination Surveys*
NAVSTA PS-Tt-007	*Radiologically Controlled Areas – Posting and Access Control*
NAVSTA PS-Tt-008	*Control of Radioactive Materials*
NAVSTA PS-Tt-010	*Decontamination of Equipment and Tools*
NAVSTA PS-Tt-012	*Radiological Protective Clothing Selection, Monitoring, and Decontamination*

8.0 ATTACHMENTS

Attachment 1 – Unconditional Release of Equipment or Materials Form.

ATTACHMENT 1

UNCONDITIONAL RELEASE OF EQUIPMENT OR MATERIALS FORM

Survey #:			Date:	
Description of equipment or materials:				
SURVEY EQUIPMENT:				
Model No:	S/N:	Background:	Eff:	Cal Due Date:
Model No:	S/N:	Background:	Eff:	Cal Due Date:
Model No:	S/N:	Background:	Eff:	Cal Due Date:
CONTAMINATION LEVELS:				
		dpm/100 cm^2 $\beta\gamma$ Removable		Maximum
		dpm/100 cm^2 α Removable		Maximum
		dpm/100 cm^2 $\beta\gamma$		Maximum Fixed
		dpm/100 cm^2 α		Maximum Fixed
This is to certify that the above described equipment or materials have been surveyed and found to be within acceptable surface contamination levels for unconditional release as required by Atomic Energy Commission Regulatory Guide 1.86.				
Radiological Control Technician:				Date/Time:
Disposition of equipment or materials:				
Reviewed By:				Date:

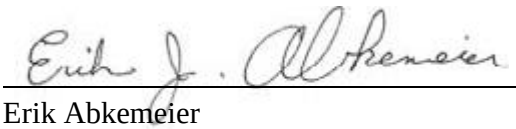
FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

DECONTAMINATION OF EQUIPMENT AND TOOLS

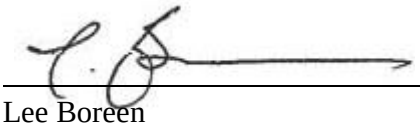
NAVSTA PS-Tt-010

Approved By:



Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date



Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

This procedure provides instruction and methods for the decontamination of equipment and tools that are contaminated with radioactive material.

2.0 SCOPE

This procedure provides the methods Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors at the former Naval Station Puget Sound (NAVSTA PS) will use for decontamination of equipment and tools that are contaminated with radioactive material.

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) is responsible for compliance with this procedure and with updating this procedure as required. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Construction Manager – The construction manager shall be responsible for identifying locations that can be used for decontamination of equipment and materials, if necessary.

Radiation Safety Officer – The RSO is responsible for selecting the location that will be used for decontamination of equipment and materials. The RSO is also responsible for performing periodic surveillance of the decontamination operation and to ensure adherence to this procedure. The RSO shall review documentation generated while implementing this procedure and periodically inspect decontamination activities.

Radiation Safety Officer Representative – The **Radiation Safety Officer Representative** (RSOR) is responsible for the implementation of this procedure. This requires conducting periodic reviews of the adherence of personnel to the requirements of this procedure, supervising the personnel performing decontamination activities, and ensuring that the technicians have appropriate knowledge, training, and experience to perform the requirements of this procedure. In addition, the RSOR will assign staff to direct and monitor decontamination activities, conduct decontamination operation pre-job briefings, and provide release evaluations of decontaminated materials.

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) is responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible for ensuring that the Radiological Control Technicians (RCTs) implement and use this procedure. The RTS will ensure that personnel under their cognizance observe proper precautions when using this procedure.

Radiation Control Technicians – RCTs are responsible for performing the surveys of decontaminated items and ensuring that radioactive material is not released to the public or environment.

Radiological Support Personnel - Radiological support personnel are laborers performing field activities in support of decontamination activities.

5.0 DEFINITIONS AND ABBREVIATIONS

Decontamination – The processes whereby contamination can be safely and effectively removed from equipment and tools.

HERCULITE® – A plastic or polyethylene floor covering and containment material used for decontamination operations. HERCULITE is a brand name.

Material Safety Data Sheet (MSDS) – Manufacturer directions, safety information and limitations for use of decontamination-related solvents or cleaning solution.

6.0 PROCEDURE DETAILS

6.1 GENERAL

6.1.1 PRECAUTIONS

The following precautions shall be observed during decontamination activities:

- Decontamination of contaminated tools or equipment shall be performed under the supervision of the RTS or RCT providing the job coverage.
- Areas used for decontamination shall be posted and controlled in accordance with the provisions of procedure NAVSTA PS-Tt-007, *Radiologically Controlled Areas - Posting and Access Control.*
- Controls to contain the spread of loose contamination during the decontamination activity shall be planned and established prior to the decontamination of equipment, material and tools.
- Use of chemicals or solvents for decontamination purposes that have the potential to produce mixed waste shall be avoided whenever possible. Use of these chemicals or solvents requires the prior approval of the RSO.
- Survey instruments that will be used to survey suspected contaminated equipment or tools should be protected (wrapped in plastic, etc.) against possible contamination before use.

- Abrasive measures should only be applied to surfaces that are not critical for operation of devices being returned to working condition.
- Electric power tools should not be used on a wet working surface. Liquids will be kept away from electric power tools.

6.1.2 LIMITATIONS

The following limitations apply to decontamination activities:

- Protective clothing worn by the personnel involved in decontamination activities shall be determined according to the RWP.
- Decontamination cleaning solvents/solutions shall only be used in accordance with the directions and limitations listed on the manufacturer-supplied MSDS and in accordance with the requirements listed in Section 6.1.1.
- Respiratory protection devices required by the RWP for decontamination operations shall be selected and used in accordance with the provisions of NAVSTA PS-Tt-011, *Radiological Respiratory Protection Policy.*
- A pre-job briefing shall be held to review the conditions of the RWP. All personnel performing work in the decontamination area shall read, understand, and sign the RWP prior to work.
- Contamination controls shall be observed throughout a decontamination operation.
- Radiation and contamination surveys shall be performed in accordance with the provisions of procedure NAVSTA PS-Tt-003, *Radiation and Contamination Surveys.*
- Release of equipment and tools from the decontamination area shall be performed in accordance with the provisions of NAVSTA PS-Tt-009, *Release of Materials and Equipment from Radiologically Controlled Areas*.

6.2 PRE-DECONTAMINATION PREPARATION

The following steps shall be used for pre-decontamination preparation:

1. The RSOR, or designee shall review available data regarding the item(s) requiring decontamination and, in consultation with the RSO, develop a decontamination approach from the applicable alternatives described herein. The RSO will have final approval authority of the decontamination approach.
2. A radiological survey shall be performed to identify the level of radioactive contamination that is present by an RCT on objects that are to be removed from a controlled area.
3. If radiological survey results indicate that an RWP is required specifically for item decontamination, the RSOR shall prepare the RWP in accordance with the provisions of procedure NAVSTA PS-Tt-001, *Issue and Use of Radiation Work Permits.*
4. The RSO shall approve or disapprove the decontamination operation based on conditions of the RWP and the cost-effectiveness of the operation versus disposal costs.

6.3 ESTABLISHMENT OF THE DECONTAMINATION AREA

The RSO, working with the Construction Manager, shall determine a location for set-up of the decontamination area. As applicable to the specific decontamination activity being performed, the decontamination area may consist of and contain one or more of the following (as needed):

- Covered floor surfaces. A double-layer of HERCULITE (or equivalent) may be laid on the floor at the direction of the RCT.
- Covered (HERCULITE or equivalent) wall surfaces.
- Engineering controls [high-efficiency particulate air (HEPA) ventilation, vacuum cleaners, containment tent walls, glove bags, etc.]. Engineering controls shall be determined on the basis of the as low as reasonably achievable (ALARA) considerations section of the RWP.
- Safe, sturdy work stations with contamination-resistant surfaces, tables that will support decontamination attempts on heavy pieces of equipment.
- Adequate lighting, electrical and compressed air supply for the operation of electrical and/or pneumatic-driven equipment.
- Overhead lifting equipment.

- Adequate supply of approved cleaning solutions and solvents; adequate supply of decontamination equipment such as:
  - Light-duty decontamination equipment such as paper wipes, paper towels, masslin towels, etc.
  - Medium- to heavy-duty decontamination equipment such as scrub pads, wire brushes, steel wool, files, sandpaper, etc.
  - Fully stocked hand tool kit for disassembly of contaminated equipment
  - Power tools, such as drills, saws, needle-guns, electric screwdrivers, etc.
  - Radioactive material storage bags and stickers
  - Buckets, barrels or drums for the storage of contaminated liquids, sludges or slurries
  - Blotter paper or sorbent
  - Approved absorbent material such as oil dry
  - Storage drums/bags for the storage of contaminated protective clothing
  - Proper surveillance instruments (air monitor/sampler, contamination monitor, friskers, exposure rate meter, etc.)
  - Adequate supply of personal protective clothing, gloves, respiratory equipment
  - A designated area within the decontamination area for the segregation of radioactive waste
  - Fire extinguisher(s)

After radiological posting of the decontamination area, all requirements of the RWP shall be observed.

6.4 ITEM PREPARATION FOR DECONTAMINATION

Contaminated or controlled items should always be escorted under the direction of a RCT to the decontamination area.

If an item is wrapped, position it so that the written information on the wrapping is visible and then perform the following:

- The RCT shall direct the removal of the item from the wrapping in such a manner (rolling plastic wrapping inside out, etc.) to control the spread of contamination.

- An item that is highly contaminated with removable contamination may need to be misted with an approved liquid to minimize the possibility of creating airborne contamination.
- Once the item has been removed from the wrapping and has been properly positioned, discard the wrapping as radioactive waste.

The following conditions shall be considered for the decontamination of equipment and tools:

- Any equipment with inaccessible areas shall be dismantled so that all surfaces are accessible for decontamination and survey.
- Decontamination shall be performed in a safe, effective manner.
- The RSO shall be notified immediately if the job conditions change (e.g., suspected asbestos is found, the presence of mercury in a switch or a light bulb, a fluid leak, or any other special circumstances).
- A fire watch shall be assigned to watch if any spark-producing decontamination techniques (grinding, etc.) are used. There shall be a dedicated fire extinguisher located within the decontamination area.
- The decontamination area shall remain organized and free of debris. The Radiological Control/ Decontamination Technicians shall "clean as they go."
- Air monitoring for airborne radioactivity shall be conducted as needed or directed by the RWP.
- A HEPA vacuum cleaner may be used during the decontamination operation.

6.5 DECONTAMINATION OF REMOVABLE CONTAMINATION

When an item is properly positioned for decontamination and the pre-survey activities have been completed, the RCT will perform one or more of the following activities in accordance with the decontamination action approach approved by the RSO:

- Moisten the surface of the item with an approved liquid.
- Fold a paper or cloth wipe into sections, using one surface of the wipe; gently wipe contamination off in one direction away from the user's body to reduce the possibility of personnel contamination.
- Re-fold the paper or cloth wipe so that a clean surface is available to prevent cross-contamination and continue until item is ready for survey.
- For some equipment or tools, duct tape will effectively remove removable contamination. Wrap the duct tape loosely around the gloved hand, adhesive side out. Roll the tape over the contaminated area.

6.6 DECONTAMINATION OF FIXED CONTAMINATION

There are many techniques that can be used to remove fixed contamination. The general idea is to remove the material that is fixing the activity to the surface, or remove a very thin layer of the surface material. It is very important to note that fixed contamination decontamination methods can and do result in the creation of removable surface contamination. This creates a condition that may generate airborne radioactive materials. The activities should be controlled in such a manner that airborne radioactivity is minimized, and air sampling shall be performed during these operations to properly evaluate any resultant airborne radioactivity. Air monitoring activities will be performed in accordance with NAVSTA PS-Tt-005, *Air Sampling and Sample Analysis*.

For the purposes of this procedure, the potential removal techniques have been divided into the following two categories:

- Abrasive hand decontamination
- Power tool decontamination

In addition, the following methods could be used, but are not defined in this procedure and would require the development of a Task-specific Plan or Work Instruction:

- Machine decontamination (use of abrasive bead blasters, grit blasters, high-pressure water wash systems, etc.)
- Cleaning solutions/solvents (use of ultrasonic cleaners, acid baths, electropolishing, etc.).

The actual method or combination of methods applied will be in accordance with the decontamination approach approved by the RSO.

6.6.1 ABRASIVE HAND DECONTAMINATION

Abrasive hand decontamination shall be performed in the following manner:

1. Remove as much removable contamination as possible as indicated in Section 6.5 of this procedure.
2. Moisten the surface of the item(s) to help contain contamination.
3. Use an abrasive cleaning tool (e.g., sandpaper, steel wool, steel brush, hand grinder, etc.) to loosen fixed contamination. Clean in one direction only, away from the body to prevent personnel contamination.
4. Continue to moisten the surface of the item(s) to contain contamination.
5. Remove as much of the loosened contamination as possible as per Section 6.5 of this procedure.

6.6.2 POWER TOOL DECONTAMINATION

Power tool decontamination shall be performed under the direction of the RCT, with concurrence from the RSO.

6.6.2.1 Electric Power Tools

Electric power tools that may be used in decontamination operations are:

- Drills - used to drill out contaminated areas, to disassemble contaminated components, and when used with grinding wheels or disks, may be used as an abrasive tool
- Saws - used to separate contaminated pieces from clean pieces
- Grinders - used to grind fixed contamination from surfaces
- Electric screwdrivers - used in the disassembly of component parts

6.6.2.2 Air-powered Tools

Air-powered tools that may be used in decontamination operations are:

- Needle gun - a pneumatic tool that can remove contamination from concrete and/or steel surfaces
- Socket tools or impact hammer - used in disassembly of component parts
- Jackhammer/rotary hammer - a pneumatic tool which can remove contamination from concrete and/or steel surfaces

6.6.2.3 Decontamination of Power Tools

Power tool decontamination shall be performed in the following manner:

1. Remove as much removable contamination as possible as per Section 6.5 of this procedure.
2. Moisten the surface of the item lightly to help contain contamination. Use a spray bottle for moistening.
3. Whenever feasible the use of containment devices (e.g., glove box, etc.) should be used to contain the spread of contamination when using power tools for decontamination operations.
4. Use the power tool to remove fixed contamination. Clean in one direction only and away from the body to prevent personnel contamination.

6.7 POST-DECONTAMINATION

Following decontamination procedures, the RCT shall perform a release survey. The survey will include the work area and any tools, equipment and materials used during decontamination activities and shall be conducted in accordance with SOP NAVSTA PS-Tt-009, *Release of Materials and Equipment from Radiologically Controlled Areas*. Post-decontamination release shall be performed as follows:

1. If the item satisfies the criteria for release, remove the item to a holding area and document results.
2. If the item remains contaminated, inform the RSO and repeat the decontamination.
3. If the item remains contaminated, attempt a third decontamination only by direction of the RSO.

If an item cannot be effectively or economically decontaminated, the Project Manager may direct the crew to volume-reduce (reduce to component parts) the equipment, material, or tools as much as possible. If the item is expendable, the individual parts may be surveyed and released.

Any tools, equipment or materials that cannot be decontaminated will be packaged in an appropriate waste container for subsequent disposal as radioactive waste. The waste containers will be staged in Building 406 and maintained under New World Technology, Inc.'s license, until disposed of via the Navy's Low-level Radioactive Waste program.

After decontamination operations have been completed, a RCT shall perform a release survey of the decontamination area and de-post the area in accordance with NAVSTA PS-Tt-003, *Radiation and Contamination Surveys*, NAVSTA PS-Tt-007, *Radiologically Controlled Areas – Posting and Access Control*, and NAVSTA PS-Tt-009, *Release of Materials and Equipment from Radiologically Controlled Areas*.

7.0 RECORDS

The records generated by the use of this procedure are documented in accordance with the provisions of NAVSTA PS-Tt-009, *Release of Materials and Equipment from Radiologically Controlled Areas*, and NAVSTA PS-Tt-011, *Radiological Respiratory Protection Policy*.

8.0 REFERENCES

Number	***Title***
NAVSTA PS-Tt-001	*Issue and Use of Radiation Work Permits*
NAVSTA PS-Tt-003	*Radiation and Contamination Surveys*
NAVSTA PS-Tt-005	*Air Sampling and Sample Analysis*
NAVSTA PS-Tt-007	*Radiologically Controlled Areas – Posting and Access Control*
NAVSTA PS-Tt-009	*Release of Materials and Equipment from Radiologically Controlled Areas*
NAVSTA PS-Tt-011	*Radiological Respiratory Protection Policy*

9.0 ATTACHMENTS

None.

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

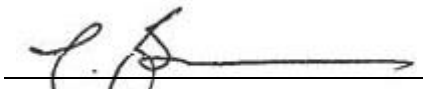
RADIOLOGICAL RESPIRATORY PROTECTION POLICY

NAVSTA PS-Tt-011

Approved By:

Erik Abkemeier
Radiation Safety Officer

July 10, 2013
Date



Lee Boreen
Project Manager

July 10, 2013
Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

The purpose of this procedure is to ensure protection of personnel from internal exposure to radioactive materials. This procedure describes the requirements and policies associated with respiratory protection during activities at NAVSTA PS while working in an airborne radioactivity area.

2.0 SCOPE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors to implement radiological respiratory protection at the former Naval Station Puget Sound (NAVSTA PS).

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) maintains and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer – The RSO is responsible for the implementation and compliance with this procedure as it pertains to radiological activities. The RSO shall conduct periodic reviews, via personal observation of use of respiratory protection, to ensure adherence to the requirements of this procedure. The RSO shall ensure that personnel are adhering to the requirements of this procedure. The RSO shall periodically review documentation generated by the use of this procedure.

Site Health and Safety Specialist – The Site Health and Safety Specialist (SHSS) shall be responsible for the training of personnel in the selection and use of respirators. The SHSS shall ensure that all workers are qualified by training and experience to perform the requirements of this procedure. The SHSS, or designee, shall be responsible for performing qualified fit tests for all radiation workers. The SHSS shall conduct periodic reviews, via personal observation, of use of respiratory protection to ensure adherence to the requirements of this procedure.

Radiation Safety Officer Representative – The Radiation Safety Officer Representative (RSOR) shall be responsible for ensuring that personnel performing the tasks required by this procedure are properly assigned. The RSOR is responsible for ensuring that personnel using respiratory protection are familiar with the requirements of this procedure and have access to a copy of the Radiation Work Permits (RWPs).

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) shall be responsible for assisting in the assignment of personnel that will perform the tasks required by this procedure. The RTS is responsible for ensuring that the Radiological Control Technicians (RCTs) implement and use this procedure. The RTS will ensure that personnel under their cognizance observe proper precautions when using this procedure.

Radiological Control Technician – The RCT shall be responsible for ensuring that radiation workers are following the requirements of this procedure and that all documentation is prepared properly.

5.0 DEFINITIONS AND ABBREVIATIONS

Airborne Radioactivity Area – A room, enclosure or area in which radioactive material is dispersed in air in the form of dusts, fumes, particulates, mists, vapors, or gases, and the concentration of the dispersed radioactive materials is in excess of:

- The derived air concentrations (DACs) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of CFR.
- Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

Derived Air Concentration (DAC) - The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one Annual Limit on Intake (ALI). DAC values are given in Table 1, Column 3, of Appendix B of 10 Code of Federal Regulations (CFR) 20, *Standards for Protection Against Radiation*. One DAC-Hr is approximately 2.5 mrem total effective dose equivalent.

6.0 PROCEDURE DETAILS

6.1 GENERAL

Engineering and process controls shall be used to the extent practicable to limit the concentrations of airborne radioactive materials to levels less than 10 percent of the DAC values listed in Table 1, Column 1, of Appendix B, 10 CFR 20.

When it is impractical to use engineering and process controls, or while they are being implemented, other precautionary steps such as limiting stay times, increased surveillance and/or the use of respiratory protective equipment may be used to limit the intake of airborne radioactive materials.

No emergency situations involving potential respiratory hazards are expected under use of this program.

Although respiratory protection for potential radiological exposure may not be required by this procedure, respiratory protection as required by the Site-specific Health and Safety Plan for other chemical contaminants may be required.

6.2 RADIOLOGICAL CRITERIA FOR RESPIRATOR USE

Use of a respirator is required when airborne radioactivity concentrations cannot be maintained at less than 10 percent of DAC values (Table 1, Column 1, of Appendix B, 10 CFR 20).

Individuals approved to select respiratory protection equipment for use by others shall consider the nature and extent of the hazard, the work requirements and conditions, and the characteristics and limitations of the respirators available.

Respirators should be selected on the basis of airborne contamination levels that develop during work activities.

Radiological respiratory protective equipment shall be selected to provide a protection factor greater than the multiple by which peak concentrations of radioactive materials are expected to exceed the values in Table 1 Column 1, of Appendix B, 10 CFR 20. The equipment selected shall be used so that the average concentration of radioactive material inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by an individual using the equipment, shall not exceed the values specified in Table 1, Column 1, of Appendix B, 10 CFR 20.

Personnel exposure to airborne radioactivity shall not exceed 10 DAC-Hrs in any 7 consecutive days.

Calculated DAC-Hrs greater than or equal to two in 1 day or ten in any 7 consecutive days shall be recorded. Exposures exceeding these guidelines will be evaluated by bioassay. The RSO will evaluate the bioassay results to identify:

- A higher value, then the higher value shall be recorded.
- A lower value, then the lower value MAY be recorded.

6.3 AIR SAMPLING PROGRAM

The air sampling program is established to provide adequate identification of all respiratory hazards present, including radiological, oxygen-deficient and toxic materials.

Air sample data will be used to select the proper respirator and provide estimates of worker exposure.

Air samples will be representative of the air being breathed by the worker(s).

Air sampling program details are presented in NAVSTA PS-Tt-005.

6.4 BIOASSAY PROGRAM

Measurements of radioactive materials in the body and/or excreted from the body will be performed as necessary for timely detection and assessment of individual intakes of radioactive materials. The techniques used, (e.g., whole-body counts, urine samples, etc.) will be appropriate with respect to the material exposed. Baseline bioassay data shall be obtained.

Periodic bioassay samples will be taken, as needed, to determine the adequacy of the respiratory protection program and will be used to determine actual exposures, if any.

6.5 EFFECTIVENESS OF THE RESPIRATORY PROTECTION PROGRAM

Periodic surveillance of individuals working in respirators will be performed to evaluate actual exposures and monitor workers stress and equipment performance. Any problems shall be reported to the RSO.

6.6 RESPIRATOR SURVEY AND DECONTAMINATION

Survey the respirator and cartridge for radioactive contamination.

Remove the P-100 (High Efficiency Particulate Air) cartridge and properly dispose of as radioactive waste (if required).

Respirators with > 10,000 disintegrations per minute (dpm)/100 square centimeters (cm^2) $\beta\gamma$ and/or 200 dpm/100 $cm^2\alpha$ removable contamination shall be decontaminated using the following steps:

- Fill a container with warm water.
  - Add cleaner/sanitizer, or 2 fluid ounces of chlorine bleach per gallon of water used.

- Gently scrub the respirator with a soft bristle brush, sponge, or cloth.
- Thoroughly rinse the respirator in warm water and allow it to air dry.
- Re-survey the respirator after it is completely dry for removable and fixed contamination.

The RCT shall thoroughly swipe the respirator with a disc swipe. Swipes should be counted on a Ludlum Model 2929 or equivalent to determine the activity level of the swipe. If removable contamination is below the release limits, a direct survey of the respirator will be performed. If removable contamination is above the release limits; the respirator shall be re-washed and re-surveyed. The removable contamination release limits are:

- Alpha < 20 dpm/100 cm^2
- Beta-gamma < 200 dpm/100 cm^2

After the respirator is determined to meet removable contamination criteria, the respirator shall be direct surveyed with a Ludlum Model-3 instrument or equivalent equipped with a Model 44-9 (Beta-Gamma) probe or equivalent, and a Ludlum Model 2360 instrument or equivalent equipped with a Model 43-89 scintillation probe or equivalent. The fixed activity of the respirator shall be determined in accordance with the operating procedure of the instrument used and if acceptable, document the survey results. If unacceptable, the RCT shall identify the respirator and remove the respirator from service. The fixed activity limits shall be:

- 1,000 dpm/100 cm^2 net beta-gamma and 20 dpm/100 cm^2 net alpha on the interior of the respirator per direct scan.
- 5,000 dpm/100 cm^2 net beta-gamma and 100 dpm/100 cm^2 net alpha on the exterior of the respirator per direct scan.

The survey results for each respirator will be documented.

7.0 RECORDS

Records of the following shall be maintained for each individual who wears respiratory protection devices (other than dust masks) at any worksite:

- Physical qualifications
- Fit testing
- Respirator issue
- Respirator maintenance
- Bioassay data - before and after exposure
- Air sample results
- Respirator Evaluation/Repair Report

8.0 REFERENCES

Number	Title
10 CFR 20	*Standards for Protection Against Radiation*
NAVSTA PS-Tt-005	*Air Sampling and Sample Analysis*

9.0 ATTACHMENTS

None.

FORMER NAVAL STATION PUGET SOUND

Standard Operating Procedure

RADIOLOGICAL PROTECTIVE CLOTHING SELECTION, MONITORING, AND DECONTAMINATION

NAVSTA PS-Tt-012

Approved By:

Erik J. Abkemeier	July 10, 2013
Erik Abkemeier Radiation Safety Officer	Date
	July 10, 2013
Lee Boreen Project Manager	Date

REVISION HISTORY

Revision (Date)	*Rev. No*	*Prepared By*	*Description of Changes*	*Affected Pages*

TABLE OF CONTENTS

PAGE

1.0 PURPOSE

This procedure provides the methods for donning, wearing, and removing protective clothing while working within, accessing or leaving known or suspected areas with radioactive contamination.

2.0 SCOPE

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors while performing activities in known or suspected areas with radioactive contamination at the former Naval Station Puget Sound (NAVSTA PS).

3.0 MAINTENANCE

The Radiation Safety Officer (RSO) maintains and is responsible for updating this procedure. Approval authority rests with the Project Manager.

4.0 RESPONSIBILITIES

Radiation Safety Officer – The Radiation Safety Officer (RSO) is responsible the overall implementation and compliance with this procedure during all project operations. The RSO shall conduct periodic reviews, via personal observation of conducting radiation and contamination surveys, to ensure adherence to the requirements of this procedure. The RSO shall review documentation generated by the use of this procedure.

Radiation Safety Officer Representative – The Radiation Safety Officer Representative (RSOR) is responsible for ensuring that personnel assigned tasks involving access to radiological controlled areas (RCAs) are adequately trained in the use of protective clothing, are familiar with the requirements of this SOP, and have access to a copy of the associated Radiation Work Permits (RWPs).

Radiological Task Supervisor – The Radiological Task Supervisor (RTS) is responsible for the control of radioactive material, coverage of radiation workers, and assuring that personnel under their cognizance observe proper precautions. Documentation required by this procedure will be reviewed by the RTS, or designee.

Radiological Control Technician – The Radiological Control Technician (RCT) shall be responsible for the performance of the requirements of this procedure and documentation of work performed.

5.0 DEFINITIONS AND ABBREVIATIONS

Contaminated Area – Any area where removable surface contamination levels exceed 20 percent of the contamination limits provided in Table 1 of NAVSTA PS-Tt-007, *Radiologically Controlled Areas – Posting and Access Control*.
Hot Particle – A discrete, minute, fragment of radioactive material.

Radiologically Controlled Area (RCA) – An area containing radioactive materials in excess of the levels provided in Table 1 of NAVSTA PS-Tt-007, *Radiologically Controlled Areas – Posting and Access Control* to which access is controlled to protect individuals from exposure to ionizing radiation

6.0 PROCEDURE DETAILS

6.1 SELECTION OF PROTECTIVE CLOTHING

The following factors should be considered when selecting protective clothing (PC):

- The levels and types of radiological material present or expected in the work area.
- The presence of chemical hazards.
- The base in which the contamination is carried (dry, wet, oily).
- The work to be performed or work in progress.
- The location of the contamination (e.g. floor, walls, overhead, air handling systems, sewer systems).
- The physical configuration of the work area.
- Environmental conditions such as heat and humidity.
- Exposure situation (vapor, pressured splash, liquid splash, intermittent liquid contact, and continuous liquid contact).
- Toxicity of the radioactive materials and/or chemical(s) (ability to permeate the skin and systemic toxicity).
- Physical properties of the contaminant (vapor pressure, molecular weight, and polarity).
- Functional requirements of the task (dexterity, thermal protection, fire protection, and mechanical durability requirements).

Table 6-1 provides guidance for the selection of protective clothing when radiological hazards are present or suspected.

TABLE 6-1

GUIDE FOR THE SELECTION OF RADIOLOGICAL PROTECTIVE CLOTHING

Removable Contamination Levels	Clothing for Access Only No Work *	Clothing for Work or Access During Work *
General contamination levels < 1000 dpm/100 cm^2	Level D PPE	Level D PPE
General contamination levels > 1000 dpm/100 cm^2, but ≤ 10,000 dpm/100 cm^2	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**
General contamination levels > 10,000 dpm/ 100 cm^2, but ≤ 100,000 dpm/100 cm^2 .	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (or hood) Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**
General contamination levels > 100,000 dpm/100 cm^2 .	Glove liners Gloves (2 pair) Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**	Glove liners Gloves (2 pair) Booties (2 pair), cloth or PVC Tyvek (2 pair) Cap Hood Rubber shoe covers**

Notes:

* Plastics or partial plastics may be required anytime water or liquid chemicals are present, such as when handling wet components.

** Composition of Rubber shoe covers will be selected based on work area conditions and presence of any chemical hazards.

cm^2 – square centimeters
dpm – disintegration per minute
PPE – personal protective clothing
PVC – polyvinyl chloride

The guidelines specified in Table 6-1 for protective clothing selection may be modified under unusual circumstances. The following are examples:

- Wet areas - Where splashing water or spray is present, use rain suits in addition to the protective clothing listed in Table 6-1. A second set of coveralls may not be necessary when a rain suit is worn.
- Standing water - In addition to the clothing requirements for wet areas, use hip boots or waders for deep standing water areas.
- Face shields – Consider for use when there is significant beta radiation or a likelihood of water splashing and respirators are not required.
- High temperature areas - Consult with the RSO and Site Health and Safety Specialist (SHSS).

Actual requirements will be specified in the RWP.

6.2 PROCEDURE PROCESS

6.2.1 DONNING PROTECTIVE CLOTHING

1. Select the protective clothing specified on the RWP.
2. Inspect the clothing for holes, tears, or other indications of damage. If damaged, remove protective clothing from service.
3. Put on any additional required special dosimetry (for example, finger rings) prior to donning protective clothing.
4. Place dosimetry, if worn, in the upper body area on interior portion of the breast tab with the window of the dosimeter facing out. When Tyvek is worn that does not have a breast tab or pocket, dosimetry should be attached per the direction of the RSOR or designee.
    - The dosimeter shall not be worn inside clothing or placed in pockets if exposure of bare skin to beta radiation is expected.
5. If a respirator is specified on the RWP, then:
    - Ensure that any required surgeons cap or hood is situated such that it will not interfere with the respirator face to facepiece seal area.
    - Don the respirator.
    - Don the hood if required, allowing it to overlap the rubber around the lens of the face piece and fall over the shoulder.
    - If required, tape the hood to the respirator and to the coveralls.
    - Ensure that any required hood is slack enough around the shoulders to allow for full head movement.

6. Don rubber gloves.
    - More than one pair of rubber gloves may be required for certain jobs.
    - Tape the innermost pair of rubber gloves to the coverall sleeves.
    - Leather work gloves may be substituted for outer rubber gloves on some jobs as specified by the corresponding RWP.
7. If specified on the RWP, then don additional PPE as required.

6.2.2 REMOVAL OF PROTECTIVE CLOTHING

1. Remove any tape and place in the designated collection receptacle.
2. Remove outer gloves, if worn.
3. If worn remove the hood and place it in the designated collection receptacle.
4. If worn, then remove respirator.
5. Remove dosimetry if worn and place on the final step-off-pad.
6. Remove coveralls by peeling off inside out and rolling downward over the shoes or inner booties.
7. Carefully place coveralls in the designated collection receptacle.

> **CAUTION**: Pushing clothing or trash into an already full collection container to compress the contents is forbidden as the act can result in the potential for airborne radioactivity.

8. Perform a personal self frisk, or be frisked by an RCT, in accordance with corresponding RWP requirements and check dosimetry, if worn.

The sequence for protective clothing removal may vary from that described above:

- At the discretion of the RCT providing job coverage.
- As designated on the assigned RWP.
- Dependent upon radiological and hazardous material conditions encountered during the work evolution.

6.2.3 MONITORING

6.2.3.1 Exit Surveys

1. Use the portable instrument staged for the area of concern, which should have both a visual and an audible response.

2. Ensure that the instrument is set on slow response, if available, and operating with an audible response.
3. Verify that the instrument is operational on the lowest scale and that the area background count rate is acceptable.
4. Hold the detector with the window at approximately 1/4 inch from the surface being monitored.
5. Move the detector over the surface being monitored at a rate not to exceed 2 to 3 inches per second.
6. If an increase in the audible response is noted, then cease detector movement and allow the meter 5 to 10 seconds to stabilize.
7. Pause (approximately 5 seconds) at the nose and mouth area to check for indications of inhalation/ingestion of radioactive material.
8. Pay particular attention to hands, feet (shoes), elbows, knees, or other areas with a high potential for contamination.
9. If no contamination can be detected as indicated by an alarm or by an audible or visual response distinguishable from background, then exit the area.
10. If an audible or visual response distinguishable from background is noted, then notify the RCT.
11. Remain in the area until a RCT arrives to provide assistance.
12. If personnel are found to be contaminated, proceed to the procedures outlined in Section 6.2.3.2.

6.2.3.2 Contaminated Personnel

1. Notify the RSOR or RTS of any individual with known or suspected contamination.
2. If the contamination is on a personal article of clothing, then perform the following:
    - Survey the inside surface(s) which was against the skin.
    - Verify that no contamination was transferred to the skin.
3. If the contamination is on the skin, then determine if the contamination is in the form of a hot particle.
4. If the contamination is a hot particle, then:
    - Quickly evaluate the particle.
        - o Particle size
        - o Radiation type
        - o Visible characteristics

- Attempt to collect and retain the particle for subsequent evaluation.
- Decontaminate the individual in accordance with Section 6.2.4.

5. If the contamination is not a particle, then:
    - Evaluate the contamination levels.
    - Decontaminate the individual in accordance with Section 6.2.4.
6. Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

6.2.4 PERSONNEL DECONTAMINATION

> **NOTE**: First aid measures take precedence over decontamination efforts. The RTS shall request support from qualified medical personnel when an injured person requires decontamination.

1. Perform personnel decontamination in a manner that prevents the spread of contamination to other body parts or the ingestion or inhalation of radioactive material.
2. Take appropriate precautions to minimize the spread of contamination when proceeding from the control point or step-off pad to the decontamination area.
3. Personnel will not be released if detectable skin contamination is present unless authorized by the RSO.
4. When performing skin decontamination:
    - Exercise care to avoid damaging the skin.
    - If skin irritation becomes apparent, then discontinue the decontamination and notify the RSOR and RSO.
    - Record results after each decontamination attempt.
    - Indicate the method of decontamination used.
    - Decontamination of ears, eyes and mouth shall be limited to damp swabs, water or saline solution rinses conducted by the individual. Further decontamination shall be performed under the direction of qualified medical personnel.
    - Decontamination of nasal passages shall be limited to repeated nose blowing by the individual. Supplemental nasal irrigations shall be performed under the direction of qualified medical personnel, as required.
    - Use of decontamination processes or materials other than those listed in Table 6-2 will only be performed under the specific direction of qualified medical personnel.

- Immediately report incidents of individual contamination to the RSOR and RSO.
- Note the final survey results and time of survey.
- Record the area of the skin contaminated in cm^2 on Attachment 1.
- For contamination distributed over an area greater than or equal to the area of the probe, the measured activity may be assumed to be distributed over the probe area (area of typical pancake probe is 15.5 cm^2).
- If the area of contamination is less than the area of the probe but greater than 1 cm^2, the actual area of the activity must be determined.
- If the contamination area is less than or equal to 1 cm^2, assume an area of 1 cm^2.
- When skin decontamination has been successfully completed, obtain the information needed to complete the Personnel Contamination Report.
- Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

TABLE 6-2

PERSONNEL DECONTAMINATION METHODS

METHOD	EFFECTIVE FOR	INSTRUCTIONS
Masking Tape	Dry contamination, Hot particles	Apply tape to skin by lightly patting. Remove carefully.
Waterless Hand Cleaner	All skin contamination	Apply to affected area and allow it to melt onto the skin. Remove with cotton or soft disposable towel.
Soap and Tepid Water	All skin contamination except tritium	Wash area with soap and lukewarm water. Repeat until further attempts do not reduce the level. A cloth or surgical hand brush may be used with moderate pressure.
Soap and Cool Water	Tritium contamination	Wash area with soap and cool water. Repeat until further attempts do not reduce the level. A cloth may be used with moderate pressure.
Carbonated Water	All skin contamination	Apply to affected area with cotton or soft disposable towel and wipe with dry towel.
Cornmeal Detergent Paste	All skin contamination	Mix cornmeal and powder detergent in equal parts with enough water to form a paste. Rub onto affected area for 5 minutes. Remove with cotton or disposable towel. Rinse skin.
Shampoo	Hair contamination	Wash hair and rinse. Repeat as necessary.
Parafilm	All particulate contamination	Apply to affected area of skin. Remove.
Sweating	All skin contaminations	Cover affected area with impermeable cover (plastic, glove, Parafilm) to cause sweating. Remove after sweating has occurred and wipe area.

6.2.5 RADIOLOGICAL FOLLOW-UP

The RCT shall:

1. Ensure that the Personnel Contamination Report (Attachment 1) has been completed.
2. Check the location of the contamination event - Contaminated Area, Hot Particle Area, clean area inside a radiological control area (RCA), or clean area outside RCA.

3. Enter any additional information felt to be pertinent.
4. Complete the "Contamination Event Description and Cause" sections of Attachment 1.
5. If the event was directly related to wearing protective clothing, then complete Section A, “Event Directly Related to Wearing PC”.
    - Check the appropriate Contamination Event Description.
    - Check the appropriate Basic Cause.
6. If the contamination occurred while removing protective clothing, then complete Section B, “Event Occurred While Removing PC”.
    - Check the appropriate “Contaminating Event Description”.
    - Check the appropriate “Basic Cause”.
7. If the contamination event was not related to wearing protective clothing, then complete Section C, “Event Not Directly Related to Using PC”.
    - Check the appropriate “Contaminating Event Description”.
    - Check the appropriate “Basic Cause”.
8. Review the report with the individual and have them sign and date the form.
9. Sign and date the form.

The RTS shall:

1. Review the Personnel Contamination Report to verify that all required information has been accurately recorded.
2. Complete the “Radiological Task Supervisor” section.
    - Check the appropriate brackets ([ ]) to indicate actions taken.
    - Enter any comments.
3. Sign and date the form.
4. Request support from the qualified medical personnel when:
    - The personnel decontamination methods provided in this procedure are ineffective; or
    - Injured personnel require decontamination.
5. Determine reimbursements and disposition of personal property that cannot be decontaminated.
6. Forward the completed Personnel Contamination Report to the RSOR for review.

The RSOR and Site Health and Safety Specialist shall:

1. Review and sign the Personnel Contamination Report.
2. Conduct an investigation into the cause of the contamination.
3. Conduct training on the cause of the contamination and lessons learned and preventive measures.
4. Sign and transmit the Personnel Contamination Report to the RSO for review.

7.0 RECORDS

The administrative form included in this procedure (Personnel Contamination Report) shall not be modified without the written authorization of the Project Manager and the documented concurrence of the RSO or designee. In no case shall modifications reduce the content required by the original form.

8.0 REFERENCES

Number	***Title***
NAVSTA PS-Tt-007	*Radiologically Controlled Areas – Posting and Access Control*

9.0 ATTACHMENTS

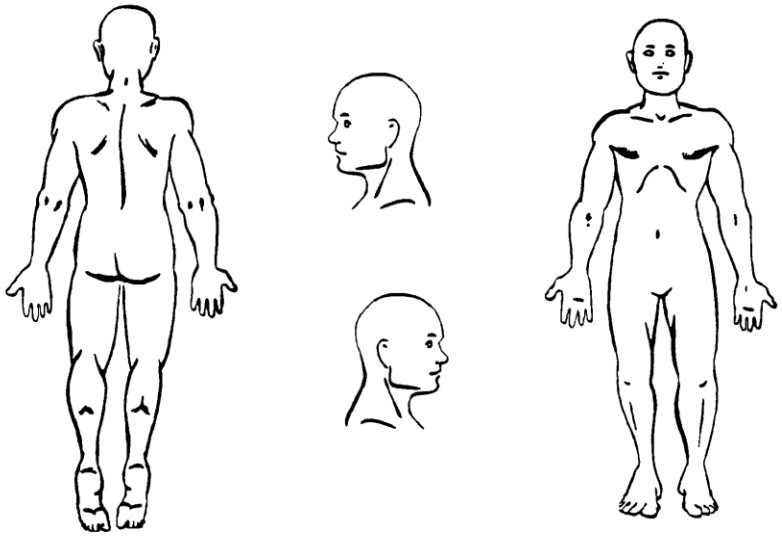
The following form is attached to this procedure:

Attachment 1 – Personnel Contamination Report

ATTACHMENT 1

PERSONNEL CONTAMINATION REPORT

Name		Company	Date	Time
EID	Dosimeter#	Dept.	Supervisor	
Instrument		Serial #	Cal. Due Date	
Probe		Serial #	Cal. Due Date	
Location of Personnel Contamination			RWP # Survey #	



Contamination Levels (Use # to reference drawing)

Number	Time	Initial Count Rate	Size of Area (cm^2)	Time	Final Count Rate

Decontamination Methods	__ Wash __ Number of washes	__ Other:
	__ Shower __ Number of showers	
Radiological Control Technician Signature:		Date
I acknowledge the above information represents the contamination event.		
Individual Signature:		Date

Name EID

CLOTHING CONTAMINATION

Item:	Max cpm	[ ] Decon/Return	[ ] Contaminated/Retained
Item:	Max cpm	[ ] Decon/Return	[ ] Contaminated/Retained
Item:	Max cpm	[ ] Decon/Return	[ ] Contaminated/Retained

RADIOLOGICAL FOLLOW-UP

Location of Event:	[ ] Contamination Area	[ ] Clean area inside RCA	[ ] Clean area outside RCA
Follow-up actions:			
Additional information:			

CONTAMINATION EVENT DESCRIPTION and CAUSE

A - Event Directly Related To Wearing PC

Contaminating Event Description

[ ] Contaminated by physical compromise of PC (tear, etc.)
[ ] Contamination penetration of intact PC
[ ] Contamination came from PC
[ ] Contaminated skin by touching contaminated item
[ ] Contamination came from contaminated liquid
[ ] Contamination came from airborne radioactivity

Basic Cause

[ ] Improper donning of PC
[ ] Improper PC use related to worker knowledge/experience
[ ] Work area not deconned to extent practicable
[ ] Practical limitation of available alternatives
[ ] Improper PC requirement on RWP
[ ] Improper control by RCT of worker activity in PC
[ ] Improper laundry/monitoring of PC

B - Event Occurred While Removing PC

Contaminating Event Description

[ ] Contaminated during removal of hood
[ ] Contaminated during removal of respiratory equipment
[ ] Contaminated during removal of outer PC
[ ] Contaminated during removal of inner PC
[ ] Contaminated during removal of plastics
[ ] Contamination came from airborne radioactivity

Basic Cause

[ ] Lack of knowledge in proper methods to remove PC
[ ] Lack of knowledge in proper methods to remove respirator
[ ] [ ] Worker actions while removing PC - accident
[ ] RCT technician actions
[ ] [ ] Improper monitoring of PC

C - Event Not Directly Related To Using PC

Contaminating Event Description

[ ] Contaminated while in area designated as clean RCA
[ ] Contaminated while in area designated clean non - RCA
[ ] Contaminated by liquid
[ ] Contamination spread to area and not identified
[ ] Improper control of airborne radioactive material

Basic Cause

[ ] Noncompliance with postings/rad controls
[ ] Improper monitoring/control of rad material by worker
[ ] Improper actions at work area (sitting, lying)
[ ] Accidental contact with contamination beyond worker control
[ ] Surveys not appropriate for existing conditions

Health Physics Supervisor

[ ] Interview with job coverage RCT
[ ] Exclude individual from further RCA access
[ ] Discussed with individual and supervisor
[ ] Released with residual contamination
[ ] Initiated skin dose calculation
[ ] No further action required, routine close out

Radiological Task Supervisor	Print	/	Sign	Date
Radiationl Safety Officer Representative	Print	/	Sign	Date
Radiation Safety Officer	Print	/	Sign	Date

ATTACHMENT 5

AIR EMISSIONS PLAN

This page intentionally left blank.

U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

ATTACHMENT 5

FINAL

AIR EMISSIONS PLAN

July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION
AT FORMER NAVAL STATION PUGET SOUND
SEATTLE, WASHINGTON

TETRA TECH EC, INC.

1230 Columbia Street, Suite 750
San Diego, California 92101-8536

AIR EMISSIONS PLAN
Former Naval Station Puget Sound, Seattle, Washington

June 30, 2013

This submittal contains information detailing an Airborne Emissions Monitoring Plan that is consistent with a Washington State Air Emission License application for radiological remediation work at the former Naval Station Puget Sound. During a teleconference on March 25, 2013, the consensus was that the Navy could commit to an Airborne Emissions Monitoring Plan in lieu of directly obtaining an Air Emission License, because the Navy is following the CERCLA process. Preliminary telecommunication with the Washington Department of Health has been used as a basis for developing this plan.

For ease of review, each WAC 246-247-110 Appendix A requirement has been copied and presented in *italic* font, followed by a response in **bold**:

(1) Name and address of the facility, and location (latitude and longitude) of the emission unit(s).

Former Naval Station Puget Sound, Seattle Washington, 98115, Buildings 2, 27, and adjacent soil, N47^{o} 41.16'/W122^{o} 15.80'.

(2) Name, title, address, and phone number of the responsible manager.

Chris Generous, Remedial Project Manager
U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101
360-396-0935

(3) Identify the type of proposed action for which this application is submitted:

Removal of soil and building components/materials potentially contaminated with Ra-226, Sr-90, and Cs-137.

(a) Construction of new emission unit(s);

Excavator, hand tools, cutting/grinding tools

(b) Modification of existing emission unit(s); identify whether this is a significant modification;

N/A

(c) Modification of existing unit(s), unregistered.

N/A

(4) If this project is subject to the requirements of the State Environmental Policy Act (SEPA) contained in chapter 197-11 WAC, provide the name of the lead agency, lead agency contact person, and their phone number.

N/A

(5) Describe the chemical and physical processes upstream of the emission unit(s).

No chemical processes occur upstream. Emission unit operations consist of removal of soil using an excavator and hand tools. Fugitive emissions within buildings consist of removal of contaminated areas through cutting around contaminated areas and grinding contaminated concrete areas, as applicable.

(6) Describe the existing and proposed (as applicable) abatement technology. Describe the basis for the use of the proposed system. Include expected efficiency of each control device, and the annual average volumetric flow rate(s) in meters^3/sec for the emission unit(s).

Prior to removal of soil, misting with water will be used, as necessary, to mitigate potential airborne dust during transfer from the ground surface to the disposal containers. Average volumetric flow rate is expected to be negligible. For cutting and grinding operations within buildings, high efficiency particulate air (HEPA) vacuums will be used to collect fugitive dusts at the point of creation.

(7) Provide conceptual drawings showing all applicable control technology components from the point of entry of radionuclides into the vapor space to release to the environment.

Misting will be used to minimize soil airborne particulates. HEPA vacuums will be used to minimize fugitive dust emissions from cutting and grinding operations within building structures. HEPA vacuums will be FESTOOL brand Renovation, Repair and Painting full unit HEPA certified. Grinding and sanding attachments will be connected to the suction hose of the HEPA vacuums whenever possible. For cutting operations, the inlet of the vacuum hose will be stationed approximately 12 inches from the cutting instrument, with adjustments based on safety concerns. The manufacturer does not list limitations of use. No minimum operational distance with regards to nominal flow rate is listed. No methods of operational verification are listed for spark generating activity. HEPA vacuums will be aerosol tested with di octyl phthalate, poly alpha olefin (or equivalent) prior to use and after each change out of filter.

An air sampler will be located at the Radiologically Controlled Area boundary on the north, south, east, and west directions for the area located adjacent to Building 27, as delineated on the attached figure. These air samplers will remain in these locations

for the entirety of the remediation project, and weekly air filters will be collected for quarterly composite analysis by TestAmerica St. Louis. Note that some smaller remedial actions will occur outside this larger Radiologically Controlled Area (as delineated on the attached figure); however, these remediations will be within 300 meters of the air samplers.

(8) Identify each radionuclide that could contribute greater than ten percent of the potential-to-emit TEDE to the MEI, or greater than 0.1 mrem/yr potential-to-emit TEDE to the MEI.

Bismuth-214, a progeny of radium-226, could contribute greater than ten percent of the potential to emit TEDE to the MEI, or greater than 0.1 mrem/yr potential to emit TEDE to the MEI. Lead-214, strontium-90, cesium-137, and barium-137 could contribute greater than ten percent of the potential to emit TEDE to the MEI.

(9) Describe the effluent monitoring system for the proposed control system. Describe each piece of monitoring equipment and its monitoring capability, including detection limits, for each radionuclide that could contribute greater than ten percent of the potential-to-emit TEDE to the MEI, or greater than 0.1 mrem/yr potential-to-emit TEDE to the MEI, or greater than twenty-five percent of the TEDE to the MEI, after controls. Describe the method for monitoring or calculating those radionuclide emissions. Describe the method with detail sufficient to demonstrate compliance with the applicable requirements.

During soil remediation actions, four air sampling units will be stationed at the north, south, east, and west Radiologically Controlled Area boundary adjacent to Building 27, and operated continuously while remediation operations take place. Air samplers shall be operated for a minimum of 20 hours per week. The air samplers used will be Tisch Environmental Model TE-5170DV Volumetric Flow Controlled Air Samplers (see Appendix A for specifications). The nominal flow rate is 42-45 ft^3/minute, and the filter media is a glass fiber 8" x 10" TE-G653 model filter. Air filters will be collected weekly, to minimize dust loading concerns, and shipped to TestAmerica St. Louis on a quarterly basis for composite sampling by alpha/beta gas flow proportional counting (or equivalent) and gamma spectroscopy analysis. This analysis is capable of achieving the 40CFR61 Appendix E minimum detectable concentrations (MDCs) of 3.3E-15 Ci/m^3 for Ra-226 and 1.9E-14 Ci/m^3 for Cs-137 and Sr-90. Ensuring that these MDCs are met will ensure that no member of the general public will exceed a dose greater than 10 mrem/year from airborne emissions. Air sampling will comply with 40CFR61 Appendix B Method 114.

(10) Indicate the annual possession quantity for each radionuclide.

Soil concentrations for radionuclides are unknown; however, the quantities have been conservatively estimated based on an assumed removal of 2,000 cubic yards of soil at a density of 1.6 grams/cm^3. A conservatively elevated estimate of 10 pCi/g was assumed for Ra-226 contamination based on the previous core sampling conducted during remedial investigation activities, as well as experience with Ra-226 contamination remediation. Ra-226 contamination once introduced to soil tends to

remain within several feet of the point of introduction to the soil. Only a few core samples showed Ra-226 concentrations greater than 10 pCi/g, one as elevated as 2,160 pCi/g; however, the vast majority of samples showed Ra-226 concentrations less than 2 pCi/g. Less than 20 cubic yards of soil with concentrations exceeding 10 pCi/g Ra-226 is expected, whereas the remaining potential 1,980 cubic yards of soil remediated is expected to be significantly less than 10 pCi/g, in the range of 2 pCi/g. A maximum soil contamination concentration of 3.7 pCi/g and 7.4 pCi/g was assumed for Sr-90 and Cs-137, respectively. These assumptions yield a quantity of 24 mCi Ra-226, 9 mCi Sr-90, and 18 mCi Cs-137.

(11) Indicate the physical form of each radionuclide in inventory: Solid, particulate solids, liquid, or gas.

Radionuclides are in solid form, either as soil contamination or contamination on building materials.

(12) Indicate the release form of each radionuclide in inventory: Particulate solids, vapor, or gas. Give the chemical form and ICRP 30 solubility class, if known.

Particulate solid

(13) Release rates.

(a) New emission unit(s): Give predicted release rates without any emissions control equipment (the potential-to-emit) and with the proposed control equipment using the efficiencies described in subsection (6) of this section.

Release rates are not measurable, but essentially negligible. The release rate used in the CAP-88 model was a plume of "none," and a plume rise of zero for each Pasquill category.

(b) Modified emission unit(s): Give predicted release rates without any emissions control equipment (the potential-to-emit) and with the existing and proposed control equipment using the efficiencies described in subsection (6) of this section. Provide the latest year's emissions data or emissions estimates.

N/A

In all cases, indicate whether the emission unit is operating in a batch or continuous mode.

In a batch mode – soil may be removed for a period of time, and then no removal for several days while radiological surveys, soil sample collection, and soil sample analysis occur. Similarly, building materials may be removed for a short period of time, followed by no activity in the building.

(14) *Identify the MEI by distance and direction from the emission unit(s). The MEI is determined by considering distance, windrose data, presence of vegetable gardens, and meat or milk producing animals at unrestricted areas surrounding the emission unit.*

The Maximum Exposed Individual as modeled in CAP-88 (Appendix A) was determined to be 250 meters north.

(15) *Calculate the TEDE to the MEI using an approved procedure (see WAC 246-247-085). For each radionuclide identified in subsection (8) of this section, determine the TEDE to the MEI for existing and proposed emission controls, and without any emission controls (the potential-to-emit) using the release rates from subsection (13) of this section. Provide all input data used in the calculations.*

The Total Effective Dose Equivalent to the Maximum Exposed Individual calculated using CAP-88 was 0.303 mrem/year. This value was determined using an "area" emission unit with a "height" assumed to be 2 meters based on the height of an excavator bucket, and the "area" as 1 meter corresponding to the area of an excavator bucket. A conservative population map was used modeling a minimum of one person residing in each direction at 250, 750, 1,500, 2,500, 3,500, 4,500, 7,500, 15,000, 25,000, 35,000, 45,000, 55,000 and 70,000 meters in each 16 wind directions. The wind map for Seattle-Tacoma Airport was used. Default parameters were used for all other input parameters.

(16) *Provide cost factors for construction, operation, and maintenance of the proposed control technology components and system, if a BARCT or ALARACT demonstration is not submitted with the NOC.*

4 air samplers – $25,000
TestAmerica radioanalysis of filters – $325/quarter
Misters/water wagon – $500/month
2 HEPA vacuums/filters – $1,750

17) *Provide an estimate of the lifetime for the facility process with the emission rates provided in this application.*

Remediation operations may occur over a 6-month period.

(18) *Indicate which of the following control technology standards have been considered and will be complied with in the design and operation of new or modified emission unit(s) described in this application:*

ASME/ANSI AG-1, *Code on Nuclear Air and Gas Treatment (where there are conflicts in standards with the other listed references, this standard shall take precedence)*

ASME/ANSI N509, *Nuclear Power Plant Air-Cleaning Units and Components*

ASME/ANSI N510, *Testing of Nuclear Air Treatment Systems*

ANSI/ASME NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*

40 C.F.R. 60, Appendix A, *Methods 1, 1A, 2, 2A, 2C, 2D, 4, 5, and 17*

ANSI/HPS N13.1-1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities if the unit's potential-to-emit exceeds 0.1 mrem/yr TEDE to the MEI and the unit is required to meet ANSI/HPS N13.1-1999 under federal regulations.*

ANSI N13.1-1969, *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities if the unit's potential-to-emit exceeds 0.1 mrem/yr TEDE to the MEI and the unit is not required to meet ANSI/HPS N13.1-1999 under federal regulations.*

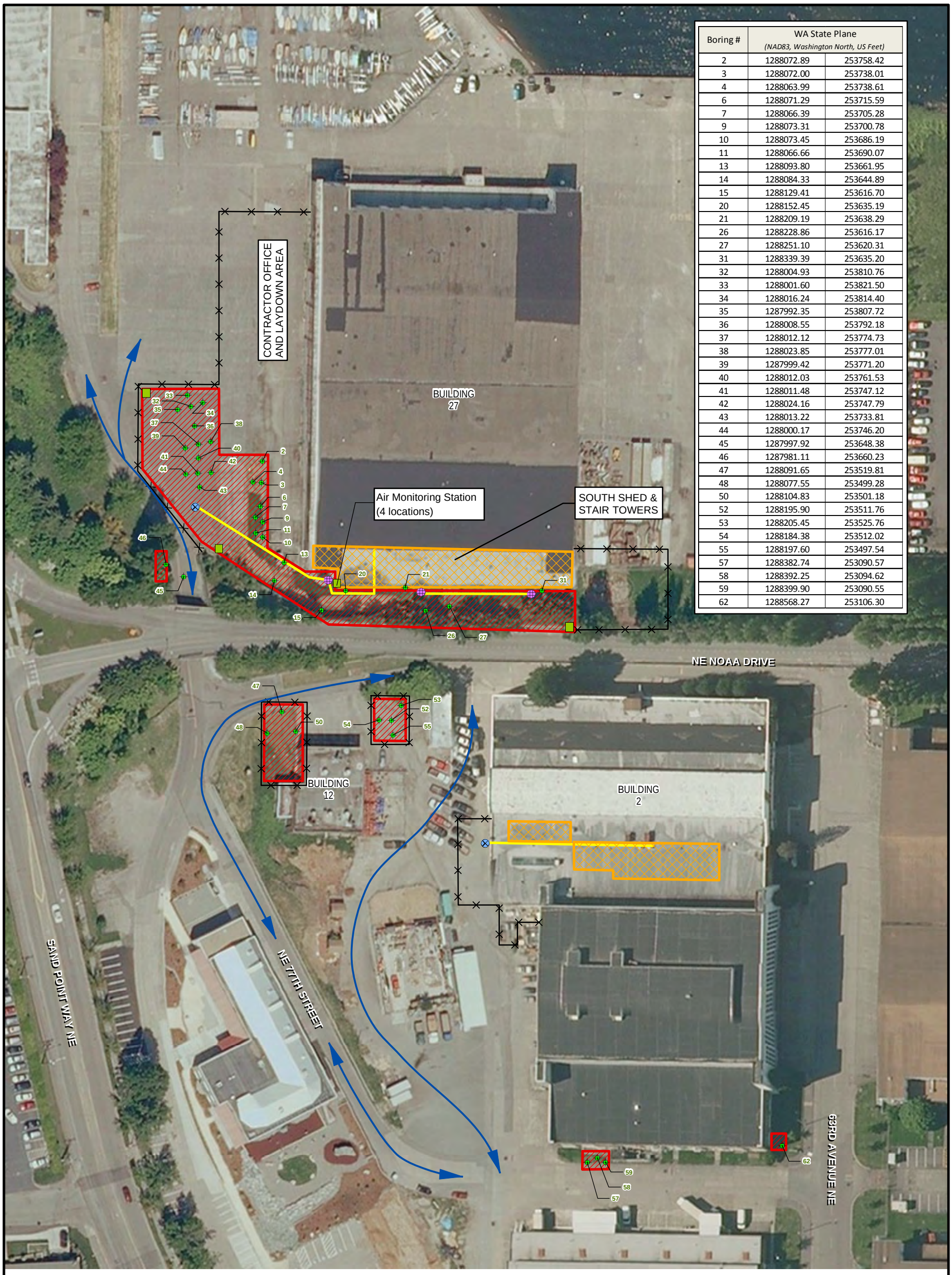
For each standard not so indicated, give reason(s) to support adequacy of the design and operation of the emission unit(s) as proposed.

None of the proposed documents appears to adequately address emissions from soil removal operations.

The CAP-88 modeling (Appendix A) provides conservative modeling for potential radiological airborne emissions. Should you have any questions concerning this plan, please contact Erik Abkemeier at (757) 944-0921 or erik.abkemeier@tetratech.com.

FIGURES

This page intentionally left blank.



Boring #	WA State Plane (NAD83, Washington North, US Feet)	
2	1288072.89	253758.42
3	1288072.00	253738.01
4	1288063.99	253738.61
6	1288071.29	253715.59
7	1288066.39	253705.28
9	1288073.31	253700.78
10	1288073.45	253686.19
11	1288066.66	253690.07
13	1288093.80	253661.95
14	1288084.33	253644.89
15	1288129.41	253616.70
20	1288152.45	253635.19
21	1288209.19	253638.29
26	1288228.86	253616.17
27	1288251.10	253620.31
31	1288339.39	253635.20
32	1288004.93	253810.76
33	1288001.60	253821.50
34	1288016.24	253814.40
35	1287992.35	253807.72
36	1288008.55	253792.18
37	1288012.12	253774.73
38	1288023.85	253777.01
39	1287999.42	253771.20
40	1288012.03	253761.53
41	1288011.48	253747.12
42	1288024.16	253747.79
43	1288013.22	253733.81
44	1288000.17	253746.20
45	1287997.92	253648.38
46	1287981.11	253660.23
47	1288091.65	253519.81
48	1288077.55	253499.28
50	1288104.83	253501.18
52	1288195.90	253511.76
53	1288205.45	253525.76
54	1288184.38	253512.02
55	1288197.60	253497.54
57	1288382.74	253090.57
58	1288392.25	253094.62
59	1288399.90	253090.55
62	1288568.27	253106.30

LEGEND

- PLANNED SOIL REMOVAL ACTION AREAS
- PLANNED BUILDING REMOVAL ACTION AREAS
- PLANNED STORM DRAIN AND SINK DRAIN REMOVAL ACTION AREAS
- MANHOLE
- CATCH BASIN
- CONTRACTOR CONTROLLED AREA
- TRAFFIC ROUTING
- SOIL CHARACTERIZATION BORING

90 0 90 Feet

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

RADIOLOGICAL REMOVAL ACTION WORK PLAN
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 3-1

PLANNED REMOVAL ACTION AREAS

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: L7421.mxd

TETRA TECH EC, INC.

APPENDIX A

SUPPLEMENTAL INFORMATION
(on CD only)

This page intentionally left blank.

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

C H I / Q T A B L E S

Non-Radon Population Assessment
Mar 10, 2013 06:46 pm

Facility: Sand Point
Address:
City: Seattle
State: WA Zip:

Source Category:
Source Type: Area
Emission Year: 2010

Comments: Max values for all radionuclides for 2000 cubic yd
See above

Dataset Name: Sand Point
Dataset Date: 3/10/2013 6:43:00 PM
Wind File: C:\Program Files\CAP88-PC30\WindLib\24233.WND
Population File: C:\Program Files\CAP88-PC30\Poplib\Sand Point.pop

GROUND-LEVEL CHI/Q VALUES FOR Ra-226
SOLUBILITY: M
CHEMFORM: solid
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

Distance (meters)

Dir	250	750	1500	2500	3500	4500	7500
N	6.458E-05	8.642E-06	2.531E-06	1.060E-06	6.141E-07	4.168E-07	1.875E-07
NNW	1.385E-05	1.847E-06	5.403E-07	2.265E-07	1.313E-07	8.927E-08	4.025E-08
NW	1.648E-05	2.202E-06	6.429E-07	2.695E-07	1.563E-07	1.063E-07	4.795E-08
WNW	1.182E-05	1.579E-06	4.604E-07	1.929E-07	1.119E-07	7.609E-08	3.427E-08
W	7.358E-06	9.795E-07	2.852E-07	1.194E-07	6.918E-08	4.701E-08	2.114E-08
WSW	4.796E-06	6.393E-07	1.862E-07	7.802E-08	4.532E-08	3.087E-08	1.395E-08
SW	1.548E-05	2.063E-06	6.014E-07	2.525E-07	1.469E-07	1.003E-07	4.553E-08
SSW	2.645E-05	3.532E-06	1.034E-06	4.351E-07	2.537E-07	1.734E-07	7.919E-08
S	3.703E-05	4.920E-06	1.436E-06	6.026E-07	3.501E-07	2.386E-07	1.082E-07
SSE	1.452E-05	1.915E-06	5.529E-07	2.303E-07	1.332E-07	9.031E-08	4.040E-08
SE	1.097E-05	1.429E-06	4.081E-07	1.683E-07	9.651E-08	6.491E-08	2.851E-08
ESE	1.313E-05	1.698E-06	4.836E-07	1.987E-07	1.133E-07	7.586E-08	3.301E-08
E	1.624E-05	2.094E-06	5.942E-07	2.432E-07	1.383E-07	9.226E-08	3.980E-08
ENE	1.387E-05	1.812E-06	5.206E-07	2.149E-07	1.230E-07	8.252E-08	3.617E-08
NE	2.154E-05	2.856E-06	8.311E-07	3.459E-07	1.991E-07	1.344E-07	5.978E-08
NNE	3.135E-05	4.190E-06	1.227E-06	5.131E-07	2.963E-07	2.005E-07	8.983E-08

Distance (meters)

Dir	15000	25000	35000	45000	55000	70000
N	6.603E-08	2.838E-08	1.711E-08	1.145E-08	7.961E-09	4.638E-09
NNW	1.438E-08	6.234E-09	3.798E-09	2.555E-09	1.775E-09	1.014E-09
NW	1.719E-08	7.387E-09	4.509E-09	3.033E-09	2.097E-09	1.165E-09
WNW	1.227E-08	5.232E-09	3.191E-09	2.143E-09	1.478E-09	8.119E-10
W	7.575E-09	3.237E-09	1.978E-09	1.330E-09	9.185E-10	5.077E-10
WSW	5.074E-09	2.194E-09	1.356E-09	9.192E-10	6.377E-10	3.482E-10
SW	1.681E-08	7.416E-09	4.637E-09	3.177E-09	2.229E-09	1.241E-09
SSW	2.948E-08	1.330E-08	8.371E-09	5.782E-09	4.106E-09	2.369E-09
S	3.984E-08	1.778E-08	1.113E-08	7.657E-09	5.426E-09	3.159E-09
SSE	1.466E-08	6.229E-09	3.858E-09	2.615E-09	1.807E-09	9.706E-10
SE	1.012E-08	4.142E-09	2.531E-09	1.692E-09	1.149E-09	5.969E-10
ESE	1.148E-08	4.640E-09	2.810E-09	1.868E-09	1.268E-09	6.791E-10
E	1.360E-08	5.344E-09	3.188E-09	2.091E-09	1.404E-09	7.504E-10
ENE	1.245E-08	5.084E-09	3.037E-09	2.007E-09	1.371E-09	7.753E-10
NE	2.070E-08	8.755E-09	5.240E-09	3.491E-09	2.430E-09	1.447E-09
NNE	3.116E-08	1.336E-08	7.993E-09	5.336E-09	3.737E-09	2.268E-09

GROUND-LEVEL CHI/Q VALUES FOR Rn-222
SOLUBILITY: G
CHEMFORM: unspecified
SIZE: 0
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

Distance (meters)

Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Distance (meters)

Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Po-218
SOLUBILITY: M
CHEMFORM: inorganic
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Pb-214
SOLUBILITY: M
CHEMFORM: unspecified
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR At-218
SOLUBILITY: M
CHEMFORM: unspecified
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Bi-214
SOLUBILITY: M
CHEMFORM: unspecified
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

Distance (meters)

Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Distance (meters)

Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Po-214
SOLUBILITY: M
CHEMFORM: inorganic
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Pb-210
SOLUBILITY: M
CHEMFORM: unspecified
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Bi-210
SOLUBILITY: M
CHEMFORM: unspecified
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Po-210
SOLUBILITY: M
CHEMFORM: inorganic
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Sr-90
SOLUBILITY: M
CHEMFORM: solid
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	6.458E-05	8.642E-06	2.531E-06	1.060E-06	6.141E-07	4.168E-07	1.875E-07
NNW	1.385E-05	1.847E-06	5.403E-07	2.265E-07	1.313E-07	8.927E-08	4.025E-08
NW	1.648E-05	2.202E-06	6.429E-07	2.695E-07	1.563E-07	1.063E-07	4.795E-08
WNW	1.182E-05	1.579E-06	4.604E-07	1.929E-07	1.119E-07	7.609E-08	3.427E-08
W	7.358E-06	9.795E-07	2.852E-07	1.194E-07	6.918E-08	4.701E-08	2.114E-08
WSW	4.796E-06	6.393E-07	1.862E-07	7.802E-08	4.532E-08	3.087E-08	1.395E-08
SW	1.548E-05	2.063E-06	6.014E-07	2.525E-07	1.469E-07	1.003E-07	4.553E-08
SSW	2.645E-05	3.532E-06	1.034E-06	4.351E-07	2.537E-07	1.734E-07	7.919E-08
S	3.703E-05	4.920E-06	1.436E-06	6.026E-07	3.501E-07	2.386E-07	1.082E-07
SSE	1.452E-05	1.915E-06	5.529E-07	2.303E-07	1.332E-07	9.031E-08	4.040E-08
SE	1.097E-05	1.429E-06	4.081E-07	1.683E-07	9.651E-08	6.491E-08	2.851E-08
ESE	1.313E-05	1.698E-06	4.836E-07	1.987E-07	1.133E-07	7.586E-08	3.301E-08
E	1.624E-05	2.094E-06	5.942E-07	2.432E-07	1.383E-07	9.226E-08	3.980E-08
ENE	1.387E-05	1.812E-06	5.206E-07	2.149E-07	1.230E-07	8.252E-08	3.617E-08
NE	2.154E-05	2.856E-06	8.311E-07	3.459E-07	1.991E-07	1.344E-07	5.978E-08
NNE	3.135E-05	4.190E-06	1.227E-06	5.131E-07	2.963E-07	2.005E-07	8.983E-08

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	6.603E-08	2.838E-08	1.711E-08	1.145E-08	7.961E-09	4.638E-09
NNW	1.438E-08	6.234E-09	3.798E-09	2.555E-09	1.775E-09	1.014E-09
NW	1.719E-08	7.387E-09	4.509E-09	3.033E-09	2.097E-09	1.165E-09
WNW	1.227E-08	5.232E-09	3.191E-09	2.143E-09	1.478E-09	8.119E-10
W	7.575E-09	3.237E-09	1.978E-09	1.330E-09	9.185E-10	5.077E-10
WSW	5.074E-09	2.194E-09	1.356E-09	9.192E-10	6.377E-10	3.482E-10
SW	1.681E-08	7.416E-09	4.637E-09	3.177E-09	2.229E-09	1.241E-09
SSW	2.948E-08	1.330E-08	8.371E-09	5.782E-09	4.106E-09	2.369E-09
S	3.984E-08	1.778E-08	1.113E-08	7.657E-09	5.426E-09	3.159E-09
SSE	1.466E-08	6.229E-09	3.858E-09	2.615E-09	1.807E-09	9.706E-10
SE	1.012E-08	4.142E-09	2.531E-09	1.692E-09	1.149E-09	5.969E-10
ESE	1.148E-08	4.640E-09	2.810E-09	1.868E-09	1.268E-09	6.791E-10
E	1.360E-08	5.344E-09	3.188E-09	2.091E-09	1.404E-09	7.504E-10
ENE	1.245E-08	5.084E-09	3.037E-09	2.007E-09	1.371E-09	7.753E-10
NE	2.070E-08	8.755E-09	5.240E-09	3.491E-09	2.430E-09	1.447E-09
NNE	3.116E-08	1.336E-08	7.993E-09	5.336E-09	3.737E-09	2.268E-09

GROUND-LEVEL CHI/Q VALUES FOR Y-90
SOLUBILITY: M
CHEMFORM: unspecified
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

GROUND-LEVEL CHI/Q VALUES FOR Cs-137
SOLUBILITY: F
CHEMFORM: Solid
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

	Distance (meters)						
Dir	250	750	1500	2500	3500	4500	7500
N	6.458E-05	8.642E-06	2.531E-06	1.060E-06	6.141E-07	4.168E-07	1.875E-07
NNW	1.385E-05	1.847E-06	5.403E-07	2.265E-07	1.313E-07	8.927E-08	4.025E-08
NW	1.648E-05	2.202E-06	6.429E-07	2.695E-07	1.563E-07	1.063E-07	4.795E-08
WNW	1.182E-05	1.579E-06	4.604E-07	1.929E-07	1.119E-07	7.609E-08	3.427E-08
W	7.358E-06	9.795E-07	2.852E-07	1.194E-07	6.918E-08	4.701E-08	2.114E-08
WSW	4.796E-06	6.393E-07	1.862E-07	7.802E-08	4.532E-08	3.087E-08	1.395E-08
SW	1.548E-05	2.063E-06	6.014E-07	2.525E-07	1.469E-07	1.003E-07	4.553E-08
SSW	2.645E-05	3.532E-06	1.034E-06	4.351E-07	2.537E-07	1.734E-07	7.919E-08
S	3.703E-05	4.920E-06	1.436E-06	6.026E-07	3.501E-07	2.386E-07	1.082E-07
SSE	1.452E-05	1.915E-06	5.529E-07	2.303E-07	1.332E-07	9.031E-08	4.040E-08
SE	1.097E-05	1.429E-06	4.081E-07	1.683E-07	9.651E-08	6.491E-08	2.851E-08
ESE	1.313E-05	1.698E-06	4.836E-07	1.987E-07	1.133E-07	7.586E-08	3.301E-08
E	1.624E-05	2.094E-06	5.942E-07	2.432E-07	1.383E-07	9.226E-08	3.980E-08
ENE	1.387E-05	1.812E-06	5.206E-07	2.149E-07	1.230E-07	8.252E-08	3.617E-08
NE	2.154E-05	2.856E-06	8.311E-07	3.459E-07	1.991E-07	1.344E-07	5.978E-08
NNE	3.135E-05	4.190E-06	1.227E-06	5.131E-07	2.963E-07	2.005E-07	8.983E-08

	Distance (meters)					
Dir	15000	25000	35000	45000	55000	70000
N	6.603E-08	2.838E-08	1.711E-08	1.145E-08	7.961E-09	4.638E-09
NNW	1.438E-08	6.234E-09	3.798E-09	2.555E-09	1.775E-09	1.014E-09
NW	1.719E-08	7.387E-09	4.509E-09	3.033E-09	2.097E-09	1.165E-09
WNW	1.227E-08	5.232E-09	3.191E-09	2.143E-09	1.478E-09	8.119E-10
W	7.575E-09	3.237E-09	1.978E-09	1.330E-09	9.185E-10	5.077E-10
WSW	5.074E-09	2.194E-09	1.356E-09	9.192E-10	6.377E-10	3.482E-10
SW	1.681E-08	7.416E-09	4.637E-09	3.177E-09	2.229E-09	1.241E-09
SSW	2.948E-08	1.330E-08	8.371E-09	5.782E-09	4.106E-09	2.369E-09
S	3.984E-08	1.778E-08	1.113E-08	7.657E-09	5.426E-09	3.159E-09
SSE	1.466E-08	6.229E-09	3.858E-09	2.615E-09	1.807E-09	9.706E-10
SE	1.012E-08	4.142E-09	2.531E-09	1.692E-09	1.149E-09	5.969E-10
ESE	1.148E-08	4.640E-09	2.810E-09	1.868E-09	1.268E-09	6.791E-10
E	1.360E-08	5.344E-09	3.188E-09	2.091E-09	1.404E-09	7.504E-10
ENE	1.245E-08	5.084E-09	3.037E-09	2.007E-09	1.371E-09	7.753E-10
NE	2.070E-08	8.755E-09	5.240E-09	3.491E-09	2.430E-09	1.447E-09
NNE	3.116E-08	1.336E-08	7.993E-09	5.336E-09	3.737E-09	2.268E-09

GROUND-LEVEL CHI/Q VALUES FOR Ba-137m
SOLUBILITY: M
CHEMFORM: unspecified
SIZE: 1
CHI/Q TOWARD INDICATED DIRECTION (SEC/CUBIC METER)

Distance (meters)

Dir	250	750	1500	2500	3500	4500	7500
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Distance (meters)

Dir	15000	25000	35000	45000	55000	70000
N	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WNW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
W	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
WSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSW	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
S	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SSE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ESE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
E	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
ENE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NNE	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

C O N C E N T R A T I O N T A B L E S

Non-Radon Population Assessment
Mar 10, 2013 06:46 pm

Facility: Sand Point
Address:
City: Seattle
State: WA Zip:

Source Category:
Source Type: Area
Emission Year: 2010

Comments: Max values for all radionuclides for 2000 cubic yd
See above

Dataset Name: Sand Point
Dataset Date: 3/10/2013 6:43:00 PM
Wind File: C:\Program Files\CAP88-PC30\WindLib\24233.WND
Population File: C:\Program Files\CAP88-PC30\Poplib\Sand Point.pop

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
N	250	Ra-226	4.92E-02	8.85E-09	5.50E-10	9.40E-09
N	250	Rn-222	5.32E-05	0.00E+00	0.00E+00	0.00E+00
N	250	Po-218	2.84E-05	5.11E-12	3.18E-13	5.43E-12
N	250	Pb-214	2.19E-06	3.94E-13	2.45E-14	4.19E-13
N	250	Bi-214	1.64E-07	2.95E-14	1.84E-15	3.14E-14
N	250	Po-214	1.64E-07	2.95E-14	1.84E-15	3.14E-14
N	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	250	At-218	5.63E-09	1.01E-15	6.30E-17	1.08E-15
N	250	Sr-90	1.84E-02	3.32E-09	2.06E-10	3.52E-09
N	250	Y-90	2.77E-05	4.98E-12	3.10E-13	5.29E-12
N	250	Cs-137	3.69E-02	6.64E-09	4.12E-10	7.05E-09
N	250	Ba-137m	3.13E-02	5.63E-09	3.50E-10	5.97E-09
N	750	Ra-226	6.58E-03	1.18E-09	1.79E-10	1.36E-09
N	750	Rn-222	7.40E-06	0.00E+00	0.00E+00	0.00E+00
N	750	Po-218	3.80E-06	6.84E-13	1.03E-13	7.88E-13
N	750	Pb-214	2.93E-07	5.27E-14	7.96E-15	6.07E-14
N	750	Bi-214	2.20E-08	3.95E-15	5.97E-16	4.55E-15
N	750	Po-214	2.20E-08	3.95E-15	5.97E-16	4.55E-15
N	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	750	At-218	7.54E-10	1.36E-16	2.05E-17	1.56E-16
N	750	Sr-90	2.47E-03	4.44E-10	6.71E-11	5.11E-10
N	750	Y-90	3.71E-06	6.67E-13	1.01E-13	7.68E-13
N	750	Cs-137	4.93E-03	8.88E-10	1.34E-10	1.02E-09
N	750	Ba-137m	4.18E-03	7.53E-10	1.14E-10	8.66E-10
N	1500	Ra-226	1.93E-03	3.47E-10	8.77E-11	4.34E-10
N	1500	Rn-222	2.23E-06	0.00E+00	0.00E+00	0.00E+00
N	1500	Po-218	1.11E-06	2.00E-13	5.07E-14	2.51E-13
N	1500	Pb-214	8.58E-08	1.54E-14	3.91E-15	1.94E-14
N	1500	Bi-214	6.43E-09	1.16E-15	2.93E-16	1.45E-15
N	1500	Po-214	6.43E-09	1.16E-15	2.93E-16	1.45E-15
N	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	1500	At-218	2.21E-10	3.97E-17	1.00E-17	4.98E-17
N	1500	Sr-90	7.22E-04	1.30E-10	3.29E-11	1.63E-10
N	1500	Y-90	1.09E-06	1.95E-13	4.94E-14	2.45E-13
N	1500	Cs-137	1.44E-03	2.60E-10	6.58E-11	3.26E-10
N	1500	Ba-137m	1.22E-03	2.20E-10	5.57E-11	2.76E-10
N	2500	Ra-226	8.07E-04	1.45E-10	5.17E-11	1.97E-10
N	2500	Rn-222	9.59E-07	0.00E+00	0.00E+00	0.00E+00
N	2500	Po-218	4.66E-07	8.40E-14	2.99E-14	1.14E-13
N	2500	Pb-214	3.59E-08	6.47E-15	2.30E-15	8.78E-15
N	2500	Bi-214	2.70E-09	4.85E-16	1.73E-16	6.58E-16

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
N	2500	Po-214	2.69E-09	4.85E-16	1.73E-16	6.58E-16
N	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	2500	At-218	9.25E-11	1.66E-17	5.93E-18	2.26E-17
N	2500	Sr-90	3.03E-04	5.45E-11	1.94E-11	7.39E-11
N	2500	Y-90	4.55E-07	8.18E-14	2.91E-14	1.11E-13
N	2500	Cs-137	6.05E-04	1.09E-10	3.88E-11	1.48E-10
N	2500	Ba-137m	5.13E-04	9.24E-11	3.29E-11	1.25E-10
N	3500	Ra-226	4.67E-04	8.41E-11	3.64E-11	1.21E-10
N	3500	Rn-222	5.69E-07	0.00E+00	0.00E+00	0.00E+00
N	3500	Po-218	2.70E-07	4.86E-14	2.10E-14	6.97E-14
N	3500	Pb-214	2.08E-08	3.75E-15	1.62E-15	5.37E-15
N	3500	Bi-214	1.56E-09	2.81E-16	1.22E-16	4.03E-16
N	3500	Po-214	1.56E-09	2.81E-16	1.22E-16	4.02E-16
N	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	3500	At-218	5.35E-11	9.64E-18	4.17E-18	1.38E-17
N	3500	Sr-90	1.75E-04	3.15E-11	1.37E-11	4.52E-11
N	3500	Y-90	2.63E-07	4.74E-14	2.05E-14	6.79E-14
N	3500	Cs-137	3.51E-04	6.31E-11	2.73E-11	9.04E-11
N	3500	Ba-137m	2.97E-04	5.35E-11	2.32E-11	7.66E-11
N	4500	Ra-226	3.17E-04	5.71E-11	2.79E-11	8.50E-11
N	4500	Rn-222	3.96E-07	0.00E+00	0.00E+00	0.00E+00
N	4500	Po-218	1.83E-07	3.30E-14	1.61E-14	4.91E-14
N	4500	Pb-214	1.41E-08	2.54E-15	1.24E-15	3.79E-15
N	4500	Bi-214	1.06E-09	1.91E-16	9.33E-17	2.84E-16
N	4500	Po-214	1.06E-09	1.91E-16	9.33E-17	2.84E-16
N	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N	4500	At-218	3.63E-11	6.54E-18	3.20E-18	9.74E-18
N	4500	Sr-90	1.19E-04	2.14E-11	1.05E-11	3.19E-11
N	4500	Y-90	1.79E-07	3.22E-14	1.57E-14	4.79E-14
N	4500	Cs-137	2.38E-04	4.28E-11	2.10E-11	6.38E-11
N	4500	Ba-137m	2.02E-04	3.63E-11	1.78E-11	5.41E-11
N	7500	Ra-226	1.43E-04	2.57E-11	1.62E-11	4.19E-11
N	7500	Rn-222	1.89E-07	0.00E+00	0.00E+00	0.00E+00
N	7500	Po-218	8.25E-08	1.48E-14	1.04E-14	2.53E-14
N	7500	Pb-214	6.36E-09	1.14E-15	9.00E-16	2.04E-15
N	7500	Bi-214	4.77E-10	8.58E-17	8.33E-17	1.69E-16
N	7500	Po-214	4.77E-10	8.58E-17	5.89E-17	1.45E-16
N	7500	Pb-210	0.00E+00	0.00E+00	7.87E-19	7.87E-19
N	7500	Bi-210	0.00E+00	0.00E+00	1.29E-19	1.29E-19
N	7500	Po-210	0.00E+00	0.00E+00	2.12E-20	2.12E-20
N	7500	At-218	1.64E-11	2.94E-18	1.86E-18	4.80E-18

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
N	7500	Sr-90	5.35E-05	9.63E-12	6.07E-12	1.57E-11
N	7500	Y-90	8.04E-08	1.45E-14	9.12E-15	2.36E-14
N	7500	Cs-137	1.07E-04	1.93E-11	1.21E-11	3.14E-11
N	7500	Ba-137m	9.08E-05	1.63E-11	1.03E-11	2.66E-11
N	15000	Ra-226	5.03E-05	9.05E-12	7.68E-12	1.67E-11
N	15000	Rn-222	7.39E-08	0.00E+00	0.00E+00	0.00E+00
N	15000	Po-218	2.90E-08	5.23E-15	4.77E-15	1.00E-14
N	15000	Pb-214	2.24E-09	4.03E-16	3.74E-16	7.77E-16
N	15000	Bi-214	1.68E-10	3.02E-17	2.87E-17	5.89E-17
N	15000	Po-214	1.68E-10	3.02E-17	2.58E-17	5.60E-17
N	15000	Pb-210	0.00E+00	0.00E+00	2.93E-20	2.93E-20
N	15000	Bi-210	0.00E+00	0.00E+00	2.80E-21	2.80E-21
N	15000	Po-210	0.00E+00	0.00E+00	2.67E-22	2.67E-22
N	15000	At-218	5.76E-12	1.04E-18	8.76E-19	1.91E-18
N	15000	Sr-90	1.88E-05	3.39E-12	2.87E-12	6.26E-12
N	15000	Y-90	2.83E-08	5.10E-15	4.30E-15	9.40E-15
N	15000	Cs-137	3.77E-05	6.78E-12	5.73E-12	1.25E-11
N	15000	Ba-137m	3.20E-05	5.75E-12	4.86E-12	1.06E-11
N	25000	Ra-226	2.16E-05	3.89E-12	4.34E-12	8.23E-12
N	25000	Rn-222	3.86E-08	0.00E+00	0.00E+00	0.00E+00
N	25000	Po-218	1.25E-08	2.25E-15	2.90E-15	5.15E-15
N	25000	Pb-214	9.62E-10	1.73E-16	2.13E-16	3.86E-16
N	25000	Bi-214	7.21E-11	1.30E-17	1.55E-17	2.85E-17
N	25000	Po-214	7.21E-11	1.30E-17	1.41E-17	2.70E-17
N	25000	Pb-210	0.00E+00	0.00E+00	4.62E-21	4.62E-21
N	25000	Bi-210	0.00E+00	0.00E+00	2.57E-22	2.57E-22
N	25000	Po-210	0.00E+00	0.00E+00	1.43E-23	1.43E-23
N	25000	At-218	2.47E-12	4.45E-19	4.79E-19	9.25E-19
N	25000	Sr-90	8.10E-06	1.46E-12	1.57E-12	3.03E-12
N	25000	Y-90	1.22E-08	2.19E-15	2.36E-15	4.55E-15
N	25000	Cs-137	1.62E-05	2.92E-12	3.14E-12	6.05E-12
N	25000	Ba-137m	1.37E-05	2.47E-12	2.66E-12	5.13E-12
N	35000	Ra-226	1.30E-05	2.34E-12	2.95E-12	5.29E-12
N	35000	Rn-222	2.54E-08	0.00E+00	0.00E+00	0.00E+00
N	35000	Po-218	7.53E-09	1.35E-15	1.88E-15	3.23E-15
N	35000	Pb-214	5.80E-10	1.04E-16	1.38E-16	2.43E-16
N	35000	Bi-214	4.35E-11	7.83E-18	1.01E-17	1.79E-17
N	35000	Po-214	4.35E-11	7.83E-18	9.56E-18	1.74E-17
N	35000	Pb-210	0.00E+00	0.00E+00	1.33E-21	1.33E-21
N	35000	Bi-210	0.00E+00	0.00E+00	6.55E-23	6.55E-23
N	35000	Po-210	0.00E+00	0.00E+00	3.22E-24	3.22E-24
N	35000	At-218	1.49E-12	2.69E-19	3.27E-19	5.96E-19
N	35000	Sr-90	4.88E-06	8.79E-13	1.07E-12	1.95E-12
N	35000	Y-90	7.34E-09	1.32E-15	1.61E-15	2.93E-15
N	35000	Cs-137	9.77E-06	1.76E-12	2.14E-12	3.90E-12
N	35000	Ba-137m	8.28E-06	1.49E-12	1.82E-12	3.31E-12
N	45000	Ra-226	8.71E-06	1.57E-12	2.18E-12	3.75E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
N	45000	Rn-222	1.86E-08	0.00E+00	0.00E+00	0.00E+00
N	45000	Po-218	5.04E-09	9.06E-16	1.35E-15	2.26E-15
N	45000	Pb-214	3.88E-10	6.99E-17	9.99E-17	1.70E-16
N	45000	Bi-214	2.91E-11	5.24E-18	7.32E-18	1.26E-17
N	45000	Po-214	2.91E-11	5.24E-18	7.07E-18	1.23E-17
N	45000	Pb-210	0.00E+00	0.00E+00	5.20E-22	5.20E-22
N	45000	Bi-210	0.00E+00	0.00E+00	2.33E-23	2.33E-23
N	45000	Po-210	0.00E+00	0.00E+00	1.05E-24	1.05E-24
N	45000	At-218	9.98E-13	1.80E-19	2.42E-19	4.22E-19
N	45000	Sr-90	3.27E-06	5.88E-13	7.92E-13	1.38E-12
N	45000	Y-90	4.91E-09	8.84E-16	1.19E-15	2.07E-15
N	45000	Cs-137	6.54E-06	1.18E-12	1.58E-12	2.76E-12
N	45000	Ba-137m	5.54E-06	9.97E-13	1.34E-12	2.34E-12
N	55000	Ra-226	6.06E-06	1.09E-12	1.68E-12	2.77E-12
N	55000	Rn-222	1.45E-08	0.00E+00	0.00E+00	0.00E+00
N	55000	Po-218	3.50E-09	6.30E-16	1.02E-15	1.65E-15
N	55000	Pb-214	2.70E-10	4.86E-17	7.60E-17	1.25E-16
N	55000	Bi-214	2.02E-11	3.64E-18	5.58E-18	9.23E-18
N	55000	Po-214	2.02E-11	3.64E-18	5.45E-18	9.09E-18
N	55000	Pb-210	0.00E+00	0.00E+00	2.44E-22	2.44E-22
N	55000	Bi-210	0.00E+00	0.00E+00	1.01E-23	1.01E-23
N	55000	Po-210	0.00E+00	0.00E+00	4.23E-25	4.23E-25
N	55000	At-218	6.94E-13	1.25E-19	1.87E-19	3.12E-19
N	55000	Sr-90	2.27E-06	4.09E-13	6.11E-13	1.02E-12
N	55000	Y-90	3.41E-09	6.14E-16	9.18E-16	1.53E-15
N	55000	Cs-137	4.54E-06	8.18E-13	1.22E-12	2.04E-12
N	55000	Ba-137m	3.85E-06	6.93E-13	1.04E-12	1.73E-12
N	70000	Ra-226	3.53E-06	6.35E-13	1.19E-12	1.83E-12
N	70000	Rn-222	1.08E-08	0.00E+00	0.00E+00	0.00E+00
N	70000	Po-218	2.04E-09	3.67E-16	7.17E-16	1.08E-15
N	70000	Pb-214	1.57E-10	2.83E-17	5.35E-17	8.18E-17
N	70000	Bi-214	1.18E-11	2.12E-18	3.95E-18	6.07E-18
N	70000	Po-214	1.18E-11	2.12E-18	3.88E-18	6.01E-18
N	70000	Pb-210	0.00E+00	0.00E+00	9.66E-23	9.66E-23
N	70000	Bi-210	0.00E+00	0.00E+00	3.69E-24	3.69E-24
N	70000	Po-210	0.00E+00	0.00E+00	1.41E-25	1.41E-25
N	70000	At-218	4.04E-13	7.28E-20	1.33E-19	2.06E-19
N	70000	Sr-90	1.32E-06	2.38E-13	4.36E-13	6.74E-13
N	70000	Y-90	1.99E-09	3.58E-16	6.55E-16	1.01E-15
N	70000	Cs-137	2.65E-06	4.77E-13	8.72E-13	1.35E-12
N	70000	Ba-137m	2.24E-06	4.04E-13	7.39E-13	1.14E-12
NNW	250	Ra-226	1.05E-02	1.90E-09	1.11E-10	2.01E-09
NNW	250	Rn-222	1.14E-05	0.00E+00	0.00E+00	0.00E+00
NNW	250	Po-218	6.09E-06	1.10E-12	6.40E-14	1.16E-12
NNW	250	Pb-214	4.69E-07	8.45E-14	4.94E-15	8.94E-14
NNW	250	Bi-214	3.52E-08	6.33E-15	3.70E-16	6.70E-15
NNW	250	Po-214	3.52E-08	6.33E-15	3.70E-16	6.70E-15

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NNW	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	250	At-218	1.21E-09	2.17E-16	1.27E-17	2.30E-16
NNW	250	Sr-90	3.95E-03	7.11E-10	4.16E-11	7.53E-10
NNW	250	Y-90	5.94E-06	1.07E-12	6.24E-14	1.13E-12
NNW	250	Cs-137	7.90E-03	1.42E-09	8.31E-11	1.51E-09
NNW	250	Ba-137m	6.70E-03	1.21E-09	7.05E-11	1.28E-09
NNW	750	Ra-226	1.41E-03	2.53E-10	3.59E-11	2.89E-10
NNW	750	Rn-222	1.59E-06	0.00E+00	0.00E+00	0.00E+00
NNW	750	Po-218	8.12E-07	1.46E-13	2.08E-14	1.67E-13
NNW	750	Pb-214	6.26E-08	1.13E-14	1.60E-15	1.29E-14
NNW	750	Bi-214	4.69E-09	8.45E-16	1.20E-16	9.65E-16
NNW	750	Po-214	4.69E-09	8.45E-16	1.20E-16	9.65E-16
NNW	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	750	At-218	1.61E-10	2.90E-17	4.12E-18	3.31E-17
NNW	750	Sr-90	5.27E-04	9.49E-11	1.35E-11	1.08E-10
NNW	750	Y-90	7.92E-07	1.43E-13	2.02E-14	1.63E-13
NNW	750	Cs-137	1.05E-03	1.90E-10	2.69E-11	2.17E-10
NNW	750	Ba-137m	8.94E-04	1.61E-10	2.28E-11	1.84E-10
NNW	1500	Ra-226	4.11E-04	7.40E-11	1.76E-11	9.16E-11
NNW	1500	Rn-222	4.79E-07	0.00E+00	0.00E+00	0.00E+00
NNW	1500	Po-218	2.38E-07	4.28E-14	1.02E-14	5.29E-14
NNW	1500	Pb-214	1.83E-08	3.30E-15	7.82E-16	4.08E-15
NNW	1500	Bi-214	1.37E-09	2.47E-16	5.87E-17	3.06E-16
NNW	1500	Po-214	1.37E-09	2.47E-16	5.87E-17	3.06E-16
NNW	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	1500	At-218	4.71E-11	8.48E-18	2.01E-18	1.05E-17
NNW	1500	Sr-90	1.54E-04	2.78E-11	6.59E-12	3.43E-11
NNW	1500	Y-90	2.32E-07	4.17E-14	9.90E-15	5.16E-14
NNW	1500	Cs-137	3.08E-04	5.55E-11	1.32E-11	6.87E-11
NNW	1500	Ba-137m	2.61E-04	4.71E-11	1.12E-11	5.82E-11
NNW	2500	Ra-226	1.72E-04	3.10E-11	1.03E-11	4.14E-11
NNW	2500	Rn-222	2.07E-07	0.00E+00	0.00E+00	0.00E+00
NNW	2500	Po-218	9.96E-08	1.79E-14	5.98E-15	2.39E-14
NNW	2500	Pb-214	7.68E-09	1.38E-15	4.61E-16	1.84E-15
NNW	2500	Bi-214	5.76E-10	1.04E-16	3.45E-17	1.38E-16
NNW	2500	Po-214	5.76E-10	1.04E-16	3.45E-17	1.38E-16
NNW	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	2500	At-218	1.98E-11	3.56E-18	1.19E-18	4.74E-18
NNW	2500	Sr-90	6.46E-05	1.16E-11	3.88E-12	1.55E-11

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NNW	2500	Y-90	9.71E-08	1.75E-14	5.83E-15	2.33E-14
NNW	2500	Cs-137	1.29E-04	2.33E-11	7.76E-12	3.10E-11
NNW	2500	Ba-137m	1.10E-04	1.97E-11	6.58E-12	2.63E-11
NNW	3500	Ra-226	9.99E-05	1.80E-11	7.26E-12	2.53E-11
NNW	3500	Rn-222	1.23E-07	0.00E+00	0.00E+00	0.00E+00
NNW	3500	Po-218	5.77E-08	1.04E-14	4.20E-15	1.46E-14
NNW	3500	Pb-214	4.45E-09	8.01E-16	3.24E-16	1.12E-15
NNW	3500	Bi-214	3.34E-10	6.01E-17	2.43E-17	8.43E-17
NNW	3500	Po-214	3.34E-10	6.01E-17	2.43E-17	8.43E-17
NNW	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	3500	At-218	1.14E-11	2.06E-18	8.32E-19	2.89E-18
NNW	3500	Sr-90	3.75E-05	6.74E-12	2.72E-12	9.47E-12
NNW	3500	Y-90	5.63E-08	1.01E-14	4.09E-15	1.42E-14
NNW	3500	Cs-137	7.49E-05	1.35E-11	5.45E-12	1.89E-11
NNW	3500	Ba-137m	6.35E-05	1.14E-11	4.62E-12	1.61E-11
NNW	4500	Ra-226	6.79E-05	1.22E-11	5.56E-12	1.78E-11
NNW	4500	Rn-222	8.56E-08	0.00E+00	0.00E+00	0.00E+00
NNW	4500	Po-218	3.93E-08	7.07E-15	3.21E-15	1.03E-14
NNW	4500	Pb-214	3.03E-09	5.45E-16	2.48E-16	7.92E-16
NNW	4500	Bi-214	2.27E-10	4.08E-17	1.86E-17	5.94E-17
NNW	4500	Po-214	2.27E-10	4.08E-17	1.86E-17	5.94E-17
NNW	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNW	4500	At-218	7.78E-12	1.40E-18	6.37E-19	2.04E-18
NNW	4500	Sr-90	2.55E-05	4.59E-12	2.09E-12	6.67E-12
NNW	4500	Y-90	3.83E-08	6.89E-15	3.13E-15	1.00E-14
NNW	4500	Cs-137	5.10E-05	9.17E-12	4.17E-12	1.33E-11
NNW	4500	Ba-137m	4.32E-05	7.78E-12	3.54E-12	1.13E-11
NNW	7500	Ra-226	3.06E-05	5.51E-12	3.21E-12	8.72E-12
NNW	7500	Rn-222	4.11E-08	0.00E+00	0.00E+00	0.00E+00
NNW	7500	Po-218	1.77E-08	3.19E-15	1.85E-15	5.04E-15
NNW	7500	Pb-214	1.36E-09	2.46E-16	1.43E-16	3.88E-16
NNW	7500	Bi-214	1.02E-10	1.84E-17	1.07E-17	2.91E-17
NNW	7500	Po-214	1.02E-10	1.84E-17	1.07E-17	2.91E-17
NNW	7500	Pb-210	0.00E+00	0.00E+00	3.99E-25	3.99E-25
NNW	7500	Bi-210	0.00E+00	0.00E+00	1.13E-26	1.13E-26
NNW	7500	Po-210	0.00E+00	0.00E+00	3.20E-28	3.20E-28
NNW	7500	At-218	3.51E-12	6.32E-19	3.67E-19	9.99E-19
NNW	7500	Sr-90	1.15E-05	2.07E-12	1.20E-12	3.27E-12
NNW	7500	Y-90	1.73E-08	3.11E-15	1.81E-15	4.91E-15
NNW	7500	Cs-137	2.30E-05	4.14E-12	2.40E-12	6.54E-12
NNW	7500	Ba-137m	1.95E-05	3.51E-12	2.04E-12	5.54E-12
NNW	15000	Ra-226	1.09E-05	1.97E-12	1.50E-12	3.47E-12
NNW	15000	Rn-222	1.64E-08	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NNW	15000	Po-218	6.32E-09	1.14E-15	8.67E-16	2.01E-15
NNW	15000	Pb-214	4.87E-10	8.77E-17	6.68E-17	1.55E-16
NNW	15000	Bi-214	3.65E-11	6.58E-18	5.01E-18	1.16E-17
NNW	15000	Po-214	3.65E-11	6.58E-18	5.01E-18	1.16E-17
NNW	15000	Pb-210	0.00E+00	0.00E+00	2.69E-26	2.69E-26
NNW	15000	Bi-210	0.00E+00	0.00E+00	4.43E-28	4.43E-28
NNW	15000	Po-210	0.00E+00	0.00E+00	7.31E-30	7.31E-30
NNW	15000	At-218	1.25E-12	2.26E-19	1.72E-19	3.98E-19
NNW	15000	Sr-90	4.10E-06	7.39E-13	5.62E-13	1.30E-12
NNW	15000	Y-90	6.16E-09	1.11E-15	8.45E-16	1.95E-15
NNW	15000	Cs-137	8.21E-06	1.48E-12	1.12E-12	2.60E-12
NNW	15000	Ba-137m	6.96E-06	1.25E-12	9.54E-13	2.21E-12
NNW	25000	Ra-226	4.74E-06	8.54E-13	8.12E-13	1.67E-12
NNW	25000	Rn-222	8.71E-09	0.00E+00	0.00E+00	0.00E+00
NNW	25000	Po-218	2.74E-09	4.93E-16	4.67E-16	9.61E-16
NNW	25000	Pb-214	2.11E-10	3.80E-17	3.60E-17	7.40E-17
NNW	25000	Bi-214	1.58E-11	2.85E-18	2.70E-18	5.55E-18
NNW	25000	Po-214	1.58E-11	2.85E-18	2.70E-18	5.55E-18
NNW	25000	Pb-210	0.00E+00	0.00E+00	3.49E-27	3.49E-27
NNW	25000	Bi-210	0.00E+00	0.00E+00	3.35E-29	3.35E-29
NNW	25000	Po-210	0.00E+00	0.00E+00	3.22E-31	3.22E-31
NNW	25000	At-218	5.44E-13	9.78E-20	9.25E-20	1.90E-19
NNW	25000	Sr-90	1.78E-06	3.20E-13	3.03E-13	6.23E-13
NNW	25000	Y-90	2.67E-09	4.81E-16	4.55E-16	9.36E-16
NNW	25000	Cs-137	3.56E-06	6.40E-13	6.06E-13	1.25E-12
NNW	25000	Ba-137m	3.02E-06	5.43E-13	5.13E-13	1.06E-12
NNW	35000	Ra-226	2.89E-06	5.20E-13	5.49E-13	1.07E-12
NNW	35000	Rn-222	5.78E-09	0.00E+00	0.00E+00	0.00E+00
NNW	35000	Po-218	1.67E-09	3.01E-16	3.16E-16	6.17E-16
NNW	35000	Pb-214	1.29E-10	2.32E-17	2.43E-17	4.75E-17
NNW	35000	Bi-214	9.65E-12	1.74E-18	1.83E-18	3.56E-18
NNW	35000	Po-214	9.65E-12	1.74E-18	1.83E-18	3.56E-18
NNW	35000	Pb-210	0.00E+00	0.00E+00	1.00E-27	1.00E-27
NNW	35000	Bi-210	0.00E+00	0.00E+00	8.50E-30	8.50E-30
NNW	35000	Po-210	0.00E+00	0.00E+00	7.22E-32	7.22E-32
NNW	35000	At-218	3.31E-13	5.96E-20	6.26E-20	1.22E-19
NNW	35000	Sr-90	1.08E-06	1.95E-13	2.05E-13	4.00E-13
NNW	35000	Y-90	1.63E-09	2.93E-16	3.08E-16	6.01E-16
NNW	35000	Cs-137	2.17E-06	3.90E-13	4.10E-13	8.00E-13
NNW	35000	Ba-137m	1.84E-06	3.31E-13	3.48E-13	6.78E-13
NNW	45000	Ra-226	1.94E-06	3.50E-13	4.03E-13	7.53E-13
NNW	45000	Rn-222	4.27E-09	0.00E+00	0.00E+00	0.00E+00
NNW	45000	Po-218	1.12E-09	2.02E-16	2.32E-16	4.34E-16
NNW	45000	Pb-214	8.66E-11	1.56E-17	1.79E-17	3.35E-17
NNW	45000	Bi-214	6.49E-12	1.17E-18	1.34E-18	2.51E-18
NNW	45000	Po-214	6.49E-12	1.17E-18	1.34E-18	2.51E-18
NNW	45000	Pb-210	0.00E+00	0.00E+00	3.88E-28	3.88E-28

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NNW	45000	Bi-210	0.00E+00	0.00E+00	3.01E-30	3.01E-30
NNW	45000	Po-210	0.00E+00	0.00E+00	2.33E-32	2.33E-32
NNW	45000	At-218	2.23E-13	4.01E-20	4.59E-20	8.61E-20
NNW	45000	Sr-90	7.29E-07	1.31E-13	1.50E-13	2.82E-13
NNW	45000	Y-90	1.10E-09	1.97E-16	2.26E-16	4.23E-16
NNW	45000	Cs-137	1.46E-06	2.63E-13	3.01E-13	5.63E-13
NNW	45000	Ba-137m	1.24E-06	2.23E-13	2.55E-13	4.78E-13
NNW	55000	Ra-226	1.35E-06	2.43E-13	3.07E-13	5.50E-13
NNW	55000	Rn-222	3.35E-09	0.00E+00	0.00E+00	0.00E+00
NNW	55000	Po-218	7.81E-10	1.41E-16	1.77E-16	3.17E-16
NNW	55000	Pb-214	6.02E-11	1.08E-17	1.36E-17	2.44E-17
NNW	55000	Bi-214	4.51E-12	8.12E-19	1.02E-18	1.83E-18
NNW	55000	Po-214	4.51E-12	8.12E-19	1.02E-18	1.83E-18
NNW	55000	Pb-210	0.00E+00	0.00E+00	1.81E-28	1.81E-28
NNW	55000	Bi-210	0.00E+00	0.00E+00	1.30E-30	1.30E-30
NNW	55000	Po-210	0.00E+00	0.00E+00	9.37E-33	9.37E-33
NNW	55000	At-218	1.55E-13	2.79E-20	3.50E-20	6.29E-20
NNW	55000	Sr-90	5.07E-07	9.12E-14	1.15E-13	2.06E-13
NNW	55000	Y-90	7.61E-10	1.37E-16	1.72E-16	3.09E-16
NNW	55000	Cs-137	1.01E-06	1.82E-13	2.29E-13	4.11E-13
NNW	55000	Ba-137m	8.59E-07	1.55E-13	1.94E-13	3.49E-13
NNW	70000	Ra-226	7.72E-07	1.39E-13	2.13E-13	3.52E-13
NNW	70000	Rn-222	2.51E-09	0.00E+00	0.00E+00	0.00E+00
NNW	70000	Po-218	4.46E-10	8.03E-17	1.23E-16	2.03E-16
NNW	70000	Pb-214	3.44E-11	6.19E-18	9.46E-18	1.56E-17
NNW	70000	Bi-214	2.58E-12	4.64E-19	7.09E-19	1.17E-18
NNW	70000	Po-214	2.58E-12	4.64E-19	7.09E-19	1.17E-18
NNW	70000	Pb-210	0.00E+00	0.00E+00	7.10E-29	7.10E-29
NNW	70000	Bi-210	0.00E+00	0.00E+00	4.68E-31	4.68E-31
NNW	70000	Po-210	0.00E+00	0.00E+00	3.09E-33	3.09E-33
NNW	70000	At-218	8.85E-14	1.59E-20	2.43E-20	4.02E-20
NNW	70000	Sr-90	2.90E-07	5.21E-14	7.96E-14	1.32E-13
NNW	70000	Y-90	4.35E-10	7.83E-17	1.20E-16	1.98E-16
NNW	70000	Cs-137	5.79E-07	1.04E-13	1.59E-13	2.63E-13
NNW	70000	Ba-137m	4.91E-07	8.84E-14	1.35E-13	2.23E-13
NW	250	Ra-226	1.25E-02	2.26E-09	1.24E-10	2.38E-09
NW	250	Rn-222	1.36E-05	0.00E+00	0.00E+00	0.00E+00
NW	250	Po-218	7.25E-06	1.30E-12	7.15E-14	1.38E-12
NW	250	Pb-214	5.59E-07	1.01E-13	5.51E-15	1.06E-13
NW	250	Bi-214	4.19E-08	7.54E-15	4.13E-16	7.95E-15
NW	250	Po-214	4.19E-08	7.54E-15	4.13E-16	7.95E-15
NW	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	250	At-218	1.44E-09	2.59E-16	1.42E-17	2.73E-16
NW	250	Sr-90	4.70E-03	8.47E-10	4.64E-11	8.93E-10
NW	250	Y-90	7.07E-06	1.27E-12	6.97E-14	1.34E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NW	250	Cs-137	9.41E-03	1.69E-09	9.27E-11	1.79E-09
NW	250	Ba-137m	7.98E-03	1.44E-09	7.86E-11	1.51E-09
NW	750	Ra-226	1.68E-03	3.02E-10	4.00E-11	3.42E-10
NW	750	Rn-222	1.90E-06	0.00E+00	0.00E+00	0.00E+00
NW	750	Po-218	9.68E-07	1.74E-13	2.31E-14	1.97E-13
NW	750	Pb-214	7.46E-08	1.34E-14	1.78E-15	1.52E-14
NW	750	Bi-214	5.60E-09	1.01E-15	1.34E-16	1.14E-15
NW	750	Po-214	5.59E-09	1.01E-15	1.33E-16	1.14E-15
NW	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	750	At-218	1.92E-10	3.46E-17	4.58E-18	3.91E-17
NW	750	Sr-90	6.28E-04	1.13E-10	1.50E-11	1.28E-10
NW	750	Y-90	9.44E-07	1.70E-13	2.25E-14	1.92E-13
NW	750	Cs-137	1.26E-03	2.26E-10	3.00E-11	2.56E-10
NW	750	Ba-137m	1.07E-03	1.92E-10	2.54E-11	2.17E-10
NW	1500	Ra-226	4.89E-04	8.81E-11	1.95E-11	1.08E-10
NW	1500	Rn-222	5.75E-07	0.00E+00	0.00E+00	0.00E+00
NW	1500	Po-218	2.83E-07	5.09E-14	1.13E-14	6.22E-14
NW	1500	Pb-214	2.18E-08	3.92E-15	8.69E-16	4.79E-15
NW	1500	Bi-214	1.63E-09	2.94E-16	6.52E-17	3.59E-16
NW	1500	Po-214	1.63E-09	2.94E-16	6.52E-17	3.59E-16
NW	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	1500	At-218	5.61E-11	1.01E-17	2.24E-18	1.23E-17
NW	1500	Sr-90	1.83E-04	3.30E-11	7.32E-12	4.03E-11
NW	1500	Y-90	2.76E-07	4.96E-14	1.10E-14	6.06E-14
NW	1500	Cs-137	3.67E-04	6.60E-11	1.46E-11	8.07E-11
NW	1500	Ba-137m	3.11E-04	5.60E-11	1.24E-11	6.84E-11
NW	2500	Ra-226	2.05E-04	3.69E-11	1.15E-11	4.84E-11
NW	2500	Rn-222	2.48E-07	0.00E+00	0.00E+00	0.00E+00
NW	2500	Po-218	1.19E-07	2.13E-14	6.63E-15	2.80E-14
NW	2500	Pb-214	9.13E-09	1.64E-15	5.11E-16	2.16E-15
NW	2500	Bi-214	6.85E-10	1.23E-16	3.83E-17	1.62E-16
NW	2500	Po-214	6.85E-10	1.23E-16	3.83E-17	1.62E-16
NW	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	2500	At-218	2.35E-11	4.23E-18	1.31E-18	5.54E-18
NW	2500	Sr-90	7.69E-05	1.38E-11	4.30E-12	1.81E-11
NW	2500	Y-90	1.16E-07	2.08E-14	6.46E-15	2.73E-14
NW	2500	Cs-137	1.54E-04	2.77E-11	8.61E-12	3.63E-11
NW	2500	Ba-137m	1.30E-04	2.35E-11	7.30E-12	3.08E-11
NW	3500	Ra-226	1.19E-04	2.14E-11	8.05E-12	2.95E-11
NW	3500	Rn-222	1.48E-07	0.00E+00	0.00E+00	0.00E+00
NW	3500	Po-218	6.88E-08	1.24E-14	4.65E-15	1.70E-14

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NW	3500	Pb-214	5.30E-09	9.54E-16	3.58E-16	1.31E-15
NW	3500	Bi-214	3.97E-10	7.15E-17	2.69E-17	9.84E-17
NW	3500	Po-214	3.97E-10	7.15E-17	2.69E-17	9.84E-17
NW	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	3500	At-218	1.36E-11	2.45E-18	9.22E-19	3.38E-18
NW	3500	Sr-90	4.46E-05	8.03E-12	3.02E-12	1.10E-11
NW	3500	Y-90	6.70E-08	1.21E-14	4.53E-15	1.66E-14
NW	3500	Cs-137	8.92E-05	1.61E-11	6.04E-12	2.21E-11
NW	3500	Ba-137m	7.56E-05	1.36E-11	5.12E-12	1.87E-11
NW	4500	Ra-226	8.09E-05	1.46E-11	6.15E-12	2.07E-11
NW	4500	Rn-222	1.03E-07	0.00E+00	0.00E+00	0.00E+00
NW	4500	Po-218	4.68E-08	8.42E-15	3.56E-15	1.20E-14
NW	4500	Pb-214	3.60E-09	6.49E-16	2.74E-16	9.23E-16
NW	4500	Bi-214	2.70E-10	4.87E-17	2.05E-17	6.92E-17
NW	4500	Po-214	2.70E-10	4.86E-17	2.05E-17	6.92E-17
NW	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	4500	At-218	9.27E-12	1.67E-18	7.05E-19	2.37E-18
NW	4500	Sr-90	3.04E-05	5.46E-12	2.31E-12	7.77E-12
NW	4500	Y-90	4.56E-08	8.21E-15	3.47E-15	1.17E-14
NW	4500	Cs-137	6.07E-05	1.09E-11	4.62E-12	1.55E-11
NW	4500	Ba-137m	5.15E-05	9.26E-12	3.91E-12	1.32E-11
NW	7500	Ra-226	3.65E-05	6.57E-12	3.54E-12	1.01E-11
NW	7500	Rn-222	4.99E-08	0.00E+00	0.00E+00	0.00E+00
NW	7500	Po-218	2.11E-08	3.80E-15	2.04E-15	5.84E-15
NW	7500	Pb-214	1.63E-09	2.93E-16	1.57E-16	4.50E-16
NW	7500	Bi-214	1.22E-10	2.19E-17	1.18E-17	3.37E-17
NW	7500	Po-214	1.22E-10	2.19E-17	1.18E-17	3.37E-17
NW	7500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	7500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	7500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NW	7500	At-218	4.18E-12	7.53E-19	4.05E-19	1.16E-18
NW	7500	Sr-90	1.37E-05	2.46E-12	1.33E-12	3.79E-12
NW	7500	Y-90	2.06E-08	3.70E-15	1.99E-15	5.69E-15
NW	7500	Cs-137	2.74E-05	4.93E-12	2.65E-12	7.58E-12
NW	7500	Ba-137m	2.32E-05	4.18E-12	2.25E-12	6.42E-12
NW	15000	Ra-226	1.31E-05	2.35E-12	1.65E-12	4.00E-12
NW	15000	Rn-222	2.00E-08	0.00E+00	0.00E+00	0.00E+00
NW	15000	Po-218	7.56E-09	1.36E-15	9.53E-16	2.31E-15
NW	15000	Pb-214	5.83E-10	1.05E-16	7.34E-17	1.78E-16
NW	15000	Bi-214	4.37E-11	7.86E-18	5.50E-18	1.34E-17
NW	15000	Po-214	4.37E-11	7.86E-18	5.50E-18	1.34E-17
NW	15000	Pb-210	0.00E+00	0.00E+00	5.10E-26	5.10E-26
NW	15000	Bi-210	0.00E+00	0.00E+00	9.39E-28	9.39E-28

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NW	15000	Po-210	0.00E+00	0.00E+00	1.73E-29	1.73E-29
NW	15000	At-218	1.50E-12	2.70E-19	1.89E-19	4.59E-19
NW	15000	Sr-90	4.90E-06	8.83E-13	6.18E-13	1.50E-12
NW	15000	Y-90	7.37E-09	1.33E-15	9.29E-16	2.25E-15
NW	15000	Cs-137	9.81E-06	1.77E-12	1.24E-12	3.00E-12
NW	15000	Ba-137m	8.32E-06	1.50E-12	1.05E-12	2.54E-12
NW	25000	Ra-226	5.62E-06	1.01E-12	8.84E-13	1.90E-12
NW	25000	Rn-222	1.07E-08	0.00E+00	0.00E+00	0.00E+00
NW	25000	Po-218	3.25E-09	5.85E-16	5.09E-16	1.09E-15
NW	25000	Pb-214	2.50E-10	4.51E-17	3.92E-17	8.43E-17
NW	25000	Bi-214	1.88E-11	3.38E-18	2.94E-18	6.32E-18
NW	25000	Po-214	1.88E-11	3.38E-18	2.94E-18	6.32E-18
NW	25000	Pb-210	0.00E+00	0.00E+00	7.44E-27	7.44E-27
NW	25000	Bi-210	0.00E+00	0.00E+00	7.98E-29	7.98E-29
NW	25000	Po-210	0.00E+00	0.00E+00	8.55E-31	8.55E-31
NW	25000	At-218	6.44E-13	1.16E-19	1.01E-19	2.17E-19
NW	25000	Sr-90	2.11E-06	3.79E-13	3.30E-13	7.09E-13
NW	25000	Y-90	3.17E-09	5.70E-16	4.95E-16	1.07E-15
NW	25000	Cs-137	4.22E-06	7.59E-13	6.60E-13	1.42E-12
NW	25000	Ba-137m	3.57E-06	6.43E-13	5.59E-13	1.20E-12
NW	35000	Ra-226	3.43E-06	6.18E-13	5.98E-13	1.22E-12
NW	35000	Rn-222	7.16E-09	0.00E+00	0.00E+00	0.00E+00
NW	35000	Po-218	1.98E-09	3.57E-16	3.44E-16	7.01E-16
NW	35000	Pb-214	1.53E-10	2.75E-17	2.65E-17	5.40E-17
NW	35000	Bi-214	1.15E-11	2.06E-18	1.99E-18	4.05E-18
NW	35000	Po-214	1.15E-11	2.06E-18	1.99E-18	4.05E-18
NW	35000	Pb-210	0.00E+00	0.00E+00	2.15E-27	2.15E-27
NW	35000	Bi-210	0.00E+00	0.00E+00	2.03E-29	2.03E-29
NW	35000	Po-210	0.00E+00	0.00E+00	1.93E-31	1.93E-31
NW	35000	At-218	3.93E-13	7.08E-20	6.82E-20	1.39E-19
NW	35000	Sr-90	1.29E-06	2.32E-13	2.23E-13	4.55E-13
NW	35000	Y-90	1.93E-09	3.48E-16	3.35E-16	6.83E-16
NW	35000	Cs-137	2.57E-06	4.63E-13	4.46E-13	9.09E-13
NW	35000	Ba-137m	2.18E-06	3.93E-13	3.78E-13	7.71E-13
NW	45000	Ra-226	2.31E-06	4.15E-13	4.38E-13	8.53E-13
NW	45000	Rn-222	5.30E-09	0.00E+00	0.00E+00	0.00E+00
NW	45000	Po-218	1.33E-09	2.40E-16	2.52E-16	4.92E-16
NW	45000	Pb-214	1.03E-10	1.85E-17	1.94E-17	3.79E-17
NW	45000	Bi-214	7.71E-12	1.39E-18	1.46E-18	2.84E-18
NW	45000	Po-214	7.71E-12	1.39E-18	1.46E-18	2.84E-18
NW	45000	Pb-210	0.00E+00	0.00E+00	8.37E-28	8.37E-28
NW	45000	Bi-210	0.00E+00	0.00E+00	7.24E-30	7.24E-30
NW	45000	Po-210	0.00E+00	0.00E+00	6.26E-32	6.26E-32
NW	45000	At-218	2.64E-13	4.76E-20	5.00E-20	9.76E-20
NW	45000	Sr-90	8.65E-07	1.56E-13	1.64E-13	3.19E-13
NW	45000	Y-90	1.30E-09	2.34E-16	2.46E-16	4.80E-16
NW	45000	Cs-137	1.73E-06	3.12E-13	3.27E-13	6.39E-13

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NW	45000	Ba-137m	1.47E-06	2.64E-13	2.77E-13	5.41E-13
NW	55000	Ra-226	1.60E-06	2.87E-13	3.33E-13	6.20E-13
NW	55000	Rn-222	4.18E-09	0.00E+00	0.00E+00	0.00E+00
NW	55000	Po-218	9.22E-10	1.66E-16	1.92E-16	3.58E-16
NW	55000	Pb-214	7.11E-11	1.28E-17	1.48E-17	2.76E-17
NW	55000	Bi-214	5.33E-12	9.59E-19	1.11E-18	2.07E-18
NW	55000	Po-214	5.33E-12	9.59E-19	1.11E-18	2.07E-18
NW	55000	Pb-210	0.00E+00	0.00E+00	3.92E-28	3.92E-28
NW	55000	Bi-210	0.00E+00	0.00E+00	3.15E-30	3.15E-30
NW	55000	Po-210	0.00E+00	0.00E+00	2.53E-32	2.53E-32
NW	55000	At-218	1.83E-13	3.29E-20	3.80E-20	7.09E-20
NW	55000	Sr-90	5.98E-07	1.08E-13	1.24E-13	2.32E-13
NW	55000	Y-90	8.99E-10	1.62E-16	1.87E-16	3.48E-16
NW	55000	Cs-137	1.20E-06	2.15E-13	2.48E-13	4.64E-13
NW	55000	Ba-137m	1.01E-06	1.83E-13	2.11E-13	3.93E-13
NW	70000	Ra-226	8.86E-07	1.60E-13	2.29E-13	3.89E-13
NW	70000	Rn-222	3.14E-09	0.00E+00	0.00E+00	0.00E+00
NW	70000	Po-218	5.12E-10	9.22E-17	1.32E-16	2.24E-16
NW	70000	Pb-214	3.95E-11	7.11E-18	1.02E-17	1.73E-17
NW	70000	Bi-214	2.96E-12	5.33E-19	7.61E-19	1.29E-18
NW	70000	Po-214	2.96E-12	5.33E-19	7.61E-19	1.29E-18
NW	70000	Pb-210	0.00E+00	0.00E+00	1.55E-28	1.55E-28
NW	70000	Bi-210	0.00E+00	0.00E+00	1.14E-30	1.14E-30
NW	70000	Po-210	0.00E+00	0.00E+00	8.40E-33	8.40E-33
NW	70000	At-218	1.02E-13	1.83E-20	2.61E-20	4.44E-20
NW	70000	Sr-90	3.32E-07	5.98E-14	8.55E-14	1.45E-13
NW	70000	Y-90	4.99E-10	8.99E-17	1.28E-16	2.18E-16
NW	70000	Cs-137	6.65E-07	1.20E-13	1.71E-13	2.91E-13
NW	70000	Ba-137m	5.64E-07	1.01E-13	1.45E-13	2.46E-13
WNW	250	Ra-226	8.99E-03	1.62E-09	8.63E-11	1.71E-09
WNW	250	Rn-222	9.78E-06	0.00E+00	0.00E+00	0.00E+00
WNW	250	Po-218	5.20E-06	9.36E-13	4.99E-14	9.86E-13
WNW	250	Pb-214	4.01E-07	7.21E-14	3.84E-15	7.60E-14
WNW	250	Bi-214	3.00E-08	5.41E-15	2.88E-16	5.69E-15
WNW	250	Po-214	3.00E-08	5.41E-15	2.88E-16	5.69E-15
WNW	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	250	At-218	1.03E-09	1.86E-16	9.89E-18	1.95E-16
WNW	250	Sr-90	3.37E-03	6.07E-10	3.24E-11	6.39E-10
WNW	250	Y-90	5.07E-06	9.12E-13	4.86E-14	9.61E-13
WNW	250	Cs-137	6.75E-03	1.21E-09	6.47E-11	1.28E-09
WNW	250	Ba-137m	5.72E-03	1.03E-09	5.49E-11	1.08E-09
WNW	750	Ra-226	1.20E-03	2.16E-10	2.79E-11	2.44E-10
WNW	750	Rn-222	1.37E-06	0.00E+00	0.00E+00	0.00E+00
WNW	750	Po-218	6.94E-07	1.25E-13	1.61E-14	1.41E-13
WNW	750	Pb-214	5.35E-08	9.63E-15	1.24E-15	1.09E-14

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WNW	750	Bi-214	4.01E-09	7.22E-16	9.30E-17	8.15E-16
WNW	750	Po-214	4.01E-09	7.22E-16	9.30E-17	8.15E-16
WNW	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	750	At-218	1.38E-10	2.48E-17	3.19E-18	2.80E-17
WNW	750	Sr-90	4.51E-04	8.11E-11	1.04E-11	9.15E-11
WNW	750	Y-90	6.77E-07	1.22E-13	1.57E-14	1.38E-13
WNW	750	Cs-137	9.01E-04	1.62E-10	2.09E-11	1.83E-10
WNW	750	Ba-137m	7.64E-04	1.38E-10	1.77E-11	1.55E-10
WNW	1500	Ra-226	3.50E-04	6.31E-11	1.36E-11	7.67E-11
WNW	1500	Rn-222	4.14E-07	0.00E+00	0.00E+00	0.00E+00
WNW	1500	Po-218	2.02E-07	3.64E-14	7.85E-15	4.43E-14
WNW	1500	Pb-214	1.56E-08	2.81E-15	6.05E-16	3.41E-15
WNW	1500	Bi-214	1.17E-09	2.11E-16	4.54E-17	2.56E-16
WNW	1500	Po-214	1.17E-09	2.11E-16	4.54E-17	2.56E-16
WNW	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	1500	At-218	4.01E-11	7.23E-18	1.56E-18	8.78E-18
WNW	1500	Sr-90	1.31E-04	2.37E-11	5.10E-12	2.87E-11
WNW	1500	Y-90	1.97E-07	3.55E-14	7.65E-15	4.32E-14
WNW	1500	Cs-137	2.63E-04	4.73E-11	1.02E-11	5.75E-11
WNW	1500	Ba-137m	2.23E-04	4.01E-11	8.64E-12	4.87E-11
WNW	2500	Ra-226	1.47E-04	2.64E-11	7.98E-12	3.44E-11
WNW	2500	Rn-222	1.79E-07	0.00E+00	0.00E+00	0.00E+00
WNW	2500	Po-218	8.48E-08	1.53E-14	4.61E-15	1.99E-14
WNW	2500	Pb-214	6.54E-09	1.18E-15	3.56E-16	1.53E-15
WNW	2500	Bi-214	4.90E-10	8.82E-17	2.67E-17	1.15E-16
WNW	2500	Po-214	4.90E-10	8.82E-17	2.67E-17	1.15E-16
WNW	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	2500	At-218	1.68E-11	3.03E-18	9.15E-19	3.94E-18
WNW	2500	Sr-90	5.50E-05	9.91E-12	2.99E-12	1.29E-11
WNW	2500	Y-90	8.27E-08	1.49E-14	4.50E-15	1.94E-14
WNW	2500	Cs-137	1.10E-04	1.98E-11	5.99E-12	2.58E-11
WNW	2500	Ba-137m	9.33E-05	1.68E-11	5.08E-12	2.19E-11
WNW	3500	Ra-226	8.51E-05	1.53E-11	5.60E-12	2.09E-11
WNW	3500	Rn-222	1.07E-07	0.00E+00	0.00E+00	0.00E+00
WNW	3500	Po-218	4.92E-08	8.86E-15	3.23E-15	1.21E-14
WNW	3500	Pb-214	3.79E-09	6.83E-16	2.49E-16	9.32E-16
WNW	3500	Bi-214	2.84E-10	5.12E-17	1.87E-17	6.99E-17
WNW	3500	Po-214	2.84E-10	5.12E-17	1.87E-17	6.99E-17
WNW	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WNW	3500	At-218	9.76E-12	1.76E-18	6.41E-19	2.40E-18
WNW	3500	Sr-90	3.19E-05	5.75E-12	2.10E-12	7.85E-12
WNW	3500	Y-90	4.80E-08	8.63E-15	3.15E-15	1.18E-14
WNW	3500	Cs-137	6.39E-05	1.15E-11	4.20E-12	1.57E-11
WNW	3500	Ba-137m	5.41E-05	9.75E-12	3.56E-12	1.33E-11
WNW	4500	Ra-226	5.79E-05	1.04E-11	4.28E-12	1.47E-11
WNW	4500	Rn-222	7.45E-08	0.00E+00	0.00E+00	0.00E+00
WNW	4500	Po-218	3.35E-08	6.02E-15	2.47E-15	8.50E-15
WNW	4500	Pb-214	2.58E-09	4.64E-16	1.90E-16	6.55E-16
WNW	4500	Bi-214	1.93E-10	3.48E-17	1.43E-17	4.91E-17
WNW	4500	Po-214	1.93E-10	3.48E-17	1.43E-17	4.91E-17
WNW	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	4500	At-218	6.64E-12	1.19E-18	4.90E-19	1.68E-18
WNW	4500	Sr-90	2.17E-05	3.91E-12	1.60E-12	5.51E-12
WNW	4500	Y-90	3.26E-08	5.87E-15	2.41E-15	8.28E-15
WNW	4500	Cs-137	4.34E-05	7.82E-12	3.21E-12	1.10E-11
WNW	4500	Ba-137m	3.68E-05	6.63E-12	2.72E-12	9.35E-12
WNW	7500	Ra-226	2.61E-05	4.69E-12	2.45E-12	7.15E-12
WNW	7500	Rn-222	3.60E-08	0.00E+00	0.00E+00	0.00E+00
WNW	7500	Po-218	1.51E-08	2.71E-15	1.42E-15	4.13E-15
WNW	7500	Pb-214	1.16E-09	2.09E-16	1.09E-16	3.18E-16
WNW	7500	Bi-214	8.71E-11	1.57E-17	8.20E-18	2.39E-17
WNW	7500	Po-214	8.71E-11	1.57E-17	8.20E-18	2.39E-17
WNW	7500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	7500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	7500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WNW	7500	At-218	2.99E-12	5.38E-19	2.81E-19	8.19E-19
WNW	7500	Sr-90	9.78E-06	1.76E-12	9.20E-13	2.68E-12
WNW	7500	Y-90	1.47E-08	2.64E-15	1.38E-15	4.03E-15
WNW	7500	Cs-137	1.96E-05	3.52E-12	1.84E-12	5.36E-12
WNW	7500	Ba-137m	1.66E-05	2.98E-12	1.56E-12	4.55E-12
WNW	15000	Ra-226	9.33E-06	1.68E-12	1.14E-12	2.82E-12
WNW	15000	Rn-222	1.45E-08	0.00E+00	0.00E+00	0.00E+00
WNW	15000	Po-218	5.39E-09	9.71E-16	6.61E-16	1.63E-15
WNW	15000	Pb-214	4.16E-10	7.48E-17	5.09E-17	1.26E-16
WNW	15000	Bi-214	3.12E-11	5.61E-18	3.82E-18	9.43E-18
WNW	15000	Po-214	3.12E-11	5.61E-18	3.82E-18	9.43E-18
WNW	15000	Pb-210	0.00E+00	0.00E+00	3.83E-27	3.83E-27
WNW	15000	Bi-210	0.00E+00	0.00E+00	5.08E-29	5.08E-29
WNW	15000	Po-210	0.00E+00	0.00E+00	6.74E-31	6.74E-31
WNW	15000	At-218	1.07E-12	1.93E-19	1.31E-19	3.23E-19
WNW	15000	Sr-90	3.50E-06	6.30E-13	4.29E-13	1.06E-12
WNW	15000	Y-90	5.26E-09	9.46E-16	6.44E-16	1.59E-15
WNW	15000	Cs-137	7.00E-06	1.26E-12	8.57E-13	2.12E-12
WNW	15000	Ba-137m	5.94E-06	1.07E-12	7.27E-13	1.80E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WNW	25000	Ra-226	3.98E-06	7.17E-13	6.11E-13	1.33E-12
WNW	25000	Rn-222	7.80E-09	0.00E+00	0.00E+00	0.00E+00
WNW	25000	Po-218	2.30E-09	4.14E-16	3.52E-16	7.66E-16
WNW	25000	Pb-214	1.77E-10	3.19E-17	2.71E-17	5.90E-17
WNW	25000	Bi-214	1.33E-11	2.39E-18	2.03E-18	4.42E-18
WNW	25000	Po-214	1.33E-11	2.39E-18	2.03E-18	4.42E-18
WNW	25000	Pb-210	0.00E+00	0.00E+00	5.48E-28	5.48E-28
WNW	25000	Bi-210	0.00E+00	0.00E+00	4.23E-30	4.23E-30
WNW	25000	Po-210	0.00E+00	0.00E+00	3.27E-32	3.27E-32
WNW	25000	At-218	4.56E-13	8.21E-20	6.97E-20	1.52E-19
WNW	25000	Sr-90	1.49E-06	2.69E-13	2.28E-13	4.97E-13
WNW	25000	Y-90	2.24E-09	4.04E-16	3.43E-16	7.46E-16
WNW	25000	Cs-137	2.99E-06	5.38E-13	4.56E-13	9.94E-13
WNW	25000	Ba-137m	2.53E-06	4.56E-13	3.87E-13	8.42E-13
WNW	35000	Ra-226	2.43E-06	4.37E-13	4.13E-13	8.51E-13
WNW	35000	Rn-222	5.21E-09	0.00E+00	0.00E+00	0.00E+00
WNW	35000	Po-218	1.40E-09	2.53E-16	2.38E-16	4.91E-16
WNW	35000	Pb-214	1.08E-10	1.95E-17	1.83E-17	3.78E-17
WNW	35000	Bi-214	8.11E-12	1.46E-18	1.38E-18	2.84E-18
WNW	35000	Po-214	8.11E-12	1.46E-18	1.38E-18	2.83E-18
WNW	35000	Pb-210	0.00E+00	0.00E+00	1.58E-28	1.58E-28
WNW	35000	Bi-210	0.00E+00	0.00E+00	1.08E-30	1.08E-30
WNW	35000	Po-210	0.00E+00	0.00E+00	7.36E-33	7.36E-33
WNW	35000	At-218	2.78E-13	5.01E-20	4.72E-20	9.73E-20
WNW	35000	Sr-90	9.11E-07	1.64E-13	1.54E-13	3.18E-13
WNW	35000	Y-90	1.37E-09	2.46E-16	2.32E-16	4.78E-16
WNW	35000	Cs-137	1.82E-06	3.28E-13	3.09E-13	6.37E-13
WNW	35000	Ba-137m	1.54E-06	2.78E-13	2.62E-13	5.40E-13
WNW	45000	Ra-226	1.63E-06	2.94E-13	3.03E-13	5.97E-13
WNW	45000	Rn-222	3.86E-09	0.00E+00	0.00E+00	0.00E+00
WNW	45000	Po-218	9.42E-10	1.70E-16	1.75E-16	3.44E-16
WNW	45000	Pb-214	7.26E-11	1.31E-17	1.35E-17	2.65E-17
WNW	45000	Bi-214	5.45E-12	9.80E-19	1.01E-18	1.99E-18
WNW	45000	Po-214	5.45E-12	9.80E-19	1.01E-18	1.99E-18
WNW	45000	Pb-210	0.00E+00	0.00E+00	6.17E-29	6.17E-29
WNW	45000	Bi-210	0.00E+00	0.00E+00	3.84E-31	3.84E-31
WNW	45000	Po-210	0.00E+00	0.00E+00	2.39E-33	2.39E-33
WNW	45000	At-218	1.87E-13	3.36E-20	3.46E-20	6.83E-20
WNW	45000	Sr-90	6.12E-07	1.10E-13	1.13E-13	2.23E-13
WNW	45000	Y-90	9.19E-10	1.65E-16	1.70E-16	3.36E-16
WNW	45000	Cs-137	1.22E-06	2.20E-13	2.27E-13	4.47E-13
WNW	45000	Ba-137m	1.04E-06	1.87E-13	1.92E-13	3.79E-13
WNW	55000	Ra-226	1.12E-06	2.02E-13	2.31E-13	4.33E-13
WNW	55000	Rn-222	3.04E-09	0.00E+00	0.00E+00	0.00E+00
WNW	55000	Po-218	6.50E-10	1.17E-16	1.33E-16	2.50E-16
WNW	55000	Pb-214	5.01E-11	9.02E-18	1.02E-17	1.93E-17
WNW	55000	Bi-214	3.76E-12	6.76E-19	7.68E-19	1.44E-18

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WNW	55000	Po-214	3.76E-12	6.76E-19	7.68E-19	1.44E-18
WNW	55000	Pb-210	0.00E+00	0.00E+00	2.88E-29	2.88E-29
WNW	55000	Bi-210	0.00E+00	0.00E+00	1.67E-31	1.67E-31
WNW	55000	Po-210	0.00E+00	0.00E+00	9.66E-34	9.66E-34
WNW	55000	At-218	1.29E-13	2.32E-20	2.63E-20	4.95E-20
WNW	55000	Sr-90	4.22E-07	7.59E-14	8.62E-14	1.62E-13
WNW	55000	Y-90	6.34E-10	1.14E-16	1.30E-16	2.44E-16
WNW	55000	Cs-137	8.44E-07	1.52E-13	1.72E-13	3.24E-13
WNW	55000	Ba-137m	7.15E-07	1.29E-13	1.46E-13	2.75E-13
WNW	70000	Ra-226	6.18E-07	1.11E-13	1.59E-13	2.70E-13
WNW	70000	Rn-222	2.29E-09	0.00E+00	0.00E+00	0.00E+00
WNW	70000	Po-218	3.57E-10	6.43E-17	9.15E-17	1.56E-16
WNW	70000	Pb-214	2.75E-11	4.95E-18	7.05E-18	1.20E-17
WNW	70000	Bi-214	2.06E-12	3.71E-19	5.28E-19	9.00E-19
WNW	70000	Po-214	2.06E-12	3.71E-19	5.28E-19	9.00E-19
WNW	70000	Pb-210	0.00E+00	0.00E+00	1.14E-29	1.14E-29
WNW	70000	Bi-210	0.00E+00	0.00E+00	6.06E-32	6.06E-32
WNW	70000	Po-210	0.00E+00	0.00E+00	3.21E-34	3.21E-34
WNW	70000	At-218	7.08E-14	1.27E-20	1.81E-20	3.09E-20
WNW	70000	Sr-90	2.32E-07	4.17E-14	5.93E-14	1.01E-13
WNW	70000	Y-90	3.48E-10	6.27E-17	8.91E-17	1.52E-16
WNW	70000	Cs-137	4.63E-07	8.34E-14	1.19E-13	2.02E-13
WNW	70000	Ba-137m	3.93E-07	7.07E-14	1.01E-13	1.71E-13
W	250	Ra-226	5.60E-03	1.01E-09	5.43E-11	1.06E-09
W	250	Rn-222	6.09E-06	0.00E+00	0.00E+00	0.00E+00
W	250	Po-218	3.24E-06	5.83E-13	3.14E-14	6.14E-13
W	250	Pb-214	2.49E-07	4.49E-14	2.42E-15	4.73E-14
W	250	Bi-214	1.87E-08	3.37E-15	1.81E-16	3.55E-15
W	250	Po-214	1.87E-08	3.37E-15	1.81E-16	3.55E-15
W	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	250	At-218	6.42E-10	1.15E-16	6.22E-18	1.22E-16
W	250	Sr-90	2.10E-03	3.78E-10	2.04E-11	3.98E-10
W	250	Y-90	3.15E-06	5.68E-13	3.06E-14	5.98E-13
W	250	Cs-137	4.20E-03	7.56E-10	4.07E-11	7.97E-10
W	250	Ba-137m	3.56E-03	6.41E-10	3.45E-11	6.75E-10
W	750	Ra-226	7.45E-04	1.34E-10	1.75E-11	1.52E-10
W	750	Rn-222	8.50E-07	0.00E+00	0.00E+00	0.00E+00
W	750	Po-218	4.31E-07	7.75E-14	1.01E-14	8.77E-14
W	750	Pb-214	3.32E-08	5.98E-15	7.80E-16	6.76E-15
W	750	Bi-214	2.49E-09	4.48E-16	5.85E-17	5.07E-16
W	750	Po-214	2.49E-09	4.48E-16	5.85E-17	5.07E-16
W	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	750	At-218	8.54E-11	1.54E-17	2.01E-18	1.74E-17

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
W	750	Sr-90	2.80E-04	5.03E-11	6.57E-12	5.69E-11
W	750	Y-90	4.20E-07	7.56E-14	9.87E-15	8.55E-14
W	750	Cs-137	5.59E-04	1.01E-10	1.31E-11	1.14E-10
W	750	Ba-137m	4.74E-04	8.53E-11	1.11E-11	9.64E-11
W	1500	Ra-226	2.17E-04	3.91E-11	8.54E-12	4.76E-11
W	1500	Rn-222	2.57E-07	0.00E+00	0.00E+00	0.00E+00
W	1500	Po-218	1.25E-07	2.26E-14	4.93E-15	2.75E-14
W	1500	Pb-214	9.67E-09	1.74E-15	3.80E-16	2.12E-15
W	1500	Bi-214	7.25E-10	1.30E-16	2.85E-17	1.59E-16
W	1500	Po-214	7.25E-10	1.30E-16	2.85E-17	1.59E-16
W	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	1500	At-218	2.49E-11	4.48E-18	9.78E-19	5.46E-18
W	1500	Sr-90	8.14E-05	1.47E-11	3.20E-12	1.79E-11
W	1500	Y-90	1.22E-07	2.20E-14	4.81E-15	2.68E-14
W	1500	Cs-137	1.63E-04	2.93E-11	6.40E-12	3.57E-11
W	1500	Ba-137m	1.38E-04	2.48E-11	5.43E-12	3.03E-11
W	2500	Ra-226	9.08E-05	1.64E-11	5.01E-12	2.14E-11
W	2500	Rn-222	1.11E-07	0.00E+00	0.00E+00	0.00E+00
W	2500	Po-218	5.25E-08	9.45E-15	2.90E-15	1.23E-14
W	2500	Pb-214	4.05E-09	7.28E-16	2.23E-16	9.52E-16
W	2500	Bi-214	3.03E-10	5.46E-17	1.67E-17	7.13E-17
W	2500	Po-214	3.03E-10	5.46E-17	1.67E-17	7.13E-17
W	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	2500	At-218	1.04E-11	1.87E-18	5.74E-19	2.45E-18
W	2500	Sr-90	3.41E-05	6.13E-12	1.88E-12	8.01E-12
W	2500	Y-90	5.12E-08	9.21E-15	2.82E-15	1.20E-14
W	2500	Cs-137	6.81E-05	1.23E-11	3.76E-12	1.60E-11
W	2500	Ba-137m	5.78E-05	1.04E-11	3.19E-12	1.36E-11
W	3500	Ra-226	5.26E-05	9.48E-12	3.51E-12	1.30E-11
W	3500	Rn-222	6.62E-08	0.00E+00	0.00E+00	0.00E+00
W	3500	Po-218	3.04E-08	5.48E-15	2.03E-15	7.51E-15
W	3500	Pb-214	2.34E-09	4.22E-16	1.56E-16	5.79E-16
W	3500	Bi-214	1.76E-10	3.16E-17	1.17E-17	4.34E-17
W	3500	Po-214	1.76E-10	3.16E-17	1.17E-17	4.34E-17
W	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	3500	At-218	6.03E-12	1.09E-18	4.02E-19	1.49E-18
W	3500	Sr-90	1.97E-05	3.55E-12	1.32E-12	4.87E-12
W	3500	Y-90	2.97E-08	5.34E-15	1.98E-15	7.32E-15
W	3500	Cs-137	3.95E-05	7.11E-12	2.63E-12	9.74E-12
W	3500	Ba-137m	3.35E-05	6.03E-12	2.23E-12	8.26E-12
W	4500	Ra-226	3.58E-05	6.44E-12	2.68E-12	9.12E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
W	4500	Rn-222	4.63E-08	0.00E+00	0.00E+00	0.00E+00
W	4500	Po-218	2.07E-08	3.72E-15	1.55E-15	5.27E-15
W	4500	Pb-214	1.59E-09	2.87E-16	1.20E-16	4.06E-16
W	4500	Bi-214	1.19E-10	2.15E-17	8.96E-18	3.05E-17
W	4500	Po-214	1.19E-10	2.15E-17	8.96E-18	3.05E-17
W	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	4500	At-218	4.10E-12	7.38E-19	3.07E-19	1.05E-18
W	4500	Sr-90	1.34E-05	2.41E-12	1.01E-12	3.42E-12
W	4500	Y-90	2.02E-08	3.63E-15	1.51E-15	5.14E-15
W	4500	Cs-137	2.68E-05	4.83E-12	2.01E-12	6.84E-12
W	4500	Ba-137m	2.27E-05	4.09E-12	1.71E-12	5.80E-12
W	7500	Ra-226	1.61E-05	2.90E-12	1.54E-12	4.43E-12
W	7500	Rn-222	2.24E-08	0.00E+00	0.00E+00	0.00E+00
W	7500	Po-218	9.30E-09	1.67E-15	8.89E-16	2.56E-15
W	7500	Pb-214	7.17E-10	1.29E-16	6.85E-17	1.98E-16
W	7500	Bi-214	5.37E-11	9.67E-18	5.14E-18	1.48E-17
W	7500	Po-214	5.37E-11	9.67E-18	5.14E-18	1.48E-17
W	7500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	7500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	7500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W	7500	At-218	1.84E-12	3.32E-19	1.76E-19	5.08E-19
W	7500	Sr-90	6.03E-06	1.09E-12	5.77E-13	1.66E-12
W	7500	Y-90	9.06E-09	1.63E-15	8.67E-16	2.50E-15
W	7500	Cs-137	1.21E-05	2.17E-12	1.15E-12	3.33E-12
W	7500	Ba-137m	1.02E-05	1.84E-12	9.78E-13	2.82E-12
W	15000	Ra-226	5.77E-06	1.04E-12	7.15E-13	1.75E-12
W	15000	Rn-222	9.04E-09	0.00E+00	0.00E+00	0.00E+00
W	15000	Po-218	3.33E-09	6.00E-16	4.13E-16	1.01E-15
W	15000	Pb-214	2.57E-10	4.62E-17	3.18E-17	7.81E-17
W	15000	Bi-214	1.93E-11	3.47E-18	2.39E-18	5.85E-18
W	15000	Po-214	1.93E-11	3.47E-18	2.39E-18	5.85E-18
W	15000	Pb-210	0.00E+00	0.00E+00	7.32E-29	7.32E-29
W	15000	Bi-210	0.00E+00	0.00E+00	5.76E-31	5.76E-31
W	15000	Po-210	0.00E+00	0.00E+00	4.53E-33	4.53E-33
W	15000	At-218	6.61E-13	1.19E-19	8.19E-20	2.01E-19
W	15000	Sr-90	2.16E-06	3.89E-13	2.68E-13	6.57E-13
W	15000	Y-90	3.25E-09	5.85E-16	4.03E-16	9.87E-16
W	15000	Cs-137	4.32E-06	7.78E-13	5.36E-13	1.31E-12
W	15000	Ba-137m	3.67E-06	6.60E-13	4.55E-13	1.11E-12
W	25000	Ra-226	2.46E-06	4.43E-13	3.80E-13	8.24E-13
W	25000	Rn-222	4.87E-09	0.00E+00	0.00E+00	0.00E+00
W	25000	Po-218	1.42E-09	2.56E-16	2.19E-16	4.75E-16
W	25000	Pb-214	1.10E-10	1.98E-17	1.69E-17	3.66E-17
W	25000	Bi-214	8.23E-12	1.48E-18	1.27E-18	2.75E-18
W	25000	Po-214	8.23E-12	1.48E-18	1.27E-18	2.75E-18

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
W	25000	Pb-210	0.00E+00	0.00E+00	7.87E-30	7.87E-30
W	25000	Bi-210	0.00E+00	0.00E+00	3.60E-32	3.60E-32
W	25000	Po-210	0.00E+00	0.00E+00	1.65E-34	1.65E-34
W	25000	At-218	2.82E-13	5.08E-20	4.35E-20	9.43E-20
W	25000	Sr-90	9.24E-07	1.66E-13	1.42E-13	3.09E-13
W	25000	Y-90	1.39E-09	2.50E-16	2.14E-16	4.63E-16
W	25000	Cs-137	1.85E-06	3.33E-13	2.84E-13	6.17E-13
W	25000	Ba-137m	1.57E-06	2.82E-13	2.41E-13	5.23E-13
W	35000	Ra-226	1.51E-06	2.71E-13	2.57E-13	5.28E-13
W	35000	Rn-222	3.26E-09	0.00E+00	0.00E+00	0.00E+00
W	35000	Po-218	8.70E-10	1.57E-16	1.48E-16	3.05E-16
W	35000	Pb-214	6.71E-11	1.21E-17	1.14E-17	2.35E-17
W	35000	Bi-214	5.03E-12	9.05E-19	8.56E-19	1.76E-18
W	35000	Po-214	5.03E-12	9.05E-19	8.56E-19	1.76E-18
W	35000	Pb-210	0.00E+00	0.00E+00	2.27E-30	2.27E-30
W	35000	Bi-210	0.00E+00	0.00E+00	9.17E-33	9.17E-33
W	35000	Po-210	0.00E+00	0.00E+00	3.71E-35	3.71E-35
W	35000	At-218	1.73E-13	3.11E-20	2.94E-20	6.04E-20
W	35000	Sr-90	5.65E-07	1.02E-13	9.61E-14	1.98E-13
W	35000	Y-90	8.48E-10	1.53E-16	1.44E-16	2.97E-16
W	35000	Cs-137	1.13E-06	2.03E-13	1.92E-13	3.95E-13
W	35000	Ba-137m	9.57E-07	1.72E-13	1.63E-13	3.35E-13
W	45000	Ra-226	1.01E-06	1.82E-13	1.88E-13	3.70E-13
W	45000	Rn-222	2.42E-09	0.00E+00	0.00E+00	0.00E+00
W	45000	Po-218	5.85E-10	1.05E-16	1.08E-16	2.14E-16
W	45000	Pb-214	4.51E-11	8.12E-18	8.35E-18	1.65E-17
W	45000	Bi-214	3.38E-12	6.09E-19	6.26E-19	1.23E-18
W	45000	Po-214	3.38E-12	6.09E-19	6.26E-19	1.23E-18
W	45000	Pb-210	0.00E+00	0.00E+00	8.84E-31	8.84E-31
W	45000	Bi-210	0.00E+00	0.00E+00	3.26E-33	3.26E-33
W	45000	Po-210	0.00E+00	0.00E+00	1.21E-35	1.21E-35
W	45000	At-218	1.16E-13	2.09E-20	2.15E-20	4.24E-20
W	45000	Sr-90	3.80E-07	6.83E-14	7.03E-14	1.39E-13
W	45000	Y-90	5.70E-10	1.03E-16	1.06E-16	2.08E-16
W	45000	Cs-137	7.59E-07	1.37E-13	1.41E-13	2.77E-13
W	45000	Ba-137m	6.44E-07	1.16E-13	1.19E-13	2.35E-13
W	55000	Ra-226	6.99E-07	1.26E-13	1.42E-13	2.68E-13
W	55000	Rn-222	1.91E-09	0.00E+00	0.00E+00	0.00E+00
W	55000	Po-218	4.04E-10	7.27E-17	8.22E-17	1.55E-16
W	55000	Pb-214	3.11E-11	5.60E-18	6.33E-18	1.19E-17
W	55000	Bi-214	2.33E-12	4.20E-19	4.75E-19	8.95E-19
W	55000	Po-214	2.33E-12	4.20E-19	4.75E-19	8.95E-19
W	55000	Pb-210	0.00E+00	0.00E+00	4.13E-31	4.13E-31
W	55000	Bi-210	0.00E+00	0.00E+00	1.42E-33	1.42E-33
W	55000	Po-210	0.00E+00	0.00E+00	4.86E-36	4.86E-36
W	55000	At-218	8.01E-14	1.44E-20	1.63E-20	3.07E-20
W	55000	Sr-90	2.62E-07	4.72E-14	5.33E-14	1.01E-13

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
W	55000	Y-90	3.94E-10	7.09E-17	8.01E-17	1.51E-16
W	55000	Cs-137	5.24E-07	9.44E-14	1.07E-13	2.01E-13
W	55000	Ba-137m	4.44E-07	8.00E-14	9.04E-14	1.70E-13
W	70000	Ra-226	3.86E-07	6.96E-14	9.77E-14	1.67E-13
W	70000	Rn-222	1.43E-09	0.00E+00	0.00E+00	0.00E+00
W	70000	Po-218	2.23E-10	4.02E-17	5.63E-17	9.65E-17
W	70000	Pb-214	1.72E-11	3.10E-18	4.34E-18	7.44E-18
W	70000	Bi-214	1.29E-12	2.32E-19	3.26E-19	5.58E-19
W	70000	Po-214	1.29E-12	2.32E-19	3.26E-19	5.58E-19
W	70000	Pb-210	0.00E+00	0.00E+00	1.63E-31	1.63E-31
W	70000	Bi-210	0.00E+00	0.00E+00	5.14E-34	5.14E-34
W	70000	Po-210	0.00E+00	0.00E+00	1.61E-36	1.61E-36
W	70000	At-218	4.43E-14	7.97E-21	1.12E-20	1.91E-20
W	70000	Sr-90	1.45E-07	2.61E-14	3.66E-14	6.26E-14
W	70000	Y-90	2.18E-10	3.92E-17	5.49E-17	9.41E-17
W	70000	Cs-137	2.90E-07	5.22E-14	7.31E-14	1.25E-13
W	70000	Ba-137m	2.46E-07	4.42E-14	6.20E-14	1.06E-13
WSW	250	Ra-226	3.65E-03	6.57E-10	3.36E-11	6.91E-10
WSW	250	Rn-222	3.97E-06	0.00E+00	0.00E+00	0.00E+00
WSW	250	Po-218	2.11E-06	3.80E-13	1.94E-14	3.99E-13
WSW	250	Pb-214	1.63E-07	2.93E-14	1.49E-15	3.08E-14
WSW	250	Bi-214	1.22E-08	2.19E-15	1.12E-16	2.31E-15
WSW	250	Po-214	1.22E-08	2.19E-15	1.12E-16	2.31E-15
WSW	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	250	At-218	4.18E-10	7.53E-17	3.85E-18	7.91E-17
WSW	250	Sr-90	1.37E-03	2.46E-10	1.26E-11	2.59E-10
WSW	250	Y-90	2.06E-06	3.70E-13	1.89E-14	3.89E-13
WSW	250	Cs-137	2.74E-03	4.93E-10	2.52E-11	5.18E-10
WSW	250	Ba-137m	2.32E-03	4.18E-10	2.13E-11	4.39E-10
WSW	750	Ra-226	4.87E-04	8.76E-11	1.08E-11	9.84E-11
WSW	750	Rn-222	5.54E-07	0.00E+00	0.00E+00	0.00E+00
WSW	750	Po-218	2.81E-07	5.06E-14	6.25E-15	5.69E-14
WSW	750	Pb-214	2.17E-08	3.90E-15	4.82E-16	4.38E-15
WSW	750	Bi-214	1.62E-09	2.92E-16	3.61E-17	3.29E-16
WSW	750	Po-214	1.62E-09	2.92E-16	3.61E-17	3.29E-16
WSW	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	750	At-218	5.57E-11	1.00E-17	1.24E-18	1.13E-17
WSW	750	Sr-90	1.82E-04	3.28E-11	4.06E-12	3.69E-11
WSW	750	Y-90	2.74E-07	4.93E-14	6.10E-15	5.54E-14
WSW	750	Cs-137	3.65E-04	6.57E-11	8.12E-12	7.38E-11
WSW	750	Ba-137m	3.09E-04	5.57E-11	6.88E-12	6.26E-11
WSW	1500	Ra-226	1.42E-04	2.55E-11	5.27E-12	3.08E-11
WSW	1500	Rn-222	1.67E-07	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WSW	1500	Po-218	8.19E-08	1.47E-14	3.05E-15	1.78E-14
WSW	1500	Pb-214	6.31E-09	1.14E-15	2.35E-16	1.37E-15
WSW	1500	Bi-214	4.73E-10	8.52E-17	1.76E-17	1.03E-16
WSW	1500	Po-214	4.73E-10	8.52E-17	1.76E-17	1.03E-16
WSW	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	1500	At-218	1.62E-11	2.92E-18	6.04E-19	3.53E-18
WSW	1500	Sr-90	5.31E-05	9.56E-12	1.98E-12	1.15E-11
WSW	1500	Y-90	7.98E-08	1.44E-14	2.97E-15	1.73E-14
WSW	1500	Cs-137	1.06E-04	1.91E-11	3.95E-12	2.31E-11
WSW	1500	Ba-137m	9.01E-05	1.62E-11	3.35E-12	1.96E-11
WSW	2500	Ra-226	5.94E-05	1.07E-11	3.10E-12	1.38E-11
WSW	2500	Rn-222	7.23E-08	0.00E+00	0.00E+00	0.00E+00
WSW	2500	Po-218	3.43E-08	6.18E-15	1.79E-15	7.97E-15
WSW	2500	Pb-214	2.64E-09	4.76E-16	1.38E-16	6.14E-16
WSW	2500	Bi-214	1.98E-10	3.57E-17	1.03E-17	4.60E-17
WSW	2500	Po-214	1.98E-10	3.57E-17	1.03E-17	4.60E-17
WSW	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	2500	At-218	6.80E-12	1.22E-18	3.55E-19	1.58E-18
WSW	2500	Sr-90	2.23E-05	4.01E-12	1.16E-12	5.17E-12
WSW	2500	Y-90	3.34E-08	6.02E-15	1.74E-15	7.76E-15
WSW	2500	Cs-137	4.45E-05	8.02E-12	2.32E-12	1.03E-11
WSW	2500	Ba-137m	3.78E-05	6.80E-12	1.97E-12	8.76E-12
WSW	3500	Ra-226	3.45E-05	6.21E-12	2.17E-12	8.38E-12
WSW	3500	Rn-222	4.33E-08	0.00E+00	0.00E+00	0.00E+00
WSW	3500	Po-218	1.99E-08	3.59E-15	1.25E-15	4.84E-15
WSW	3500	Pb-214	1.54E-09	2.77E-16	9.66E-17	3.73E-16
WSW	3500	Bi-214	1.15E-10	2.07E-17	7.24E-18	2.80E-17
WSW	3500	Po-214	1.15E-10	2.07E-17	7.24E-18	2.80E-17
WSW	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	3500	At-218	3.95E-12	7.11E-19	2.48E-19	9.60E-19
WSW	3500	Sr-90	1.29E-05	2.33E-12	8.13E-13	3.14E-12
WSW	3500	Y-90	1.94E-08	3.50E-15	1.22E-15	4.72E-15
WSW	3500	Cs-137	2.59E-05	4.66E-12	1.63E-12	6.28E-12
WSW	3500	Ba-137m	2.19E-05	3.95E-12	1.38E-12	5.33E-12
WSW	4500	Ra-226	2.35E-05	4.23E-12	1.66E-12	5.88E-12
WSW	4500	Rn-222	3.03E-08	0.00E+00	0.00E+00	0.00E+00
WSW	4500	Po-218	1.36E-08	2.44E-15	9.57E-16	3.40E-15
WSW	4500	Pb-214	1.05E-09	1.88E-16	7.38E-17	2.62E-16
WSW	4500	Bi-214	7.85E-11	1.41E-17	5.53E-18	1.97E-17
WSW	4500	Po-214	7.84E-11	1.41E-17	5.53E-18	1.96E-17
WSW	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WSW	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	4500	At-218	2.69E-12	4.85E-19	1.90E-19	6.74E-19
WSW	4500	Sr-90	8.81E-06	1.59E-12	6.21E-13	2.21E-12
WSW	4500	Y-90	1.32E-08	2.38E-15	9.33E-16	3.31E-15
WSW	4500	Cs-137	1.76E-05	3.17E-12	1.24E-12	4.41E-12
WSW	4500	Ba-137m	1.49E-05	2.69E-12	1.05E-12	3.74E-12
WSW	7500	Ra-226	1.06E-05	1.91E-12	9.48E-13	2.86E-12
WSW	7500	Rn-222	1.47E-08	0.00E+00	0.00E+00	0.00E+00
WSW	7500	Po-218	6.13E-09	1.10E-15	5.48E-16	1.65E-15
WSW	7500	Pb-214	4.73E-10	8.51E-17	4.22E-17	1.27E-16
WSW	7500	Bi-214	3.54E-11	6.38E-18	3.17E-18	9.55E-18
WSW	7500	Po-214	3.54E-11	6.38E-18	3.17E-18	9.55E-18
WSW	7500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	7500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	7500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WSW	7500	At-218	1.22E-12	2.19E-19	1.09E-19	3.28E-19
WSW	7500	Sr-90	3.98E-06	7.16E-13	3.56E-13	1.07E-12
WSW	7500	Y-90	5.98E-09	1.08E-15	5.34E-16	1.61E-15
WSW	7500	Cs-137	7.96E-06	1.43E-12	7.11E-13	2.14E-12
WSW	7500	Ba-137m	6.75E-06	1.21E-12	6.03E-13	1.82E-12
WSW	15000	Ra-226	3.86E-06	6.95E-13	4.40E-13	1.14E-12
WSW	15000	Rn-222	6.01E-09	0.00E+00	0.00E+00	0.00E+00
WSW	15000	Po-218	2.23E-09	4.02E-16	2.54E-16	6.56E-16
WSW	15000	Pb-214	1.72E-10	3.10E-17	1.96E-17	5.06E-17
WSW	15000	Bi-214	1.29E-11	2.32E-18	1.47E-18	3.79E-18
WSW	15000	Po-214	1.29E-11	2.32E-18	1.47E-18	3.79E-18
WSW	15000	Pb-210	0.00E+00	0.00E+00	1.46E-30	1.46E-30
WSW	15000	Bi-210	0.00E+00	0.00E+00	7.11E-33	7.11E-33
WSW	15000	Po-210	0.00E+00	0.00E+00	3.47E-35	3.47E-35
WSW	15000	At-218	4.42E-13	7.96E-20	5.04E-20	1.30E-19
WSW	15000	Sr-90	1.45E-06	2.61E-13	1.65E-13	4.26E-13
WSW	15000	Y-90	2.18E-09	3.92E-16	2.48E-16	6.40E-16
WSW	15000	Cs-137	2.90E-06	5.21E-13	3.30E-13	8.51E-13
WSW	15000	Ba-137m	2.46E-06	4.42E-13	2.80E-13	7.22E-13
WSW	25000	Ra-226	1.67E-06	3.01E-13	2.32E-13	5.33E-13
WSW	25000	Rn-222	3.27E-09	0.00E+00	0.00E+00	0.00E+00
WSW	25000	Po-218	9.65E-10	1.74E-16	1.34E-16	3.08E-16
WSW	25000	Pb-214	7.44E-11	1.34E-17	1.03E-17	2.37E-17
WSW	25000	Bi-214	5.58E-12	1.00E-18	7.75E-19	1.78E-18
WSW	25000	Po-214	5.58E-12	1.00E-18	7.75E-19	1.78E-18
WSW	25000	Pb-210	0.00E+00	0.00E+00	1.66E-31	1.66E-31
WSW	25000	Bi-210	0.00E+00	0.00E+00	4.73E-34	4.73E-34
WSW	25000	Po-210	0.00E+00	0.00E+00	1.34E-36	1.34E-36
WSW	25000	At-218	1.91E-13	3.44E-20	2.66E-20	6.10E-20
WSW	25000	Sr-90	6.26E-07	1.13E-13	8.70E-14	2.00E-13
WSW	25000	Y-90	9.41E-10	1.69E-16	1.31E-16	3.00E-16

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WSW	25000	Cs-137	1.25E-06	2.25E-13	1.74E-13	3.99E-13
WSW	25000	Ba-137m	1.06E-06	1.91E-13	1.48E-13	3.39E-13
WSW	35000	Ra-226	1.03E-06	1.86E-13	1.57E-13	3.43E-13
WSW	35000	Rn-222	2.20E-09	0.00E+00	0.00E+00	0.00E+00
WSW	35000	Po-218	5.96E-10	1.07E-16	9.06E-17	1.98E-16
WSW	35000	Pb-214	4.60E-11	8.27E-18	6.98E-18	1.53E-17
WSW	35000	Bi-214	3.45E-12	6.20E-19	5.23E-19	1.14E-18
WSW	35000	Po-214	3.45E-12	6.20E-19	5.23E-19	1.14E-18
WSW	35000	Pb-210	0.00E+00	0.00E+00	4.76E-32	4.76E-32
WSW	35000	Bi-210	0.00E+00	0.00E+00	1.20E-34	1.20E-34
WSW	35000	Po-210	0.00E+00	0.00E+00	3.01E-37	3.01E-37
WSW	35000	At-218	1.18E-13	2.13E-20	1.80E-20	3.92E-20
WSW	35000	Sr-90	3.87E-07	6.96E-14	5.88E-14	1.28E-13
WSW	35000	Y-90	5.81E-10	1.05E-16	8.83E-17	1.93E-16
WSW	35000	Cs-137	7.74E-07	1.39E-13	1.18E-13	2.57E-13
WSW	35000	Ba-137m	6.56E-07	1.18E-13	9.97E-14	2.18E-13
WSW	45000	Ra-226	7.00E-07	1.26E-13	1.15E-13	2.41E-13
WSW	45000	Rn-222	1.64E-09	0.00E+00	0.00E+00	0.00E+00
WSW	45000	Po-218	4.04E-10	7.28E-17	6.62E-17	1.39E-16
WSW	45000	Pb-214	3.12E-11	5.61E-18	5.10E-18	1.07E-17
WSW	45000	Bi-214	2.34E-12	4.20E-19	3.83E-19	8.03E-19
WSW	45000	Po-214	2.34E-12	4.20E-19	3.83E-19	8.03E-19
WSW	45000	Pb-210	0.00E+00	0.00E+00	1.85E-32	1.85E-32
WSW	45000	Bi-210	0.00E+00	0.00E+00	4.24E-35	4.24E-35
WSW	45000	Po-210	0.00E+00	0.00E+00	9.72E-38	9.72E-38
WSW	45000	At-218	8.02E-14	1.44E-20	1.31E-20	2.76E-20
WSW	45000	Sr-90	2.62E-07	4.72E-14	4.30E-14	9.02E-14
WSW	45000	Y-90	3.94E-10	7.09E-17	6.46E-17	1.35E-16
WSW	45000	Cs-137	5.25E-07	9.44E-14	8.59E-14	1.80E-13
WSW	45000	Ba-137m	4.45E-07	8.01E-14	7.29E-14	1.53E-13
WSW	55000	Ra-226	4.85E-07	8.74E-14	8.68E-14	1.74E-13
WSW	55000	Rn-222	1.30E-09	0.00E+00	0.00E+00	0.00E+00
WSW	55000	Po-218	2.80E-10	5.05E-17	5.01E-17	1.01E-16
WSW	55000	Pb-214	2.16E-11	3.89E-18	3.86E-18	7.75E-18
WSW	55000	Bi-214	1.62E-12	2.92E-19	2.89E-19	5.81E-19
WSW	55000	Po-214	1.62E-12	2.92E-19	2.89E-19	5.81E-19
WSW	55000	Pb-210	0.00E+00	0.00E+00	8.61E-33	8.61E-33
WSW	55000	Bi-210	0.00E+00	0.00E+00	1.83E-35	1.83E-35
WSW	55000	Po-210	0.00E+00	0.00E+00	3.91E-38	3.91E-38
WSW	55000	At-218	5.56E-14	1.00E-20	9.93E-21	1.99E-20
WSW	55000	Sr-90	1.82E-07	3.28E-14	3.25E-14	6.53E-14
WSW	55000	Y-90	2.73E-10	4.92E-17	4.88E-17	9.80E-17
WSW	55000	Cs-137	3.64E-07	6.55E-14	6.50E-14	1.31E-13
WSW	55000	Ba-137m	3.09E-07	5.55E-14	5.51E-14	1.11E-13
WSW	70000	Ra-226	2.65E-07	4.77E-14	5.86E-14	1.06E-13
WSW	70000	Rn-222	9.81E-10	0.00E+00	0.00E+00	0.00E+00
WSW	70000	Po-218	1.53E-10	2.76E-17	3.39E-17	6.14E-17

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
WSW	70000	Pb-214	1.18E-11	2.12E-18	2.61E-18	4.73E-18
WSW	70000	Bi-214	8.85E-13	1.59E-19	1.96E-19	3.55E-19
WSW	70000	Po-214	8.85E-13	1.59E-19	1.96E-19	3.55E-19
WSW	70000	Pb-210	0.00E+00	0.00E+00	3.39E-33	3.39E-33
WSW	70000	Bi-210	0.00E+00	0.00E+00	6.61E-36	6.61E-36
WSW	70000	Po-210	0.00E+00	0.00E+00	1.29E-38	1.29E-38
WSW	70000	At-218	3.04E-14	5.47E-21	6.71E-21	1.22E-20
WSW	70000	Sr-90	9.94E-08	1.79E-14	2.20E-14	3.99E-14
WSW	70000	Y-90	1.49E-10	2.69E-17	3.30E-17	5.99E-17
WSW	70000	Cs-137	1.99E-07	3.58E-14	4.39E-14	7.97E-14
WSW	70000	Ba-137m	1.68E-07	3.03E-14	3.72E-14	6.76E-14
SW	250	Ra-226	1.18E-02	2.12E-09	1.07E-10	2.23E-09
SW	250	Rn-222	1.28E-05	0.00E+00	0.00E+00	0.00E+00
SW	250	Po-218	6.81E-06	1.23E-12	6.19E-14	1.29E-12
SW	250	Pb-214	5.25E-07	9.44E-14	4.77E-15	9.92E-14
SW	250	Bi-214	3.93E-08	7.08E-15	3.58E-16	7.44E-15
SW	250	Po-214	3.93E-08	7.08E-15	3.58E-16	7.44E-15
SW	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	250	At-218	1.35E-09	2.43E-16	1.23E-17	2.55E-16
SW	250	Sr-90	4.42E-03	7.95E-10	4.02E-11	8.35E-10
SW	250	Y-90	6.63E-06	1.19E-12	6.03E-14	1.25E-12
SW	250	Cs-137	8.83E-03	1.59E-09	8.03E-11	1.67E-09
SW	250	Ba-137m	7.49E-03	1.35E-09	6.81E-11	1.42E-09
SW	750	Ra-226	1.57E-03	2.83E-10	3.46E-11	3.17E-10
SW	750	Rn-222	1.78E-06	0.00E+00	0.00E+00	0.00E+00
SW	750	Po-218	9.07E-07	1.63E-13	2.00E-14	1.83E-13
SW	750	Pb-214	6.99E-08	1.26E-14	1.54E-15	1.41E-14
SW	750	Bi-214	5.24E-09	9.44E-16	1.16E-16	1.06E-15
SW	750	Po-214	5.24E-09	9.44E-16	1.16E-16	1.06E-15
SW	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	750	At-218	1.80E-10	3.24E-17	3.96E-18	3.63E-17
SW	750	Sr-90	5.89E-04	1.06E-10	1.30E-11	1.19E-10
SW	750	Y-90	8.84E-07	1.59E-13	1.95E-14	1.79E-13
SW	750	Cs-137	1.18E-03	2.12E-10	2.59E-11	2.38E-10
SW	750	Ba-137m	9.98E-04	1.80E-10	2.20E-11	2.02E-10
SW	1500	Ra-226	4.58E-04	8.24E-11	1.69E-11	9.93E-11
SW	1500	Rn-222	5.37E-07	0.00E+00	0.00E+00	0.00E+00
SW	1500	Po-218	2.65E-07	4.76E-14	9.76E-15	5.74E-14
SW	1500	Pb-214	2.04E-08	3.67E-15	7.52E-16	4.42E-15
SW	1500	Bi-214	1.53E-09	2.75E-16	5.64E-17	3.31E-16
SW	1500	Po-214	1.53E-09	2.75E-16	5.64E-17	3.31E-16
SW	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SW	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	1500	At-218	5.24E-11	9.44E-18	1.93E-18	1.14E-17
SW	1500	Sr-90	1.72E-04	3.09E-11	6.33E-12	3.72E-11
SW	1500	Y-90	2.58E-07	4.64E-14	9.51E-15	5.59E-14
SW	1500	Cs-137	3.43E-04	6.18E-11	1.27E-11	7.44E-11
SW	1500	Ba-137m	2.91E-04	5.24E-11	1.07E-11	6.31E-11
SW	2500	Ra-226	1.92E-04	3.46E-11	9.92E-12	4.45E-11
SW	2500	Rn-222	2.32E-07	0.00E+00	0.00E+00	0.00E+00
SW	2500	Po-218	1.11E-07	2.00E-14	5.73E-15	2.57E-14
SW	2500	Pb-214	8.56E-09	1.54E-15	4.42E-16	1.98E-15
SW	2500	Bi-214	6.42E-10	1.16E-16	3.31E-17	1.49E-16
SW	2500	Po-214	6.42E-10	1.15E-16	3.31E-17	1.49E-16
SW	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	2500	At-218	2.20E-11	3.96E-18	1.14E-18	5.10E-18
SW	2500	Sr-90	7.21E-05	1.30E-11	3.72E-12	1.67E-11
SW	2500	Y-90	1.08E-07	1.95E-14	5.59E-15	2.51E-14
SW	2500	Cs-137	1.44E-04	2.59E-11	7.44E-12	3.34E-11
SW	2500	Ba-137m	1.22E-04	2.20E-11	6.31E-12	2.83E-11
SW	3500	Ra-226	1.12E-04	2.01E-11	6.96E-12	2.71E-11
SW	3500	Rn-222	1.39E-07	0.00E+00	0.00E+00	0.00E+00
SW	3500	Po-218	6.46E-08	1.16E-14	4.02E-15	1.57E-14
SW	3500	Pb-214	4.98E-09	8.97E-16	3.10E-16	1.21E-15
SW	3500	Bi-214	3.73E-10	6.72E-17	2.32E-17	9.05E-17
SW	3500	Po-214	3.73E-10	6.72E-17	2.32E-17	9.04E-17
SW	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	3500	At-218	1.28E-11	2.31E-18	7.97E-19	3.10E-18
SW	3500	Sr-90	4.19E-05	7.55E-12	2.61E-12	1.02E-11
SW	3500	Y-90	6.30E-08	1.13E-14	3.92E-15	1.53E-14
SW	3500	Cs-137	8.39E-05	1.51E-11	5.22E-12	2.03E-11
SW	3500	Ba-137m	7.11E-05	1.28E-11	4.42E-12	1.72E-11
SW	4500	Ra-226	7.63E-05	1.37E-11	5.32E-12	1.91E-11
SW	4500	Rn-222	9.73E-08	0.00E+00	0.00E+00	0.00E+00
SW	4500	Po-218	4.41E-08	7.94E-15	3.07E-15	1.10E-14
SW	4500	Pb-214	3.40E-09	6.12E-16	2.37E-16	8.49E-16
SW	4500	Bi-214	2.55E-10	4.59E-17	1.78E-17	6.36E-17
SW	4500	Po-214	2.55E-10	4.59E-17	1.78E-17	6.36E-17
SW	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SW	4500	At-218	8.74E-12	1.57E-18	6.09E-19	2.18E-18
SW	4500	Sr-90	2.86E-05	5.15E-12	1.99E-12	7.15E-12
SW	4500	Y-90	4.30E-08	7.74E-15	3.00E-15	1.07E-14
SW	4500	Cs-137	5.72E-05	1.03E-11	3.99E-12	1.43E-11

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SW	4500	Ba-137m	4.85E-05	8.73E-12	3.38E-12	1.21E-11
SW	7500	Ra-226	3.47E-05	6.24E-12	3.05E-12	9.29E-12
SW	7500	Rn-222	4.73E-08	0.00E+00	0.00E+00	0.00E+00
SW	7500	Po-218	2.00E-08	3.60E-15	1.77E-15	5.37E-15
SW	7500	Pb-214	1.54E-09	2.78E-16	1.36E-16	4.14E-16
SW	7500	Bi-214	1.16E-10	2.08E-17	1.02E-17	3.10E-17
SW	7500	Po-214	1.16E-10	2.08E-17	1.02E-17	3.10E-17
SW	7500	Pb-210	0.00E+00	0.00E+00	7.27E-25	7.27E-25
SW	7500	Bi-210	0.00E+00	0.00E+00	2.09E-26	2.09E-26
SW	7500	Po-210	0.00E+00	0.00E+00	6.00E-28	6.00E-28
SW	7500	At-218	3.97E-12	7.15E-19	3.50E-19	1.06E-18
SW	7500	Sr-90	1.30E-05	2.34E-12	1.15E-12	3.48E-12
SW	7500	Y-90	1.95E-08	3.51E-15	1.72E-15	5.23E-15
SW	7500	Cs-137	2.60E-05	4.68E-12	2.29E-12	6.97E-12
SW	7500	Ba-137m	2.20E-05	3.97E-12	1.94E-12	5.91E-12
SW	15000	Ra-226	1.28E-05	2.30E-12	1.43E-12	3.73E-12
SW	15000	Rn-222	1.95E-08	0.00E+00	0.00E+00	0.00E+00
SW	15000	Po-218	7.39E-09	1.33E-15	8.23E-16	2.15E-15
SW	15000	Pb-214	5.70E-10	1.03E-16	6.34E-17	1.66E-16
SW	15000	Bi-214	4.27E-11	7.69E-18	4.75E-18	1.24E-17
SW	15000	Po-214	4.27E-11	7.69E-18	4.75E-18	1.24E-17
SW	15000	Pb-210	0.00E+00	0.00E+00	4.88E-26	4.88E-26
SW	15000	Bi-210	0.00E+00	0.00E+00	8.16E-28	8.16E-28
SW	15000	Po-210	0.00E+00	0.00E+00	1.36E-29	1.36E-29
SW	15000	At-218	1.47E-12	2.64E-19	1.63E-19	4.27E-19
SW	15000	Sr-90	4.80E-06	8.63E-13	5.34E-13	1.40E-12
SW	15000	Y-90	7.21E-09	1.30E-15	8.02E-16	2.10E-15
SW	15000	Cs-137	9.59E-06	1.73E-12	1.07E-12	2.79E-12
SW	15000	Ba-137m	8.13E-06	1.46E-12	9.05E-13	2.37E-12
SW	25000	Ra-226	5.64E-06	1.02E-12	7.57E-13	1.77E-12
SW	25000	Rn-222	1.07E-08	0.00E+00	0.00E+00	0.00E+00
SW	25000	Po-218	3.26E-09	5.87E-16	4.36E-16	1.02E-15
SW	25000	Pb-214	2.51E-10	4.53E-17	3.36E-17	7.89E-17
SW	25000	Bi-214	1.88E-11	3.39E-18	2.52E-18	5.91E-18
SW	25000	Po-214	1.88E-11	3.39E-18	2.52E-18	5.91E-18
SW	25000	Pb-210	0.00E+00	0.00E+00	2.18E-27	2.18E-27
SW	25000	Bi-210	0.00E+00	0.00E+00	2.13E-29	2.13E-29
SW	25000	Po-210	0.00E+00	0.00E+00	2.07E-31	2.07E-31
SW	25000	At-218	6.47E-13	1.16E-19	8.64E-20	2.03E-19
SW	25000	Sr-90	2.12E-06	3.81E-13	2.83E-13	6.64E-13
SW	25000	Y-90	3.18E-09	5.72E-16	4.25E-16	9.97E-16
SW	25000	Cs-137	4.23E-06	7.62E-13	5.66E-13	1.33E-12
SW	25000	Ba-137m	3.59E-06	6.46E-13	4.80E-13	1.13E-12
SW	35000	Ra-226	3.53E-06	6.35E-13	5.13E-13	1.15E-12
SW	35000	Rn-222	7.21E-09	0.00E+00	0.00E+00	0.00E+00
SW	35000	Po-218	2.04E-09	3.67E-16	2.95E-16	6.63E-16
SW	35000	Pb-214	1.57E-10	2.83E-17	2.28E-17	5.11E-17

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SW	35000	Bi-214	1.18E-11	2.12E-18	1.71E-18	3.83E-18
SW	35000	Po-214	1.18E-11	2.12E-18	1.71E-18	3.83E-18
SW	35000	Pb-210	0.00E+00	0.00E+00	6.32E-28	6.32E-28
SW	35000	Bi-210	0.00E+00	0.00E+00	5.44E-30	5.44E-30
SW	35000	Po-210	0.00E+00	0.00E+00	4.68E-32	4.68E-32
SW	35000	At-218	4.04E-13	7.28E-20	5.85E-20	1.31E-19
SW	35000	Sr-90	1.32E-06	2.38E-13	1.92E-13	4.30E-13
SW	35000	Y-90	1.99E-09	3.58E-16	2.88E-16	6.46E-16
SW	35000	Cs-137	2.65E-06	4.76E-13	3.83E-13	8.60E-13
SW	35000	Ba-137m	2.24E-06	4.04E-13	3.25E-13	7.29E-13
SW	45000	Ra-226	2.42E-06	4.35E-13	3.76E-13	8.11E-13
SW	45000	Rn-222	5.39E-09	0.00E+00	0.00E+00	0.00E+00
SW	45000	Po-218	1.40E-09	2.52E-16	2.17E-16	4.68E-16
SW	45000	Pb-214	1.08E-10	1.94E-17	1.67E-17	3.61E-17
SW	45000	Bi-214	8.08E-12	1.45E-18	1.25E-18	2.71E-18
SW	45000	Po-214	8.07E-12	1.45E-18	1.25E-18	2.70E-18
SW	45000	Pb-210	0.00E+00	0.00E+00	2.48E-28	2.48E-28
SW	45000	Bi-210	0.00E+00	0.00E+00	1.94E-30	1.94E-30
SW	45000	Po-210	0.00E+00	0.00E+00	1.53E-32	1.53E-32
SW	45000	At-218	2.77E-13	4.99E-20	4.29E-20	9.28E-20
SW	45000	Sr-90	9.07E-07	1.63E-13	1.41E-13	3.04E-13
SW	45000	Y-90	1.36E-09	2.45E-16	2.11E-16	4.56E-16
SW	45000	Cs-137	1.81E-06	3.26E-13	2.81E-13	6.08E-13
SW	45000	Ba-137m	1.54E-06	2.77E-13	2.38E-13	5.15E-13
SW	55000	Ra-226	1.70E-06	3.05E-13	2.85E-13	5.90E-13
SW	55000	Rn-222	4.27E-09	0.00E+00	0.00E+00	0.00E+00
SW	55000	Po-218	9.80E-10	1.76E-16	1.64E-16	3.41E-16
SW	55000	Pb-214	7.56E-11	1.36E-17	1.27E-17	2.63E-17
SW	55000	Bi-214	5.67E-12	1.02E-18	9.50E-19	1.97E-18
SW	55000	Po-214	5.67E-12	1.02E-18	9.49E-19	1.97E-18
SW	55000	Pb-210	0.00E+00	0.00E+00	1.16E-28	1.16E-28
SW	55000	Bi-210	0.00E+00	0.00E+00	8.48E-31	8.48E-31
SW	55000	Po-210	0.00E+00	0.00E+00	6.19E-33	6.19E-33
SW	55000	At-218	1.94E-13	3.50E-20	3.26E-20	6.76E-20
SW	55000	Sr-90	6.36E-07	1.15E-13	1.07E-13	2.21E-13
SW	55000	Y-90	9.56E-10	1.72E-16	1.60E-16	3.32E-16
SW	55000	Cs-137	1.27E-06	2.29E-13	2.13E-13	4.42E-13
SW	55000	Ba-137m	1.08E-06	1.94E-13	1.81E-13	3.75E-13
SW	70000	Ra-226	9.45E-07	1.70E-13	1.93E-13	3.63E-13
SW	70000	Rn-222	3.24E-09	0.00E+00	0.00E+00	0.00E+00
SW	70000	Po-218	5.46E-10	9.83E-17	1.11E-16	2.10E-16
SW	70000	Pb-214	4.21E-11	7.57E-18	8.57E-18	1.61E-17
SW	70000	Bi-214	3.15E-12	5.68E-19	6.43E-19	1.21E-18
SW	70000	Po-214	3.15E-12	5.68E-19	6.43E-19	1.21E-18
SW	70000	Pb-210	0.00E+00	0.00E+00	4.63E-29	4.63E-29
SW	70000	Bi-210	0.00E+00	0.00E+00	3.09E-31	3.09E-31
SW	70000	Po-210	0.00E+00	0.00E+00	2.07E-33	2.07E-33

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SW	70000	At-218	1.08E-13	1.95E-20	2.21E-20	4.15E-20
SW	70000	Sr-90	3.54E-07	6.38E-14	7.22E-14	1.36E-13
SW	70000	Y-90	5.32E-10	9.58E-17	1.08E-16	2.04E-16
SW	70000	Cs-137	7.08E-07	1.28E-13	1.44E-13	2.72E-13
SW	70000	Ba-137m	6.01E-07	1.08E-13	1.22E-13	2.30E-13
SSW	250	Ra-226	2.01E-02	3.62E-09	1.90E-10	3.81E-09
SSW	250	Rn-222	2.17E-05	0.00E+00	0.00E+00	0.00E+00
SSW	250	Po-218	1.16E-05	2.09E-12	1.10E-13	2.20E-12
SSW	250	Pb-214	8.97E-07	1.61E-13	8.48E-15	1.70E-13
SSW	250	Bi-214	6.72E-08	1.21E-14	6.36E-16	1.27E-14
SSW	250	Po-214	6.72E-08	1.21E-14	6.36E-16	1.27E-14
SSW	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	250	At-218	2.31E-09	4.15E-16	2.18E-17	4.37E-16
SSW	250	Sr-90	7.55E-03	1.36E-09	7.14E-11	1.43E-09
SSW	250	Y-90	1.13E-05	2.04E-12	1.07E-13	2.15E-12
SSW	250	Cs-137	1.51E-02	2.72E-09	1.43E-10	2.86E-09
SSW	250	Ba-137m	1.28E-02	2.30E-09	1.21E-10	2.42E-09
SSW	750	Ra-226	2.69E-03	4.84E-10	6.18E-11	5.46E-10
SSW	750	Rn-222	3.02E-06	0.00E+00	0.00E+00	0.00E+00
SSW	750	Po-218	1.55E-06	2.80E-13	3.57E-14	3.15E-13
SSW	750	Pb-214	1.20E-07	2.16E-14	2.75E-15	2.43E-14
SSW	750	Bi-214	8.98E-09	1.62E-15	2.06E-16	1.82E-15
SSW	750	Po-214	8.98E-09	1.62E-15	2.06E-16	1.82E-15
SSW	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	750	At-218	3.08E-10	5.54E-17	7.08E-18	6.25E-17
SSW	750	Sr-90	1.01E-03	1.81E-10	2.32E-11	2.05E-10
SSW	750	Y-90	1.51E-06	2.73E-13	3.48E-14	3.07E-13
SSW	750	Cs-137	2.02E-03	3.63E-10	4.64E-11	4.09E-10
SSW	750	Ba-137m	1.71E-03	3.08E-10	3.93E-11	3.47E-10
SSW	1500	Ra-226	7.87E-04	1.42E-10	3.03E-11	1.72E-10
SSW	1500	Rn-222	9.11E-07	0.00E+00	0.00E+00	0.00E+00
SSW	1500	Po-218	4.55E-07	8.18E-14	1.75E-14	9.93E-14
SSW	1500	Pb-214	3.50E-08	6.31E-15	1.35E-15	7.66E-15
SSW	1500	Bi-214	2.63E-09	4.73E-16	1.01E-16	5.74E-16
SSW	1500	Po-214	2.63E-09	4.73E-16	1.01E-16	5.74E-16
SSW	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	1500	At-218	9.01E-11	1.62E-17	3.47E-18	1.97E-17
SSW	1500	Sr-90	2.95E-04	5.31E-11	1.14E-11	6.45E-11
SSW	1500	Y-90	4.43E-07	7.98E-14	1.71E-14	9.68E-14
SSW	1500	Cs-137	5.90E-04	1.06E-10	2.27E-11	1.29E-10
SSW	1500	Ba-137m	5.00E-04	9.00E-11	1.92E-11	1.09E-10

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SSW	2500	Ra-226	3.31E-04	5.96E-11	1.78E-11	7.75E-11
SSW	2500	Rn-222	3.93E-07	0.00E+00	0.00E+00	0.00E+00
SSW	2500	Po-218	1.91E-07	3.44E-14	1.03E-14	4.48E-14
SSW	2500	Pb-214	1.48E-08	2.66E-15	7.95E-16	3.45E-15
SSW	2500	Bi-214	1.11E-09	1.99E-16	5.96E-17	2.59E-16
SSW	2500	Po-214	1.11E-09	1.99E-16	5.96E-17	2.59E-16
SSW	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	2500	At-218	3.79E-11	6.83E-18	2.05E-18	8.88E-18
SSW	2500	Sr-90	1.24E-04	2.24E-11	6.69E-12	2.90E-11
SSW	2500	Y-90	1.87E-07	3.36E-14	1.01E-14	4.36E-14
SSW	2500	Cs-137	2.48E-04	4.47E-11	1.34E-11	5.81E-11
SSW	2500	Ba-137m	2.11E-04	3.79E-11	1.13E-11	4.92E-11
SSW	3500	Ra-226	1.93E-04	3.47E-11	1.25E-11	4.73E-11
SSW	3500	Rn-222	2.35E-07	0.00E+00	0.00E+00	0.00E+00
SSW	3500	Po-218	1.12E-07	2.01E-14	7.25E-15	2.73E-14
SSW	3500	Pb-214	8.60E-09	1.55E-15	5.59E-16	2.11E-15
SSW	3500	Bi-214	6.45E-10	1.16E-16	4.19E-17	1.58E-16
SSW	3500	Po-214	6.45E-10	1.16E-16	4.19E-17	1.58E-16
SSW	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	3500	At-218	2.21E-11	3.98E-18	1.44E-18	5.42E-18
SSW	3500	Sr-90	7.24E-05	1.30E-11	4.71E-12	1.77E-11
SSW	3500	Y-90	1.09E-07	1.96E-14	7.07E-15	2.66E-14
SSW	3500	Cs-137	1.45E-04	2.61E-11	9.41E-12	3.55E-11
SSW	3500	Ba-137m	1.23E-04	2.21E-11	7.98E-12	3.01E-11
SSW	4500	Ra-226	1.32E-04	2.38E-11	9.62E-12	3.34E-11
SSW	4500	Rn-222	1.64E-07	0.00E+00	0.00E+00	0.00E+00
SSW	4500	Po-218	7.63E-08	1.37E-14	5.56E-15	1.93E-14
SSW	4500	Pb-214	5.88E-09	1.06E-15	4.28E-16	1.49E-15
SSW	4500	Bi-214	4.41E-10	7.93E-17	3.21E-17	1.11E-16
SSW	4500	Po-214	4.41E-10	7.93E-17	3.21E-17	1.11E-16
SSW	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSW	4500	At-218	1.51E-11	2.72E-18	1.10E-18	3.82E-18
SSW	4500	Sr-90	4.95E-05	8.91E-12	3.61E-12	1.25E-11
SSW	4500	Y-90	7.44E-08	1.34E-14	5.42E-15	1.88E-14
SSW	4500	Cs-137	9.90E-05	1.78E-11	7.21E-12	2.50E-11
SSW	4500	Ba-137m	8.39E-05	1.51E-11	6.11E-12	2.12E-11
SSW	7500	Ra-226	6.03E-05	1.08E-11	5.56E-12	1.64E-11
SSW	7500	Rn-222	7.97E-08	0.00E+00	0.00E+00	0.00E+00
SSW	7500	Po-218	3.48E-08	6.27E-15	3.23E-15	9.50E-15
SSW	7500	Pb-214	2.68E-09	4.83E-16	2.49E-16	7.32E-16
SSW	7500	Bi-214	2.01E-10	3.62E-17	1.86E-17	5.49E-17

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SSW	7500	Po-214	2.01E-10	3.62E-17	1.86E-17	5.48E-17
SSW	7500	Pb-210	0.00E+00	0.00E+00	2.83E-22	2.83E-22
SSW	7500	Bi-210	0.00E+00	0.00E+00	1.66E-23	1.66E-23
SSW	7500	Po-210	0.00E+00	0.00E+00	9.76E-25	9.76E-25
SSW	7500	At-218	6.91E-12	1.24E-18	6.37E-19	1.88E-18
SSW	7500	Sr-90	2.26E-05	4.07E-12	2.08E-12	6.15E-12
SSW	7500	Y-90	3.39E-08	6.11E-15	3.13E-15	9.24E-15
SSW	7500	Cs-137	4.52E-05	8.14E-12	4.17E-12	1.23E-11
SSW	7500	Ba-137m	3.83E-05	6.90E-12	3.53E-12	1.04E-11
SSW	15000	Ra-226	2.24E-05	4.04E-12	2.62E-12	6.66E-12
SSW	15000	Rn-222	3.27E-08	0.00E+00	0.00E+00	0.00E+00
SSW	15000	Po-218	1.30E-08	2.33E-15	1.52E-15	3.85E-15
SSW	15000	Pb-214	9.99E-10	1.80E-16	1.17E-16	2.97E-16
SSW	15000	Bi-214	7.49E-11	1.35E-17	8.74E-18	2.22E-17
SSW	15000	Po-214	7.49E-11	1.35E-17	8.73E-18	2.22E-17
SSW	15000	Pb-210	0.00E+00	0.00E+00	1.32E-23	1.32E-23
SSW	15000	Bi-210	0.00E+00	0.00E+00	4.51E-25	4.51E-25
SSW	15000	Po-210	0.00E+00	0.00E+00	1.54E-26	1.54E-26
SSW	15000	At-218	2.57E-12	4.63E-19	3.00E-19	7.62E-19
SSW	15000	Sr-90	8.41E-06	1.51E-12	9.80E-13	2.49E-12
SSW	15000	Y-90	1.26E-08	2.27E-15	1.47E-15	3.75E-15
SSW	15000	Cs-137	1.68E-05	3.03E-12	1.96E-12	4.99E-12
SSW	15000	Ba-137m	1.43E-05	2.57E-12	1.66E-12	4.23E-12
SSW	25000	Ra-226	1.01E-05	1.82E-12	1.42E-12	3.24E-12
SSW	25000	Rn-222	1.79E-08	0.00E+00	0.00E+00	0.00E+00
SSW	25000	Po-218	5.85E-09	1.05E-15	8.19E-16	1.87E-15
SSW	25000	Pb-214	4.51E-10	8.12E-17	6.29E-17	1.44E-16
SSW	25000	Bi-214	3.38E-11	6.08E-18	4.71E-18	1.08E-17
SSW	25000	Po-214	3.38E-11	6.08E-18	4.71E-18	1.08E-17
SSW	25000	Pb-210	0.00E+00	0.00E+00	5.73E-25	5.73E-25
SSW	25000	Bi-210	0.00E+00	0.00E+00	1.14E-26	1.14E-26
SSW	25000	Po-210	0.00E+00	0.00E+00	2.27E-28	2.27E-28
SSW	25000	At-218	1.16E-12	2.09E-19	1.62E-19	3.70E-19
SSW	25000	Sr-90	3.80E-06	6.83E-13	5.29E-13	1.21E-12
SSW	25000	Y-90	5.70E-09	1.03E-15	7.95E-16	1.82E-15
SSW	25000	Cs-137	7.59E-06	1.37E-12	1.06E-12	2.42E-12
SSW	25000	Ba-137m	6.44E-06	1.16E-12	8.97E-13	2.06E-12
SSW	35000	Ra-226	6.37E-06	1.15E-12	9.68E-13	2.11E-12
SSW	35000	Rn-222	1.21E-08	0.00E+00	0.00E+00	0.00E+00
SSW	35000	Po-218	3.68E-09	6.63E-16	5.58E-16	1.22E-15
SSW	35000	Pb-214	2.84E-10	5.11E-17	4.29E-17	9.40E-17
SSW	35000	Bi-214	2.13E-11	3.83E-18	3.21E-18	7.04E-18
SSW	35000	Po-214	2.13E-11	3.83E-18	3.21E-18	7.04E-18
SSW	35000	Pb-210	0.00E+00	0.00E+00	1.67E-25	1.67E-25
SSW	35000	Bi-210	0.00E+00	0.00E+00	2.94E-27	2.94E-27
SSW	35000	Po-210	0.00E+00	0.00E+00	5.18E-29	5.18E-29
SSW	35000	At-218	7.30E-13	1.31E-19	1.10E-19	2.42E-19

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SSW	35000	Sr-90	2.39E-06	4.30E-13	3.61E-13	7.91E-13
SSW	35000	Y-90	3.59E-09	6.46E-16	5.42E-16	1.19E-15
SSW	35000	Cs-137	4.78E-06	8.60E-13	7.22E-13	1.58E-12
SSW	35000	Ba-137m	4.05E-06	7.29E-13	6.12E-13	1.34E-12
SSW	45000	Ra-226	4.40E-06	7.92E-13	7.15E-13	1.51E-12
SSW	45000	Rn-222	9.00E-09	0.00E+00	0.00E+00	0.00E+00
SSW	45000	Po-218	2.54E-09	4.58E-16	4.12E-16	8.70E-16
SSW	45000	Pb-214	1.96E-10	3.53E-17	3.17E-17	6.70E-17
SSW	45000	Bi-214	1.47E-11	2.64E-18	2.37E-18	5.02E-18
SSW	45000	Po-214	1.47E-11	2.64E-18	2.37E-18	5.02E-18
SSW	45000	Pb-210	0.00E+00	0.00E+00	6.59E-26	6.59E-26
SSW	45000	Bi-210	0.00E+00	0.00E+00	1.06E-27	1.06E-27
SSW	45000	Po-210	0.00E+00	0.00E+00	1.70E-29	1.70E-29
SSW	45000	At-218	5.04E-13	9.08E-20	8.15E-20	1.72E-19
SSW	45000	Sr-90	1.65E-06	2.97E-13	2.67E-13	5.64E-13
SSW	45000	Y-90	2.48E-09	4.46E-16	4.01E-16	8.47E-16
SSW	45000	Cs-137	3.30E-06	5.94E-13	5.33E-13	1.13E-12
SSW	45000	Ba-137m	2.80E-06	5.04E-13	4.52E-13	9.56E-13
SSW	55000	Ra-226	3.12E-06	5.62E-13	5.48E-13	1.11E-12
SSW	55000	Rn-222	7.14E-09	0.00E+00	0.00E+00	0.00E+00
SSW	55000	Po-218	1.81E-09	3.25E-16	3.15E-16	6.40E-16
SSW	55000	Pb-214	1.39E-10	2.51E-17	2.43E-17	4.93E-17
SSW	55000	Bi-214	1.04E-11	1.88E-18	1.82E-18	3.70E-18
SSW	55000	Po-214	1.04E-11	1.88E-18	1.82E-18	3.70E-18
SSW	55000	Pb-210	0.00E+00	0.00E+00	3.12E-26	3.12E-26
SSW	55000	Bi-210	0.00E+00	0.00E+00	4.65E-28	4.65E-28
SSW	55000	Po-210	0.00E+00	0.00E+00	6.95E-30	6.95E-30
SSW	55000	At-218	3.58E-13	6.45E-20	6.24E-20	1.27E-19
SSW	55000	Sr-90	1.17E-06	2.11E-13	2.04E-13	4.15E-13
SSW	55000	Y-90	1.76E-09	3.17E-16	3.07E-16	6.24E-16
SSW	55000	Cs-137	2.34E-06	4.22E-13	4.09E-13	8.30E-13
SSW	55000	Ba-137m	1.99E-06	3.58E-13	3.46E-13	7.04E-13
SSW	70000	Ra-226	1.80E-06	3.25E-13	3.78E-13	7.03E-13
SSW	70000	Rn-222	5.40E-09	0.00E+00	0.00E+00	0.00E+00
SSW	70000	Po-218	1.04E-09	1.88E-16	2.18E-16	4.05E-16
SSW	70000	Pb-214	8.03E-11	1.45E-17	1.68E-17	3.12E-17
SSW	70000	Bi-214	6.02E-12	1.08E-18	1.26E-18	2.34E-18
SSW	70000	Po-214	6.02E-12	1.08E-18	1.26E-18	2.34E-18
SSW	70000	Pb-210	0.00E+00	0.00E+00	1.25E-26	1.25E-26
SSW	70000	Bi-210	0.00E+00	0.00E+00	1.71E-28	1.71E-28
SSW	70000	Po-210	0.00E+00	0.00E+00	2.34E-30	2.34E-30
SSW	70000	At-218	2.07E-13	3.72E-20	4.31E-20	8.03E-20
SSW	70000	Sr-90	6.76E-07	1.22E-13	1.41E-13	2.63E-13
SSW	70000	Y-90	1.02E-09	1.83E-16	2.12E-16	3.95E-16
SSW	70000	Cs-137	1.35E-06	2.43E-13	2.82E-13	5.26E-13
SSW	70000	Ba-137m	1.15E-06	2.06E-13	2.39E-13	4.46E-13
S	250	Ra-226	2.82E-02	5.07E-09	2.85E-10	5.36E-09

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
S	250	Rn-222	3.05E-05	0.00E+00	0.00E+00	0.00E+00
S	250	Po-218	1.63E-05	2.93E-12	1.64E-13	3.10E-12
S	250	Pb-214	1.26E-06	2.26E-13	1.27E-14	2.39E-13
S	250	Bi-214	9.41E-08	1.69E-14	9.50E-16	1.79E-14
S	250	Po-214	9.41E-08	1.69E-14	9.50E-16	1.79E-14
S	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	250	At-218	3.23E-09	5.81E-16	3.26E-17	6.14E-16
S	250	Sr-90	1.06E-02	1.90E-09	1.07E-10	2.01E-09
S	250	Y-90	1.59E-05	2.86E-12	1.60E-13	3.02E-12
S	250	Cs-137	2.11E-02	3.80E-09	2.13E-10	4.02E-09
S	250	Ba-137m	1.79E-02	3.23E-09	1.81E-10	3.41E-09
S	750	Ra-226	3.74E-03	6.74E-10	9.25E-11	7.66E-10
S	750	Rn-222	4.21E-06	0.00E+00	0.00E+00	0.00E+00
S	750	Po-218	2.16E-06	3.90E-13	5.34E-14	4.43E-13
S	750	Pb-214	1.67E-07	3.00E-14	4.12E-15	3.41E-14
S	750	Bi-214	1.25E-08	2.25E-15	3.09E-16	2.56E-15
S	750	Po-214	1.25E-08	2.25E-15	3.09E-16	2.56E-15
S	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	750	At-218	4.29E-10	7.72E-17	1.06E-17	8.78E-17
S	750	Sr-90	1.40E-03	2.53E-10	3.47E-11	2.87E-10
S	750	Y-90	2.11E-06	3.80E-13	5.21E-14	4.32E-13
S	750	Cs-137	2.81E-03	5.05E-10	6.93E-11	5.75E-10
S	750	Ba-137m	2.38E-03	4.29E-10	5.88E-11	4.87E-10
S	1500	Ra-226	1.09E-03	1.97E-10	4.53E-11	2.42E-10
S	1500	Rn-222	1.27E-06	0.00E+00	0.00E+00	0.00E+00
S	1500	Po-218	6.32E-07	1.14E-13	2.62E-14	1.40E-13
S	1500	Pb-214	4.87E-08	8.76E-15	2.02E-15	1.08E-14
S	1500	Bi-214	3.65E-09	6.57E-16	1.51E-16	8.08E-16
S	1500	Po-214	3.65E-09	6.57E-16	1.51E-16	8.08E-16
S	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	1500	At-218	1.25E-10	2.25E-17	5.19E-18	2.77E-17
S	1500	Sr-90	4.10E-04	7.38E-11	1.70E-11	9.08E-11
S	1500	Y-90	6.16E-07	1.11E-13	2.55E-14	1.36E-13
S	1500	Cs-137	8.20E-04	1.48E-10	3.40E-11	1.82E-10
S	1500	Ba-137m	6.95E-04	1.25E-10	2.88E-11	1.54E-10
S	2500	Ra-226	4.59E-04	8.26E-11	2.67E-11	1.09E-10
S	2500	Rn-222	5.47E-07	0.00E+00	0.00E+00	0.00E+00
S	2500	Po-218	2.65E-07	4.77E-14	1.54E-14	6.32E-14
S	2500	Pb-214	2.04E-08	3.68E-15	1.19E-15	4.87E-15
S	2500	Bi-214	1.53E-09	2.76E-16	8.93E-17	3.65E-16
S	2500	Po-214	1.53E-09	2.76E-16	8.93E-17	3.65E-16

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
S	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	2500	At-218	5.25E-11	9.46E-18	3.06E-18	1.25E-17
S	2500	Sr-90	1.72E-04	3.10E-11	1.00E-11	4.10E-11
S	2500	Y-90	2.58E-07	4.65E-14	1.51E-14	6.16E-14
S	2500	Cs-137	3.44E-04	6.19E-11	2.00E-11	8.20E-11
S	2500	Ba-137m	2.92E-04	5.25E-11	1.70E-11	6.95E-11
S	3500	Ra-226	2.66E-04	4.80E-11	1.88E-11	6.68E-11
S	3500	Rn-222	3.26E-07	0.00E+00	0.00E+00	0.00E+00
S	3500	Po-218	1.54E-07	2.77E-14	1.09E-14	3.86E-14
S	3500	Pb-214	1.19E-08	2.14E-15	8.38E-16	2.97E-15
S	3500	Bi-214	8.90E-10	1.60E-16	6.28E-17	2.23E-16
S	3500	Po-214	8.90E-10	1.60E-16	6.28E-17	2.23E-16
S	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	3500	At-218	3.05E-11	5.50E-18	2.15E-18	7.65E-18
S	3500	Sr-90	9.99E-05	1.80E-11	7.05E-12	2.50E-11
S	3500	Y-90	1.50E-07	2.70E-14	1.06E-14	3.76E-14
S	3500	Cs-137	2.00E-04	3.60E-11	1.41E-11	5.01E-11
S	3500	Ba-137m	1.69E-04	3.05E-11	1.20E-11	4.25E-11
S	4500	Ra-226	1.82E-04	3.27E-11	1.44E-11	4.71E-11
S	4500	Rn-222	2.28E-07	0.00E+00	0.00E+00	0.00E+00
S	4500	Po-218	1.05E-07	1.89E-14	8.34E-15	2.72E-14
S	4500	Pb-214	8.09E-09	1.46E-15	6.42E-16	2.10E-15
S	4500	Bi-214	6.06E-10	1.09E-16	4.82E-17	1.57E-16
S	4500	Po-214	6.06E-10	1.09E-16	4.82E-17	1.57E-16
S	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
S	4500	At-218	2.08E-11	3.75E-18	1.65E-18	5.40E-18
S	4500	Sr-90	6.81E-05	1.23E-11	5.41E-12	1.77E-11
S	4500	Y-90	1.02E-07	1.84E-14	8.12E-15	2.65E-14
S	4500	Cs-137	1.36E-04	2.45E-11	1.08E-11	3.53E-11
S	4500	Ba-137m	1.15E-04	2.08E-11	9.17E-12	3.00E-11
S	7500	Ra-226	8.24E-05	1.48E-11	8.38E-12	2.32E-11
S	7500	Rn-222	1.10E-07	0.00E+00	0.00E+00	0.00E+00
S	7500	Po-218	4.76E-08	8.57E-15	5.10E-15	1.37E-14
S	7500	Pb-214	3.67E-09	6.60E-16	3.98E-16	1.06E-15
S	7500	Bi-214	2.75E-10	4.95E-17	3.03E-17	7.98E-17
S	7500	Po-214	2.75E-10	4.95E-17	2.81E-17	7.76E-17
S	7500	Pb-210	0.00E+00	0.00E+00	2.09E-20	2.09E-20
S	7500	Bi-210	0.00E+00	0.00E+00	1.94E-21	1.94E-21
S	7500	Po-210	0.00E+00	0.00E+00	1.80E-22	1.80E-22
S	7500	At-218	9.44E-12	1.70E-18	9.57E-19	2.66E-18
S	7500	Sr-90	3.09E-05	5.56E-12	3.13E-12	8.69E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
S	7500	Y-90	4.64E-08	8.35E-15	4.70E-15	1.31E-14
S	7500	Cs-137	6.18E-05	1.11E-11	6.26E-12	1.74E-11
S	7500	Ba-137m	5.24E-05	9.43E-12	5.31E-12	1.47E-11
S	15000	Ra-226	3.03E-05	5.46E-12	3.97E-12	9.43E-12
S	15000	Rn-222	4.48E-08	0.00E+00	0.00E+00	0.00E+00
S	15000	Po-218	1.75E-08	3.15E-15	2.36E-15	5.51E-15
S	15000	Pb-214	1.35E-09	2.43E-16	1.80E-16	4.23E-16
S	15000	Bi-214	1.01E-10	1.82E-17	1.34E-17	3.16E-17
S	15000	Po-214	1.01E-10	1.82E-17	1.32E-17	3.14E-17
S	15000	Pb-210	0.00E+00	0.00E+00	6.83E-22	6.83E-22
S	15000	Bi-210	0.00E+00	0.00E+00	3.70E-23	3.70E-23
S	15000	Po-210	0.00E+00	0.00E+00	2.00E-24	2.00E-24
S	15000	At-218	3.47E-12	6.25E-19	4.52E-19	1.08E-18
S	15000	Sr-90	1.14E-05	2.05E-12	1.48E-12	3.52E-12
S	15000	Y-90	1.71E-08	3.07E-15	2.22E-15	5.30E-15
S	15000	Cs-137	2.27E-05	4.09E-12	2.96E-12	7.05E-12
S	15000	Ba-137m	1.93E-05	3.47E-12	2.51E-12	5.98E-12
S	25000	Ra-226	1.35E-05	2.44E-12	2.17E-12	4.60E-12
S	25000	Rn-222	2.43E-08	0.00E+00	0.00E+00	0.00E+00
S	25000	Po-218	7.82E-09	1.41E-15	1.26E-15	2.67E-15
S	25000	Pb-214	6.03E-10	1.09E-16	9.62E-17	2.05E-16
S	25000	Bi-214	4.52E-11	8.14E-18	7.19E-18	1.53E-17
S	25000	Po-214	4.52E-11	8.13E-18	7.16E-18	1.53E-17
S	25000	Pb-210	0.00E+00	0.00E+00	2.17E-23	2.17E-23
S	25000	Bi-210	0.00E+00	0.00E+00	6.86E-25	6.86E-25
S	25000	Po-210	0.00E+00	0.00E+00	2.16E-26	2.16E-26
S	25000	At-218	1.55E-12	2.79E-19	2.46E-19	5.25E-19
S	25000	Sr-90	5.08E-06	9.14E-13	8.04E-13	1.72E-12
S	25000	Y-90	7.62E-09	1.37E-15	1.21E-15	2.58E-15
S	25000	Cs-137	1.02E-05	1.83E-12	1.61E-12	3.44E-12
S	25000	Ba-137m	8.61E-06	1.55E-12	1.36E-12	2.91E-12
S	35000	Ra-226	8.47E-06	1.52E-12	1.48E-12	3.01E-12
S	35000	Rn-222	1.64E-08	0.00E+00	0.00E+00	0.00E+00
S	35000	Po-218	4.90E-09	8.81E-16	8.58E-16	1.74E-15
S	35000	Pb-214	3.77E-10	6.79E-17	6.56E-17	1.34E-16
S	35000	Bi-214	2.83E-11	5.09E-18	4.91E-18	1.00E-17
S	35000	Po-214	2.83E-11	5.09E-18	4.90E-18	9.99E-18
S	35000	Pb-210	0.00E+00	0.00E+00	6.36E-24	6.36E-24
S	35000	Bi-210	0.00E+00	0.00E+00	1.77E-25	1.77E-25
S	35000	Po-210	0.00E+00	0.00E+00	4.94E-27	4.94E-27
S	35000	At-218	9.71E-13	1.75E-19	1.68E-19	3.43E-19
S	35000	Sr-90	3.18E-06	5.72E-13	5.50E-13	1.12E-12
S	35000	Y-90	4.77E-09	8.59E-16	8.26E-16	1.69E-15
S	35000	Cs-137	6.35E-06	1.14E-12	1.10E-12	2.24E-12
S	35000	Ba-137m	5.39E-06	9.70E-13	9.33E-13	1.90E-12
S	45000	Ra-226	5.83E-06	1.05E-12	1.10E-12	2.15E-12
S	45000	Rn-222	1.22E-08	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
S	45000	Po-218	3.37E-09	6.06E-16	6.35E-16	1.24E-15
S	45000	Pb-214	2.60E-10	4.67E-17	4.86E-17	9.53E-17
S	45000	Bi-214	1.95E-11	3.50E-18	3.64E-18	7.14E-18
S	45000	Po-214	1.95E-11	3.50E-18	3.63E-18	7.13E-18
S	45000	Pb-210	0.00E+00	0.00E+00	2.52E-24	2.52E-24
S	45000	Bi-210	0.00E+00	0.00E+00	6.41E-26	6.41E-26
S	45000	Po-210	0.00E+00	0.00E+00	1.63E-27	1.63E-27
S	45000	At-218	6.68E-13	1.20E-19	1.25E-19	2.45E-19
S	45000	Sr-90	2.19E-06	3.93E-13	4.08E-13	8.01E-13
S	45000	Y-90	3.28E-09	5.91E-16	6.13E-16	1.20E-15
S	45000	Cs-137	4.37E-06	7.87E-13	8.16E-13	1.60E-12
S	45000	Ba-137m	3.71E-06	6.67E-13	6.92E-13	1.36E-12
S	55000	Ra-226	4.13E-06	7.43E-13	8.45E-13	1.59E-12
S	55000	Rn-222	9.66E-09	0.00E+00	0.00E+00	0.00E+00
S	55000	Po-218	2.39E-09	4.30E-16	4.88E-16	9.18E-16
S	55000	Pb-214	1.84E-10	3.31E-17	3.74E-17	7.05E-17
S	55000	Bi-214	1.38E-11	2.48E-18	2.80E-18	5.28E-18
S	55000	Po-214	1.38E-11	2.48E-18	2.80E-18	5.28E-18
S	55000	Pb-210	0.00E+00	0.00E+00	1.20E-24	1.20E-24
S	55000	Bi-210	0.00E+00	0.00E+00	2.83E-26	2.83E-26
S	55000	Po-210	0.00E+00	0.00E+00	6.68E-28	6.68E-28
S	55000	At-218	4.73E-13	8.52E-20	9.60E-20	1.81E-19
S	55000	Sr-90	1.55E-06	2.79E-13	3.14E-13	5.93E-13
S	55000	Y-90	2.33E-09	4.19E-16	4.72E-16	8.91E-16
S	55000	Cs-137	3.10E-06	5.57E-13	6.29E-13	1.19E-12
S	55000	Ba-137m	2.63E-06	4.73E-13	5.33E-13	1.01E-12
S	70000	Ra-226	2.40E-06	4.33E-13	5.93E-13	1.03E-12
S	70000	Rn-222	7.31E-09	0.00E+00	0.00E+00	0.00E+00
S	70000	Po-218	1.39E-09	2.50E-16	3.42E-16	5.92E-16
S	70000	Pb-214	1.07E-10	1.93E-17	2.63E-17	4.55E-17
S	70000	Bi-214	8.03E-12	1.45E-18	1.97E-18	3.41E-18
S	70000	Po-214	8.03E-12	1.44E-18	1.97E-18	3.41E-18
S	70000	Pb-210	0.00E+00	0.00E+00	4.85E-25	4.85E-25
S	70000	Bi-210	0.00E+00	0.00E+00	1.05E-26	1.05E-26
S	70000	Po-210	0.00E+00	0.00E+00	2.27E-28	2.27E-28
S	70000	At-218	2.75E-13	4.96E-20	6.74E-20	1.17E-19
S	70000	Sr-90	9.01E-07	1.62E-13	2.21E-13	3.83E-13
S	70000	Y-90	1.35E-09	2.44E-16	3.32E-16	5.75E-16
S	70000	Cs-137	1.80E-06	3.25E-13	4.41E-13	7.66E-13
S	70000	Ba-137m	1.53E-06	2.75E-13	3.74E-13	6.49E-13
SSE	250	Ra-226	1.11E-02	1.99E-09	1.05E-10	2.09E-09
SSE	250	Rn-222	1.20E-05	0.00E+00	0.00E+00	0.00E+00
SSE	250	Po-218	6.39E-06	1.15E-12	6.07E-14	1.21E-12
SSE	250	Pb-214	4.92E-07	8.86E-14	4.67E-15	9.33E-14
SSE	250	Bi-214	3.69E-08	6.64E-15	3.50E-16	6.99E-15
SSE	250	Po-214	3.69E-08	6.64E-15	3.50E-16	6.99E-15
SSE	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SSE	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	250	At-218	1.27E-09	2.28E-16	1.20E-17	2.40E-16
SSE	250	Sr-90	4.14E-03	7.46E-10	3.94E-11	7.85E-10
SSE	250	Y-90	6.23E-06	1.12E-12	5.91E-14	1.18E-12
SSE	250	Cs-137	8.29E-03	1.49E-09	7.87E-11	1.57E-09
SSE	250	Ba-137m	7.03E-03	1.26E-09	6.67E-11	1.33E-09
SSE	750	Ra-226	1.46E-03	2.62E-10	3.38E-11	2.96E-10
SSE	750	Rn-222	1.67E-06	0.00E+00	0.00E+00	0.00E+00
SSE	750	Po-218	8.42E-07	1.52E-13	1.95E-14	1.71E-13
SSE	750	Pb-214	6.49E-08	1.17E-14	1.51E-15	1.32E-14
SSE	750	Bi-214	4.87E-09	8.76E-16	1.13E-16	9.89E-16
SSE	750	Po-214	4.87E-09	8.76E-16	1.13E-16	9.89E-16
SSE	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	750	At-218	1.67E-10	3.01E-17	3.88E-18	3.39E-17
SSE	750	Sr-90	5.47E-04	9.84E-11	1.27E-11	1.11E-10
SSE	750	Y-90	8.21E-07	1.48E-13	1.91E-14	1.67E-13
SSE	750	Cs-137	1.09E-03	1.97E-10	2.54E-11	2.22E-10
SSE	750	Ba-137m	9.27E-04	1.67E-10	2.15E-11	1.88E-10
SSE	1500	Ra-226	4.21E-04	7.57E-11	1.65E-11	9.22E-11
SSE	1500	Rn-222	5.04E-07	0.00E+00	0.00E+00	0.00E+00
SSE	1500	Po-218	2.43E-07	4.38E-14	9.52E-15	5.33E-14
SSE	1500	Pb-214	1.87E-08	3.37E-15	7.33E-16	4.11E-15
SSE	1500	Bi-214	1.41E-09	2.53E-16	5.50E-17	3.08E-16
SSE	1500	Po-214	1.41E-09	2.53E-16	5.50E-17	3.08E-16
SSE	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	1500	At-218	4.82E-11	8.68E-18	1.89E-18	1.06E-17
SSE	1500	Sr-90	1.58E-04	2.84E-11	6.18E-12	3.46E-11
SSE	1500	Y-90	2.37E-07	4.27E-14	9.28E-15	5.19E-14
SSE	1500	Cs-137	3.16E-04	5.68E-11	1.24E-11	6.92E-11
SSE	1500	Ba-137m	2.68E-04	4.82E-11	1.05E-11	5.86E-11
SSE	2500	Ra-226	1.75E-04	3.15E-11	9.67E-12	4.12E-11
SSE	2500	Rn-222	2.17E-07	0.00E+00	0.00E+00	0.00E+00
SSE	2500	Po-218	1.01E-07	1.82E-14	5.59E-15	2.38E-14
SSE	2500	Pb-214	7.81E-09	1.41E-15	4.31E-16	1.84E-15
SSE	2500	Bi-214	5.85E-10	1.05E-16	3.23E-17	1.38E-16
SSE	2500	Po-214	5.85E-10	1.05E-16	3.23E-17	1.38E-16
SSE	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	2500	At-218	2.01E-11	3.62E-18	1.11E-18	4.72E-18
SSE	2500	Sr-90	6.57E-05	1.18E-11	3.63E-12	1.55E-11
SSE	2500	Y-90	9.87E-08	1.78E-14	5.45E-15	2.32E-14

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SSE	2500	Cs-137	1.31E-04	2.37E-11	7.25E-12	3.09E-11
SSE	2500	Ba-137m	1.11E-04	2.01E-11	6.15E-12	2.62E-11
SSE	3500	Ra-226	1.01E-04	1.82E-11	6.77E-12	2.50E-11
SSE	3500	Rn-222	1.30E-07	0.00E+00	0.00E+00	0.00E+00
SSE	3500	Po-218	5.86E-08	1.05E-14	3.91E-15	1.45E-14
SSE	3500	Pb-214	4.51E-09	8.13E-16	3.02E-16	1.11E-15
SSE	3500	Bi-214	3.38E-10	6.09E-17	2.26E-17	8.35E-17
SSE	3500	Po-214	3.38E-10	6.09E-17	2.26E-17	8.35E-17
SSE	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	3500	At-218	1.16E-11	2.09E-18	7.76E-19	2.87E-18
SSE	3500	Sr-90	3.80E-05	6.84E-12	2.54E-12	9.38E-12
SSE	3500	Y-90	5.71E-08	1.03E-14	3.81E-15	1.41E-14
SSE	3500	Cs-137	7.60E-05	1.37E-11	5.08E-12	1.88E-11
SSE	3500	Ba-137m	6.44E-05	1.16E-11	4.30E-12	1.59E-11
SSE	4500	Ra-226	6.87E-05	1.24E-11	5.17E-12	1.75E-11
SSE	4500	Rn-222	9.08E-08	0.00E+00	0.00E+00	0.00E+00
SSE	4500	Po-218	3.97E-08	7.15E-15	2.99E-15	1.01E-14
SSE	4500	Pb-214	3.06E-09	5.51E-16	2.30E-16	7.81E-16
SSE	4500	Bi-214	2.30E-10	4.13E-17	1.73E-17	5.86E-17
SSE	4500	Po-214	2.29E-10	4.13E-17	1.73E-17	5.86E-17
SSE	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SSE	4500	At-218	7.88E-12	1.42E-18	5.92E-19	2.01E-18
SSE	4500	Sr-90	2.58E-05	4.64E-12	1.94E-12	6.58E-12
SSE	4500	Y-90	3.87E-08	6.97E-15	2.91E-15	9.88E-15
SSE	4500	Cs-137	5.15E-05	9.28E-12	3.88E-12	1.32E-11
SSE	4500	Ba-137m	4.37E-05	7.87E-12	3.29E-12	1.12E-11
SSE	7500	Ra-226	3.07E-05	5.53E-12	2.97E-12	8.50E-12
SSE	7500	Rn-222	4.41E-08	0.00E+00	0.00E+00	0.00E+00
SSE	7500	Po-218	1.78E-08	3.20E-15	1.72E-15	4.91E-15
SSE	7500	Pb-214	1.37E-09	2.47E-16	1.32E-16	3.79E-16
SSE	7500	Bi-214	1.03E-10	1.85E-17	9.89E-18	2.84E-17
SSE	7500	Po-214	1.03E-10	1.85E-17	9.89E-18	2.84E-17
SSE	7500	Pb-210	0.00E+00	0.00E+00	2.45E-24	2.45E-24
SSE	7500	Bi-210	0.00E+00	0.00E+00	6.72E-26	6.72E-26
SSE	7500	Po-210	0.00E+00	0.00E+00	1.84E-27	1.84E-27
SSE	7500	At-218	3.52E-12	6.34E-19	3.39E-19	9.73E-19
SSE	7500	Sr-90	1.15E-05	2.08E-12	1.11E-12	3.19E-12
SSE	7500	Y-90	1.73E-08	3.12E-15	1.67E-15	4.79E-15
SSE	7500	Cs-137	2.31E-05	4.15E-12	2.22E-12	6.37E-12
SSE	7500	Ba-137m	1.96E-05	3.52E-12	1.88E-12	5.40E-12
SSE	15000	Ra-226	1.12E-05	2.01E-12	1.38E-12	3.39E-12
SSE	15000	Rn-222	1.82E-08	0.00E+00	0.00E+00	0.00E+00
SSE	15000	Po-218	6.45E-09	1.16E-15	7.96E-16	1.96E-15

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SSE	15000	Pb-214	4.97E-10	8.94E-17	6.13E-17	1.51E-16
SSE	15000	Bi-214	3.72E-11	6.70E-18	4.60E-18	1.13E-17
SSE	15000	Po-214	3.72E-11	6.70E-18	4.60E-18	1.13E-17
SSE	15000	Pb-210	0.00E+00	0.00E+00	4.64E-26	4.64E-26
SSE	15000	Bi-210	0.00E+00	0.00E+00	7.40E-28	7.40E-28
SSE	15000	Po-210	0.00E+00	0.00E+00	1.18E-29	1.18E-29
SSE	15000	At-218	1.28E-12	2.30E-19	1.58E-19	3.88E-19
SSE	15000	Sr-90	4.18E-06	7.53E-13	5.16E-13	1.27E-12
SSE	15000	Y-90	6.28E-09	1.13E-15	7.76E-16	1.91E-15
SSE	15000	Cs-137	8.36E-06	1.51E-12	1.03E-12	2.54E-12
SSE	15000	Ba-137m	7.09E-06	1.28E-12	8.75E-13	2.15E-12
SSE	25000	Ra-226	4.74E-06	8.53E-13	7.30E-13	1.58E-12
SSE	25000	Rn-222	9.97E-09	0.00E+00	0.00E+00	0.00E+00
SSE	25000	Po-218	2.74E-09	4.93E-16	4.21E-16	9.14E-16
SSE	25000	Pb-214	2.11E-10	3.80E-17	3.24E-17	7.05E-17
SSE	25000	Bi-214	1.58E-11	2.85E-18	2.43E-18	5.28E-18
SSE	25000	Po-214	1.58E-11	2.85E-18	2.43E-18	5.28E-18
SSE	25000	Pb-210	0.00E+00	0.00E+00	1.18E-27	1.18E-27
SSE	25000	Bi-210	0.00E+00	0.00E+00	1.09E-29	1.09E-29
SSE	25000	Po-210	0.00E+00	0.00E+00	1.01E-31	1.01E-31
SSE	25000	At-218	5.43E-13	9.78E-20	8.35E-20	1.81E-19
SSE	25000	Sr-90	1.78E-06	3.20E-13	2.73E-13	5.93E-13
SSE	25000	Y-90	2.67E-09	4.81E-16	4.10E-16	8.91E-16
SSE	25000	Cs-137	3.56E-06	6.40E-13	5.46E-13	1.19E-12
SSE	25000	Ba-137m	3.01E-06	5.43E-13	4.63E-13	1.01E-12
SSE	35000	Ra-226	2.94E-06	5.28E-13	4.95E-13	1.02E-12
SSE	35000	Rn-222	6.75E-09	0.00E+00	0.00E+00	0.00E+00
SSE	35000	Po-218	1.70E-09	3.05E-16	2.85E-16	5.91E-16
SSE	35000	Pb-214	1.31E-10	2.35E-17	2.20E-17	4.55E-17
SSE	35000	Bi-214	9.80E-12	1.76E-18	1.65E-18	3.41E-18
SSE	35000	Po-214	9.80E-12	1.76E-18	1.65E-18	3.41E-18
SSE	35000	Pb-210	0.00E+00	0.00E+00	3.43E-28	3.43E-28
SSE	35000	Bi-210	0.00E+00	0.00E+00	2.82E-30	2.82E-30
SSE	35000	Po-210	0.00E+00	0.00E+00	2.31E-32	2.31E-32
SSE	35000	At-218	3.36E-13	6.06E-20	5.65E-20	1.17E-19
SSE	35000	Sr-90	1.10E-06	1.98E-13	1.85E-13	3.83E-13
SSE	35000	Y-90	1.65E-09	2.98E-16	2.78E-16	5.76E-16
SSE	35000	Cs-137	2.20E-06	3.96E-13	3.70E-13	7.66E-13
SSE	35000	Ba-137m	1.87E-06	3.36E-13	3.14E-13	6.50E-13
SSE	45000	Ra-226	1.99E-06	3.58E-13	3.63E-13	7.21E-13
SSE	45000	Rn-222	5.05E-09	0.00E+00	0.00E+00	0.00E+00
SSE	45000	Po-218	1.15E-09	2.07E-16	2.09E-16	4.16E-16
SSE	45000	Pb-214	8.86E-11	1.60E-17	1.61E-17	3.21E-17
SSE	45000	Bi-214	6.65E-12	1.20E-18	1.21E-18	2.41E-18
SSE	45000	Po-214	6.65E-12	1.20E-18	1.21E-18	2.41E-18
SSE	45000	Pb-210	0.00E+00	0.00E+00	1.36E-28	1.36E-28
SSE	45000	Bi-210	0.00E+00	0.00E+00	1.02E-30	1.02E-30

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SSE	45000	Po-210	0.00E+00	0.00E+00	7.60E-33	7.60E-33
SSE	45000	At-218	2.28E-13	4.10E-20	4.15E-20	8.26E-20
SSE	45000	Sr-90	7.46E-07	1.34E-13	1.36E-13	2.70E-13
SSE	45000	Y-90	1.12E-09	2.02E-16	2.04E-16	4.06E-16
SSE	45000	Cs-137	1.49E-06	2.69E-13	2.72E-13	5.40E-13
SSE	45000	Ba-137m	1.27E-06	2.28E-13	2.30E-13	4.58E-13
SSE	55000	Ra-226	1.38E-06	2.48E-13	2.76E-13	5.24E-13
SSE	55000	Rn-222	4.01E-09	0.00E+00	0.00E+00	0.00E+00
SSE	55000	Po-218	7.95E-10	1.43E-16	1.59E-16	3.02E-16
SSE	55000	Pb-214	6.13E-11	1.10E-17	1.23E-17	2.33E-17
SSE	55000	Bi-214	4.59E-12	8.27E-19	9.21E-19	1.75E-18
SSE	55000	Po-214	4.59E-12	8.27E-19	9.21E-19	1.75E-18
SSE	55000	Pb-210	0.00E+00	0.00E+00	6.42E-29	6.42E-29
SSE	55000	Bi-210	0.00E+00	0.00E+00	4.47E-31	4.47E-31
SSE	55000	Po-210	0.00E+00	0.00E+00	3.11E-33	3.11E-33
SSE	55000	At-218	1.58E-13	2.84E-20	3.16E-20	6.00E-20
SSE	55000	Sr-90	5.16E-07	9.28E-14	1.03E-13	1.96E-13
SSE	55000	Y-90	7.75E-10	1.39E-16	1.55E-16	2.95E-16
SSE	55000	Cs-137	1.03E-06	1.86E-13	2.07E-13	3.92E-13
SSE	55000	Ba-137m	8.75E-07	1.57E-13	1.75E-13	3.33E-13
SSE	70000	Ra-226	7.39E-07	1.33E-13	1.89E-13	3.22E-13
SSE	70000	Rn-222	3.04E-09	0.00E+00	0.00E+00	0.00E+00
SSE	70000	Po-218	4.27E-10	7.68E-17	1.09E-16	1.86E-16
SSE	70000	Pb-214	3.29E-11	5.92E-18	8.40E-18	1.43E-17
SSE	70000	Bi-214	2.47E-12	4.44E-19	6.30E-19	1.07E-18
SSE	70000	Po-214	2.47E-12	4.44E-19	6.30E-19	1.07E-18
SSE	70000	Pb-210	0.00E+00	0.00E+00	2.59E-29	2.59E-29
SSE	70000	Bi-210	0.00E+00	0.00E+00	1.65E-31	1.65E-31
SSE	70000	Po-210	0.00E+00	0.00E+00	1.05E-33	1.05E-33
SSE	70000	At-218	8.46E-14	1.52E-20	2.16E-20	3.68E-20
SSE	70000	Sr-90	2.77E-07	4.99E-14	7.07E-14	1.21E-13
SSE	70000	Y-90	4.16E-10	7.49E-17	1.06E-16	1.81E-16
SSE	70000	Cs-137	5.54E-07	9.97E-14	1.41E-13	2.41E-13
SSE	70000	Ba-137m	4.70E-07	8.45E-14	1.20E-13	2.04E-13
SE	250	Ra-226	8.35E-03	1.50E-09	8.85E-11	1.59E-09
SE	250	Rn-222	9.15E-06	0.00E+00	0.00E+00	0.00E+00
SE	250	Po-218	4.83E-06	8.69E-13	5.12E-14	9.20E-13
SE	250	Pb-214	3.72E-07	6.69E-14	3.94E-15	7.09E-14
SE	250	Bi-214	2.79E-08	5.02E-15	2.96E-16	5.32E-15
SE	250	Po-214	2.79E-08	5.02E-15	2.96E-16	5.31E-15
SE	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	250	At-218	9.57E-10	1.72E-16	1.01E-17	1.82E-16
SE	250	Sr-90	3.13E-03	5.64E-10	3.32E-11	5.97E-10
SE	250	Y-90	4.70E-06	8.47E-13	4.99E-14	8.97E-13
SE	250	Cs-137	6.26E-03	1.13E-09	6.64E-11	1.19E-09

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SE	250	Ba-137m	5.31E-03	9.56E-10	5.63E-11	1.01E-09
SE	750	Ra-226	1.09E-03	1.96E-10	2.85E-11	2.24E-10
SE	750	Rn-222	1.26E-06	0.00E+00	0.00E+00	0.00E+00
SE	750	Po-218	6.28E-07	1.13E-13	1.65E-14	1.30E-13
SE	750	Pb-214	4.84E-08	8.72E-15	1.27E-15	9.99E-15
SE	750	Bi-214	3.63E-09	6.54E-16	9.52E-17	7.49E-16
SE	750	Po-214	3.63E-09	6.54E-16	9.51E-17	7.49E-16
SE	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	750	At-218	1.25E-10	2.24E-17	3.26E-18	2.57E-17
SE	750	Sr-90	4.08E-04	7.34E-11	1.07E-11	8.41E-11
SE	750	Y-90	6.12E-07	1.10E-13	1.61E-14	1.26E-13
SE	750	Cs-137	8.15E-04	1.47E-10	2.14E-11	1.68E-10
SE	750	Ba-137m	6.91E-04	1.24E-10	1.81E-11	1.43E-10
SE	1500	Ra-226	3.11E-04	5.59E-11	1.39E-11	6.98E-11
SE	1500	Rn-222	3.78E-07	0.00E+00	0.00E+00	0.00E+00
SE	1500	Po-218	1.80E-07	3.23E-14	8.01E-15	4.03E-14
SE	1500	Pb-214	1.38E-08	2.49E-15	6.17E-16	3.11E-15
SE	1500	Bi-214	1.04E-09	1.87E-16	4.63E-17	2.33E-16
SE	1500	Po-214	1.04E-09	1.87E-16	4.63E-17	2.33E-16
SE	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	1500	At-218	3.56E-11	6.41E-18	1.59E-18	7.99E-18
SE	1500	Sr-90	1.16E-04	2.10E-11	5.20E-12	2.62E-11
SE	1500	Y-90	1.75E-07	3.15E-14	7.81E-15	3.93E-14
SE	1500	Cs-137	2.33E-04	4.19E-11	1.04E-11	5.23E-11
SE	1500	Ba-137m	1.97E-04	3.55E-11	8.81E-12	4.44E-11
SE	2500	Ra-226	1.28E-04	2.31E-11	8.13E-12	3.12E-11
SE	2500	Rn-222	1.62E-07	0.00E+00	0.00E+00	0.00E+00
SE	2500	Po-218	7.40E-08	1.33E-14	4.70E-15	1.80E-14
SE	2500	Pb-214	5.71E-09	1.03E-15	3.62E-16	1.39E-15
SE	2500	Bi-214	4.28E-10	7.70E-17	2.71E-17	1.04E-16
SE	2500	Po-214	4.28E-10	7.70E-17	2.71E-17	1.04E-16
SE	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	2500	At-218	1.47E-11	2.64E-18	9.31E-19	3.57E-18
SE	2500	Sr-90	4.80E-05	8.65E-12	3.05E-12	1.17E-11
SE	2500	Y-90	7.22E-08	1.30E-14	4.58E-15	1.76E-14
SE	2500	Cs-137	9.61E-05	1.73E-11	6.10E-12	2.34E-11
SE	2500	Ba-137m	8.15E-05	1.47E-11	5.17E-12	1.98E-11
SE	3500	Ra-226	7.34E-05	1.32E-11	5.69E-12	1.89E-11
SE	3500	Rn-222	9.65E-08	0.00E+00	0.00E+00	0.00E+00
SE	3500	Po-218	4.24E-08	7.64E-15	3.29E-15	1.09E-14
SE	3500	Pb-214	3.27E-09	5.89E-16	2.53E-16	8.42E-16

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SE	3500	Bi-214	2.45E-10	4.42E-17	1.90E-17	6.31E-17
SE	3500	Po-214	2.45E-10	4.41E-17	1.90E-17	6.31E-17
SE	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	3500	At-218	8.42E-12	1.51E-18	6.52E-19	2.17E-18
SE	3500	Sr-90	2.75E-05	4.96E-12	2.13E-12	7.09E-12
SE	3500	Y-90	4.14E-08	7.45E-15	3.20E-15	1.07E-14
SE	3500	Cs-137	5.51E-05	9.92E-12	4.27E-12	1.42E-11
SE	3500	Ba-137m	4.67E-05	8.41E-12	3.62E-12	1.20E-11
SE	4500	Ra-226	4.94E-05	8.89E-12	4.34E-12	1.32E-11
SE	4500	Rn-222	6.73E-08	0.00E+00	0.00E+00	0.00E+00
SE	4500	Po-218	2.85E-08	5.14E-15	2.51E-15	7.65E-15
SE	4500	Pb-214	2.20E-09	3.96E-16	1.93E-16	5.89E-16
SE	4500	Bi-214	1.65E-10	2.97E-17	1.45E-17	4.42E-17
SE	4500	Po-214	1.65E-10	2.97E-17	1.45E-17	4.42E-17
SE	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE	4500	At-218	5.66E-12	1.02E-18	4.97E-19	1.52E-18
SE	4500	Sr-90	1.85E-05	3.33E-12	1.63E-12	4.96E-12
SE	4500	Y-90	2.78E-08	5.01E-15	2.45E-15	7.45E-15
SE	4500	Cs-137	3.71E-05	6.67E-12	3.26E-12	9.92E-12
SE	4500	Ba-137m	3.14E-05	5.65E-12	2.76E-12	8.41E-12
SE	7500	Ra-226	2.17E-05	3.91E-12	2.49E-12	6.39E-12
SE	7500	Rn-222	3.24E-08	0.00E+00	0.00E+00	0.00E+00
SE	7500	Po-218	1.25E-08	2.26E-15	1.44E-15	3.69E-15
SE	7500	Pb-214	9.67E-10	1.74E-16	1.11E-16	2.85E-16
SE	7500	Bi-214	7.25E-11	1.30E-17	8.29E-18	2.13E-17
SE	7500	Po-214	7.25E-11	1.30E-17	8.29E-18	2.13E-17
SE	7500	Pb-210	0.00E+00	0.00E+00	3.27E-25	3.27E-25
SE	7500	Bi-210	0.00E+00	0.00E+00	6.28E-27	6.28E-27
SE	7500	Po-210	0.00E+00	0.00E+00	1.21E-28	1.21E-28
SE	7500	At-218	2.49E-12	4.48E-19	2.84E-19	7.32E-19
SE	7500	Sr-90	8.14E-06	1.46E-12	9.31E-13	2.40E-12
SE	7500	Y-90	1.22E-08	2.20E-15	1.40E-15	3.60E-15
SE	7500	Cs-137	1.63E-05	2.93E-12	1.86E-12	4.79E-12
SE	7500	Ba-137m	1.38E-05	2.48E-12	1.58E-12	4.06E-12
SE	15000	Ra-226	7.70E-06	1.39E-12	1.15E-12	2.54E-12
SE	15000	Rn-222	1.33E-08	0.00E+00	0.00E+00	0.00E+00
SE	15000	Po-218	4.45E-09	8.01E-16	6.64E-16	1.46E-15
SE	15000	Pb-214	3.43E-10	6.17E-17	5.11E-17	1.13E-16
SE	15000	Bi-214	2.57E-11	4.63E-18	3.83E-18	8.46E-18
SE	15000	Po-214	2.57E-11	4.63E-18	3.83E-18	8.46E-18
SE	15000	Pb-210	0.00E+00	0.00E+00	4.41E-27	4.41E-27
SE	15000	Bi-210	0.00E+00	0.00E+00	4.93E-29	4.93E-29
SE	15000	Po-210	0.00E+00	0.00E+00	5.52E-31	5.52E-31

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SE	15000	At-218	8.82E-13	1.59E-19	1.32E-19	2.90E-19
SE	15000	Sr-90	2.89E-06	5.20E-13	4.31E-13	9.50E-13
SE	15000	Y-90	4.34E-09	7.81E-16	6.47E-16	1.43E-15
SE	15000	Cs-137	5.77E-06	1.04E-12	8.61E-13	1.90E-12
SE	15000	Ba-137m	4.90E-06	8.81E-13	7.30E-13	1.61E-12
SE	25000	Ra-226	3.15E-06	5.67E-13	6.07E-13	1.17E-12
SE	25000	Rn-222	7.28E-09	0.00E+00	0.00E+00	0.00E+00
SE	25000	Po-218	1.82E-09	3.28E-16	3.50E-16	6.78E-16
SE	25000	Pb-214	1.40E-10	2.53E-17	2.70E-17	5.23E-17
SE	25000	Bi-214	1.05E-11	1.89E-18	2.02E-18	3.92E-18
SE	25000	Po-214	1.05E-11	1.89E-18	2.02E-18	3.92E-18
SE	25000	Pb-210	0.00E+00	0.00E+00	5.39E-29	5.39E-29
SE	25000	Bi-210	0.00E+00	0.00E+00	3.51E-31	3.51E-31
SE	25000	Po-210	0.00E+00	0.00E+00	2.29E-33	2.29E-33
SE	25000	At-218	3.61E-13	6.50E-20	6.95E-20	1.34E-19
SE	25000	Sr-90	1.18E-06	2.13E-13	2.27E-13	4.40E-13
SE	25000	Y-90	1.78E-09	3.20E-16	3.42E-16	6.61E-16
SE	25000	Cs-137	2.36E-06	4.26E-13	4.55E-13	8.80E-13
SE	25000	Ba-137m	2.00E-06	3.61E-13	3.85E-13	7.46E-13
SE	35000	Ra-226	1.93E-06	3.47E-13	4.08E-13	7.55E-13
SE	35000	Rn-222	4.92E-09	0.00E+00	0.00E+00	0.00E+00
SE	35000	Po-218	1.11E-09	2.00E-16	2.36E-16	4.36E-16
SE	35000	Pb-214	8.58E-11	1.54E-17	1.82E-17	3.36E-17
SE	35000	Bi-214	6.43E-12	1.16E-18	1.36E-18	2.52E-18
SE	35000	Po-214	6.43E-12	1.16E-18	1.36E-18	2.52E-18
SE	35000	Pb-210	0.00E+00	0.00E+00	1.57E-29	1.57E-29
SE	35000	Bi-210	0.00E+00	0.00E+00	9.05E-32	9.05E-32
SE	35000	Po-210	0.00E+00	0.00E+00	5.21E-34	5.21E-34
SE	35000	At-218	2.21E-13	3.97E-20	4.67E-20	8.64E-20
SE	35000	Sr-90	7.22E-07	1.30E-13	1.53E-13	2.83E-13
SE	35000	Y-90	1.08E-09	1.95E-16	2.30E-16	4.25E-16
SE	35000	Cs-137	1.44E-06	2.60E-13	3.06E-13	5.66E-13
SE	35000	Ba-137m	1.22E-06	2.20E-13	2.59E-13	4.80E-13
SE	45000	Ra-226	1.29E-06	2.32E-13	2.98E-13	5.29E-13
SE	45000	Rn-222	3.68E-09	0.00E+00	0.00E+00	0.00E+00
SE	45000	Po-218	7.44E-10	1.34E-16	1.72E-16	3.06E-16
SE	45000	Pb-214	5.73E-11	1.03E-17	1.32E-17	2.36E-17
SE	45000	Bi-214	4.30E-12	7.74E-19	9.93E-19	1.77E-18
SE	45000	Po-214	4.30E-12	7.74E-19	9.93E-19	1.77E-18
SE	45000	Pb-210	0.00E+00	0.00E+00	6.19E-30	6.19E-30
SE	45000	Bi-210	0.00E+00	0.00E+00	3.25E-32	3.25E-32
SE	45000	Po-210	0.00E+00	0.00E+00	1.71E-34	1.71E-34
SE	45000	At-218	1.48E-13	2.66E-20	3.41E-20	6.06E-20
SE	45000	Sr-90	4.83E-07	8.69E-14	1.12E-13	1.98E-13
SE	45000	Y-90	7.25E-10	1.31E-16	1.68E-16	2.98E-16
SE	45000	Cs-137	9.65E-07	1.74E-13	2.23E-13	3.97E-13
SE	45000	Ba-137m	8.19E-07	1.47E-13	1.89E-13	3.36E-13

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
SE	55000	Ra-226	8.75E-07	1.57E-13	2.25E-13	3.83E-13
SE	55000	Rn-222	2.92E-09	0.00E+00	0.00E+00	0.00E+00
SE	55000	Po-218	5.06E-10	9.10E-17	1.30E-16	2.21E-16
SE	55000	Pb-214	3.90E-11	7.01E-18	1.00E-17	1.70E-17
SE	55000	Bi-214	2.92E-12	5.26E-19	7.52E-19	1.28E-18
SE	55000	Po-214	2.92E-12	5.26E-19	7.52E-19	1.28E-18
SE	55000	Pb-210	0.00E+00	0.00E+00	2.93E-30	2.93E-30
SE	55000	Bi-210	0.00E+00	0.00E+00	1.43E-32	1.43E-32
SE	55000	Po-210	0.00E+00	0.00E+00	6.98E-35	6.98E-35
SE	55000	At-218	1.00E-13	1.80E-20	2.58E-20	4.39E-20
SE	55000	Sr-90	3.28E-07	5.90E-14	8.45E-14	1.44E-13
SE	55000	Y-90	4.93E-10	8.87E-17	1.27E-16	2.16E-16
SE	55000	Cs-137	6.56E-07	1.18E-13	1.69E-13	2.87E-13
SE	55000	Ba-137m	5.56E-07	1.00E-13	1.43E-13	2.43E-13
SE	70000	Ra-226	4.54E-07	8.18E-14	1.54E-13	2.36E-13
SE	70000	Rn-222	2.22E-09	0.00E+00	0.00E+00	0.00E+00
SE	70000	Po-218	2.63E-10	4.73E-17	8.92E-17	1.36E-16
SE	70000	Pb-214	2.02E-11	3.64E-18	6.87E-18	1.05E-17
SE	70000	Bi-214	1.52E-12	2.73E-19	5.15E-19	7.88E-19
SE	70000	Po-214	1.52E-12	2.73E-19	5.15E-19	7.88E-19
SE	70000	Pb-210	0.00E+00	0.00E+00	1.18E-30	1.18E-30
SE	70000	Bi-210	0.00E+00	0.00E+00	5.27E-33	5.27E-33
SE	70000	Po-210	0.00E+00	0.00E+00	2.35E-35	2.35E-35
SE	70000	At-218	5.21E-14	9.37E-21	1.77E-20	2.71E-20
SE	70000	Sr-90	1.70E-07	3.07E-14	5.79E-14	8.85E-14
SE	70000	Y-90	2.56E-10	4.61E-17	8.69E-17	1.33E-16
SE	70000	Cs-137	3.41E-07	6.13E-14	1.16E-13	1.77E-13
SE	70000	Ba-137m	2.89E-07	5.20E-14	9.81E-14	1.50E-13
ESE	250	Ra-226	9.99E-03	1.80E-09	1.15E-10	1.91E-09
ESE	250	Rn-222	1.10E-05	0.00E+00	0.00E+00	0.00E+00
ESE	250	Po-218	5.77E-06	1.04E-12	6.65E-14	1.11E-12
ESE	250	Pb-214	4.45E-07	8.01E-14	5.13E-15	8.52E-14
ESE	250	Bi-214	3.34E-08	6.01E-15	3.84E-16	6.39E-15
ESE	250	Po-214	3.34E-08	6.00E-15	3.84E-16	6.39E-15
ESE	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	250	At-218	1.14E-09	2.06E-16	1.32E-17	2.19E-16
ESE	250	Sr-90	3.75E-03	6.74E-10	4.32E-11	7.18E-10
ESE	250	Y-90	5.63E-06	1.01E-12	6.48E-14	1.08E-12
ESE	250	Cs-137	7.49E-03	1.35E-09	8.63E-11	1.44E-09
ESE	250	Ba-137m	6.35E-03	1.14E-09	7.32E-11	1.22E-09
ESE	750	Ra-226	1.29E-03	2.33E-10	3.71E-11	2.70E-10
ESE	750	Rn-222	1.50E-06	0.00E+00	0.00E+00	0.00E+00
ESE	750	Po-218	7.47E-07	1.34E-13	2.14E-14	1.56E-13
ESE	750	Pb-214	5.76E-08	1.04E-14	1.65E-15	1.20E-14
ESE	750	Bi-214	4.32E-09	7.77E-16	1.24E-16	9.01E-16

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ESE	750	Po-214	4.31E-09	7.77E-16	1.24E-16	9.01E-16
ESE	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	750	At-218	1.48E-10	2.67E-17	4.25E-18	3.09E-17
ESE	750	Sr-90	4.85E-04	8.72E-11	1.39E-11	1.01E-10
ESE	750	Y-90	7.28E-07	1.31E-13	2.09E-14	1.52E-13
ESE	750	Cs-137	9.69E-04	1.74E-10	2.78E-11	2.02E-10
ESE	750	Ba-137m	8.22E-04	1.48E-10	2.36E-11	1.71E-10
ESE	1500	Ra-226	3.68E-04	6.63E-11	1.81E-11	8.43E-11
ESE	1500	Rn-222	4.49E-07	0.00E+00	0.00E+00	0.00E+00
ESE	1500	Po-218	2.13E-07	3.83E-14	1.04E-14	4.87E-14
ESE	1500	Pb-214	1.64E-08	2.95E-15	8.05E-16	3.76E-15
ESE	1500	Bi-214	1.23E-09	2.21E-16	6.03E-17	2.82E-16
ESE	1500	Po-214	1.23E-09	2.21E-16	6.03E-17	2.82E-16
ESE	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	1500	At-218	4.22E-11	7.59E-18	2.07E-18	9.66E-18
ESE	1500	Sr-90	1.38E-04	2.48E-11	6.77E-12	3.16E-11
ESE	1500	Y-90	2.07E-07	3.73E-14	1.02E-14	4.75E-14
ESE	1500	Cs-137	2.76E-04	4.97E-11	1.35E-11	6.32E-11
ESE	1500	Ba-137m	2.34E-04	4.21E-11	1.15E-11	5.36E-11
ESE	2500	Ra-226	1.51E-04	2.72E-11	1.06E-11	3.78E-11
ESE	2500	Rn-222	1.92E-07	0.00E+00	0.00E+00	0.00E+00
ESE	2500	Po-218	8.74E-08	1.57E-14	6.13E-15	2.19E-14
ESE	2500	Pb-214	6.73E-09	1.21E-15	4.72E-16	1.68E-15
ESE	2500	Bi-214	5.05E-10	9.09E-17	3.54E-17	1.26E-16
ESE	2500	Po-214	5.05E-10	9.09E-17	3.54E-17	1.26E-16
ESE	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	2500	At-218	1.73E-11	3.12E-18	1.21E-18	4.33E-18
ESE	2500	Sr-90	5.67E-05	1.02E-11	3.98E-12	1.42E-11
ESE	2500	Y-90	8.52E-08	1.53E-14	5.97E-15	2.13E-14
ESE	2500	Cs-137	1.13E-04	2.04E-11	7.95E-12	2.84E-11
ESE	2500	Ba-137m	9.61E-05	1.73E-11	6.74E-12	2.40E-11
ESE	3500	Ra-226	8.62E-05	1.55E-11	7.43E-12	2.29E-11
ESE	3500	Rn-222	1.14E-07	0.00E+00	0.00E+00	0.00E+00
ESE	3500	Po-218	4.98E-08	8.97E-15	4.29E-15	1.33E-14
ESE	3500	Pb-214	3.84E-09	6.91E-16	3.31E-16	1.02E-15
ESE	3500	Bi-214	2.88E-10	5.18E-17	2.48E-17	7.66E-17
ESE	3500	Po-214	2.88E-10	5.18E-17	2.48E-17	7.66E-17
ESE	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	3500	At-218	9.88E-12	1.78E-18	8.51E-19	2.63E-18

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ESE	3500	Sr-90	3.23E-05	5.82E-12	2.78E-12	8.61E-12
ESE	3500	Y-90	4.86E-08	8.75E-15	4.18E-15	1.29E-14
ESE	3500	Cs-137	6.47E-05	1.16E-11	5.57E-12	1.72E-11
ESE	3500	Ba-137m	5.48E-05	9.87E-12	4.72E-12	1.46E-11
ESE	4500	Ra-226	5.77E-05	1.04E-11	5.67E-12	1.61E-11
ESE	4500	Rn-222	7.91E-08	0.00E+00	0.00E+00	0.00E+00
ESE	4500	Po-218	3.34E-08	6.01E-15	3.28E-15	9.28E-15
ESE	4500	Pb-214	2.57E-09	4.63E-16	2.53E-16	7.15E-16
ESE	4500	Bi-214	1.93E-10	3.47E-17	1.89E-17	5.36E-17
ESE	4500	Po-214	1.93E-10	3.47E-17	1.89E-17	5.36E-17
ESE	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ESE	4500	At-218	6.62E-12	1.19E-18	6.50E-19	1.84E-18
ESE	4500	Sr-90	2.17E-05	3.90E-12	2.13E-12	6.02E-12
ESE	4500	Y-90	3.25E-08	5.85E-15	3.19E-15	9.05E-15
ESE	4500	Cs-137	4.33E-05	7.79E-12	4.25E-12	1.20E-11
ESE	4500	Ba-137m	3.67E-05	6.61E-12	3.61E-12	1.02E-11
ESE	7500	Ra-226	2.51E-05	4.52E-12	3.26E-12	7.78E-12
ESE	7500	Rn-222	3.79E-08	0.00E+00	0.00E+00	0.00E+00
ESE	7500	Po-218	1.45E-08	2.61E-15	1.88E-15	4.50E-15
ESE	7500	Pb-214	1.12E-09	2.01E-16	1.45E-16	3.46E-16
ESE	7500	Bi-214	8.39E-11	1.51E-17	1.09E-17	2.60E-17
ESE	7500	Po-214	8.39E-11	1.51E-17	1.09E-17	2.59E-17
ESE	7500	Pb-210	0.00E+00	0.00E+00	2.29E-24	2.29E-24
ESE	7500	Bi-210	0.00E+00	0.00E+00	5.68E-26	5.68E-26
ESE	7500	Po-210	0.00E+00	0.00E+00	1.41E-27	1.41E-27
ESE	7500	At-218	2.88E-12	5.18E-19	3.72E-19	8.90E-19
ESE	7500	Sr-90	9.42E-06	1.70E-12	1.22E-12	2.91E-12
ESE	7500	Y-90	1.42E-08	2.55E-15	1.83E-15	4.38E-15
ESE	7500	Cs-137	1.88E-05	3.39E-12	2.44E-12	5.83E-12
ESE	7500	Ba-137m	1.60E-05	2.88E-12	2.07E-12	4.94E-12
ESE	15000	Ra-226	8.74E-06	1.57E-12	1.51E-12	3.08E-12
ESE	15000	Rn-222	1.53E-08	0.00E+00	0.00E+00	0.00E+00
ESE	15000	Po-218	5.05E-09	9.09E-16	8.72E-16	1.78E-15
ESE	15000	Pb-214	3.89E-10	7.01E-17	6.72E-17	1.37E-16
ESE	15000	Bi-214	2.92E-11	5.25E-18	5.04E-18	1.03E-17
ESE	15000	Po-214	2.92E-11	5.25E-18	5.03E-18	1.03E-17
ESE	15000	Pb-210	0.00E+00	0.00E+00	3.96E-26	3.96E-26
ESE	15000	Bi-210	0.00E+00	0.00E+00	5.71E-28	5.71E-28
ESE	15000	Po-210	0.00E+00	0.00E+00	8.24E-30	8.24E-30
ESE	15000	At-218	1.00E-12	1.80E-19	1.73E-19	3.53E-19
ESE	15000	Sr-90	3.28E-06	5.90E-13	5.65E-13	1.16E-12
ESE	15000	Y-90	4.92E-09	8.86E-16	8.49E-16	1.74E-15
ESE	15000	Cs-137	6.55E-06	1.18E-12	1.13E-12	2.31E-12
ESE	15000	Ba-137m	5.56E-06	1.00E-12	9.59E-13	1.96E-12
ESE	25000	Ra-226	3.53E-06	6.36E-13	8.05E-13	1.44E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ESE	25000	Rn-222	8.29E-09	0.00E+00	0.00E+00	0.00E+00
ESE	25000	Po-218	2.04E-09	3.67E-16	4.65E-16	8.32E-16
ESE	25000	Pb-214	1.57E-10	2.83E-17	3.58E-17	6.41E-17
ESE	25000	Bi-214	1.18E-11	2.12E-18	2.68E-18	4.81E-18
ESE	25000	Po-214	1.18E-11	2.12E-18	2.68E-18	4.81E-18
ESE	25000	Pb-210	0.00E+00	0.00E+00	4.51E-28	4.51E-28
ESE	25000	Bi-210	0.00E+00	0.00E+00	3.79E-30	3.79E-30
ESE	25000	Po-210	0.00E+00	0.00E+00	3.19E-32	3.19E-32
ESE	25000	At-218	4.05E-13	7.28E-20	9.21E-20	1.65E-19
ESE	25000	Sr-90	1.32E-06	2.38E-13	3.01E-13	5.40E-13
ESE	25000	Y-90	1.99E-09	3.58E-16	4.53E-16	8.11E-16
ESE	25000	Cs-137	2.65E-06	4.77E-13	6.03E-13	1.08E-12
ESE	25000	Ba-137m	2.25E-06	4.04E-13	5.11E-13	9.15E-13
ESE	35000	Ra-226	2.14E-06	3.85E-13	5.42E-13	9.26E-13
ESE	35000	Rn-222	5.58E-09	0.00E+00	0.00E+00	0.00E+00
ESE	35000	Po-218	1.24E-09	2.22E-16	3.13E-16	5.35E-16
ESE	35000	Pb-214	9.53E-11	1.71E-17	2.41E-17	4.12E-17
ESE	35000	Bi-214	7.14E-12	1.29E-18	1.81E-18	3.09E-18
ESE	35000	Po-214	7.14E-12	1.29E-18	1.81E-18	3.09E-18
ESE	35000	Pb-210	0.00E+00	0.00E+00	1.31E-28	1.31E-28
ESE	35000	Bi-210	0.00E+00	0.00E+00	9.74E-31	9.74E-31
ESE	35000	Po-210	0.00E+00	0.00E+00	7.24E-33	7.24E-33
ESE	35000	At-218	2.45E-13	4.41E-20	6.20E-20	1.06E-19
ESE	35000	Sr-90	8.02E-07	1.44E-13	2.03E-13	3.47E-13
ESE	35000	Y-90	1.20E-09	2.17E-16	3.05E-16	5.21E-16
ESE	35000	Cs-137	1.60E-06	2.89E-13	4.06E-13	6.94E-13
ESE	35000	Ba-137m	1.36E-06	2.45E-13	3.44E-13	5.89E-13
ESE	45000	Ra-226	1.42E-06	2.56E-13	3.95E-13	6.51E-13
ESE	45000	Rn-222	4.16E-09	0.00E+00	0.00E+00	0.00E+00
ESE	45000	Po-218	8.21E-10	1.48E-16	2.28E-16	3.76E-16
ESE	45000	Pb-214	6.33E-11	1.14E-17	1.76E-17	2.90E-17
ESE	45000	Bi-214	4.75E-12	8.54E-19	1.32E-18	2.17E-18
ESE	45000	Po-214	4.75E-12	8.54E-19	1.32E-18	2.17E-18
ESE	45000	Pb-210	0.00E+00	0.00E+00	5.16E-29	5.16E-29
ESE	45000	Bi-210	0.00E+00	0.00E+00	3.50E-31	3.50E-31
ESE	45000	Po-210	0.00E+00	0.00E+00	2.37E-33	2.37E-33
ESE	45000	At-218	1.63E-13	2.93E-20	4.52E-20	7.46E-20
ESE	45000	Sr-90	5.33E-07	9.59E-14	1.48E-13	2.44E-13
ESE	45000	Y-90	8.01E-10	1.44E-16	2.22E-16	3.67E-16
ESE	45000	Cs-137	1.07E-06	1.92E-13	2.96E-13	4.88E-13
ESE	45000	Ba-137m	9.04E-07	1.63E-13	2.51E-13	4.14E-13
ESE	55000	Ra-226	9.65E-07	1.74E-13	3.01E-13	4.74E-13
ESE	55000	Rn-222	3.30E-09	0.00E+00	0.00E+00	0.00E+00
ESE	55000	Po-218	5.58E-10	1.00E-16	1.74E-16	2.74E-16
ESE	55000	Pb-214	4.30E-11	7.74E-18	1.34E-17	2.11E-17
ESE	55000	Bi-214	3.22E-12	5.80E-19	1.00E-18	1.58E-18
ESE	55000	Po-214	3.22E-12	5.80E-19	1.00E-18	1.58E-18

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ESE	55000	Pb-210	0.00E+00	0.00E+00	2.43E-29	2.43E-29
ESE	55000	Bi-210	0.00E+00	0.00E+00	1.53E-31	1.53E-31
ESE	55000	Po-210	0.00E+00	0.00E+00	9.65E-34	9.65E-34
ESE	55000	At-218	1.11E-13	1.99E-20	3.44E-20	5.43E-20
ESE	55000	Sr-90	3.62E-07	6.52E-14	1.13E-13	1.78E-13
ESE	55000	Y-90	5.44E-10	9.79E-17	1.69E-16	2.67E-16
ESE	55000	Cs-137	7.24E-07	1.30E-13	2.25E-13	3.56E-13
ESE	55000	Ba-137m	6.14E-07	1.10E-13	1.91E-13	3.01E-13
ESE	70000	Ra-226	5.17E-07	9.30E-14	2.09E-13	3.02E-13
ESE	70000	Rn-222	2.49E-09	0.00E+00	0.00E+00	0.00E+00
ESE	70000	Po-218	2.99E-10	5.38E-17	1.21E-16	1.74E-16
ESE	70000	Pb-214	2.30E-11	4.14E-18	9.30E-18	1.34E-17
ESE	70000	Bi-214	1.73E-12	3.11E-19	6.97E-19	1.01E-18
ESE	70000	Po-214	1.73E-12	3.11E-19	6.97E-19	1.01E-18
ESE	70000	Pb-210	0.00E+00	0.00E+00	9.77E-30	9.77E-30
ESE	70000	Bi-210	0.00E+00	0.00E+00	5.63E-32	5.63E-32
ESE	70000	Po-210	0.00E+00	0.00E+00	3.25E-34	3.25E-34
ESE	70000	At-218	5.92E-14	1.07E-20	2.39E-20	3.46E-20
ESE	70000	Sr-90	1.94E-07	3.49E-14	7.83E-14	1.13E-13
ESE	70000	Y-90	2.91E-10	5.24E-17	1.18E-16	1.70E-16
ESE	70000	Cs-137	3.88E-07	6.98E-14	1.57E-13	2.26E-13
ESE	70000	Ba-137m	3.29E-07	5.92E-14	1.33E-13	1.92E-13
E	250	Ra-226	1.24E-02	2.23E-09	1.41E-10	2.37E-09
E	250	Rn-222	1.36E-05	0.00E+00	0.00E+00	0.00E+00
E	250	Po-218	7.14E-06	1.29E-12	8.18E-14	1.37E-12
E	250	Pb-214	5.51E-07	9.91E-14	6.30E-15	1.05E-13
E	250	Bi-214	4.13E-08	7.43E-15	4.72E-16	7.90E-15
E	250	Po-214	4.13E-08	7.43E-15	4.72E-16	7.90E-15
E	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	250	At-218	1.42E-09	2.55E-16	1.62E-17	2.71E-16
E	250	Sr-90	4.64E-03	8.34E-10	5.30E-11	8.87E-10
E	250	Y-90	6.96E-06	1.25E-12	7.97E-14	1.33E-12
E	250	Cs-137	9.27E-03	1.67E-09	1.06E-10	1.77E-09
E	250	Ba-137m	7.86E-03	1.41E-09	8.99E-11	1.50E-09
E	750	Ra-226	1.59E-03	2.87E-10	4.54E-11	3.32E-10
E	750	Rn-222	1.88E-06	0.00E+00	0.00E+00	0.00E+00
E	750	Po-218	9.21E-07	1.66E-13	2.62E-14	1.92E-13
E	750	Pb-214	7.10E-08	1.28E-14	2.02E-15	1.48E-14
E	750	Bi-214	5.32E-09	9.58E-16	1.52E-16	1.11E-15
E	750	Po-214	5.32E-09	9.58E-16	1.52E-16	1.11E-15
E	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	750	At-218	1.83E-10	3.29E-17	5.20E-18	3.81E-17
E	750	Sr-90	5.98E-04	1.08E-10	1.70E-11	1.25E-10

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
E	750	Y-90	8.98E-07	1.62E-13	2.56E-14	1.87E-13
E	750	Cs-137	1.20E-03	2.15E-10	3.41E-11	2.49E-10
E	750	Ba-137m	1.01E-03	1.82E-10	2.89E-11	2.11E-10
E	1500	Ra-226	4.52E-04	8.14E-11	2.21E-11	1.03E-10
E	1500	Rn-222	5.61E-07	0.00E+00	0.00E+00	0.00E+00
E	1500	Po-218	2.61E-07	4.70E-14	1.27E-14	5.98E-14
E	1500	Pb-214	2.01E-08	3.63E-15	9.82E-16	4.61E-15
E	1500	Bi-214	1.51E-09	2.72E-16	7.37E-17	3.45E-16
E	1500	Po-214	1.51E-09	2.72E-16	7.37E-17	3.45E-16
E	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	1500	At-218	5.18E-11	9.33E-18	2.53E-18	1.19E-17
E	1500	Sr-90	1.70E-04	3.05E-11	8.27E-12	3.88E-11
E	1500	Y-90	2.55E-07	4.59E-14	1.24E-14	5.83E-14
E	1500	Cs-137	3.39E-04	6.10E-11	1.65E-11	7.76E-11
E	1500	Ba-137m	2.88E-04	5.18E-11	1.40E-11	6.58E-11
E	2500	Ra-226	1.85E-04	3.33E-11	1.29E-11	4.62E-11
E	2500	Rn-222	2.40E-07	0.00E+00	0.00E+00	0.00E+00
E	2500	Po-218	1.07E-07	1.93E-14	7.47E-15	2.67E-14
E	2500	Pb-214	8.24E-09	1.48E-15	5.75E-16	2.06E-15
E	2500	Bi-214	6.18E-10	1.11E-16	4.31E-17	1.54E-16
E	2500	Po-214	6.18E-10	1.11E-16	4.31E-17	1.54E-16
E	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	2500	At-218	2.12E-11	3.82E-18	1.48E-18	5.30E-18
E	2500	Sr-90	6.94E-05	1.25E-11	4.84E-12	1.73E-11
E	2500	Y-90	1.04E-07	1.88E-14	7.28E-15	2.60E-14
E	2500	Cs-137	1.39E-04	2.50E-11	9.69E-12	3.47E-11
E	2500	Ba-137m	1.18E-04	2.12E-11	8.21E-12	2.94E-11
E	3500	Ra-226	1.05E-04	1.89E-11	9.03E-12	2.80E-11
E	3500	Rn-222	1.43E-07	0.00E+00	0.00E+00	0.00E+00
E	3500	Po-218	6.08E-08	1.09E-14	5.22E-15	1.62E-14
E	3500	Pb-214	4.69E-09	8.44E-16	4.02E-16	1.25E-15
E	3500	Bi-214	3.51E-10	6.33E-17	3.02E-17	9.34E-17
E	3500	Po-214	3.51E-10	6.32E-17	3.01E-17	9.34E-17
E	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	3500	At-218	1.21E-11	2.17E-18	1.03E-18	3.21E-18
E	3500	Sr-90	3.95E-05	7.10E-12	3.39E-12	1.05E-11
E	3500	Y-90	5.93E-08	1.07E-14	5.09E-15	1.58E-14
E	3500	Cs-137	7.89E-05	1.42E-11	6.77E-12	2.10E-11
E	3500	Ba-137m	6.69E-05	1.20E-11	5.74E-12	1.78E-11
E	4500	Ra-226	7.02E-05	1.26E-11	6.88E-12	1.95E-11
E	4500	Rn-222	9.91E-08	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
E	4500	Po-218	4.06E-08	7.30E-15	3.98E-15	1.13E-14
E	4500	Pb-214	3.13E-09	5.63E-16	3.07E-16	8.70E-16
E	4500	Bi-214	2.34E-10	4.22E-17	2.30E-17	6.52E-17
E	4500	Po-214	2.34E-10	4.22E-17	2.30E-17	6.52E-17
E	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E	4500	At-218	8.05E-12	1.45E-18	7.89E-19	2.24E-18
E	4500	Sr-90	2.63E-05	4.74E-12	2.58E-12	7.32E-12
E	4500	Y-90	3.96E-08	7.12E-15	3.88E-15	1.10E-14
E	4500	Cs-137	5.27E-05	9.48E-12	5.16E-12	1.46E-11
E	4500	Ba-137m	4.46E-05	8.04E-12	4.38E-12	1.24E-11
E	7500	Ra-226	3.03E-05	5.45E-12	3.95E-12	9.40E-12
E	7500	Rn-222	4.74E-08	0.00E+00	0.00E+00	0.00E+00
E	7500	Po-218	1.75E-08	3.15E-15	2.29E-15	5.44E-15
E	7500	Pb-214	1.35E-09	2.43E-16	1.76E-16	4.18E-16
E	7500	Bi-214	1.01E-10	1.82E-17	1.31E-17	3.13E-17
E	7500	Po-214	1.01E-10	1.82E-17	1.31E-17	3.13E-17
E	7500	Pb-210	0.00E+00	0.00E+00	1.09E-23	1.09E-23
E	7500	Bi-210	0.00E+00	0.00E+00	3.11E-25	3.11E-25
E	7500	Po-210	0.00E+00	0.00E+00	8.89E-27	8.89E-27
E	7500	At-218	3.47E-12	6.25E-19	4.50E-19	1.07E-18
E	7500	Sr-90	1.14E-05	2.04E-12	1.47E-12	3.52E-12
E	7500	Y-90	1.71E-08	3.07E-15	2.21E-15	5.29E-15
E	7500	Cs-137	2.27E-05	4.09E-12	2.95E-12	7.04E-12
E	7500	Ba-137m	1.93E-05	3.47E-12	2.50E-12	5.97E-12
E	15000	Ra-226	1.03E-05	1.86E-12	1.82E-12	3.68E-12
E	15000	Rn-222	1.92E-08	0.00E+00	0.00E+00	0.00E+00
E	15000	Po-218	5.98E-09	1.08E-15	1.05E-15	2.13E-15
E	15000	Pb-214	4.61E-10	8.30E-17	8.08E-17	1.64E-16
E	15000	Bi-214	3.46E-11	6.22E-18	6.06E-18	1.23E-17
E	15000	Po-214	3.46E-11	6.22E-18	6.06E-18	1.23E-17
E	15000	Pb-210	0.00E+00	0.00E+00	9.55E-26	9.55E-26
E	15000	Bi-210	0.00E+00	0.00E+00	1.59E-27	1.59E-27
E	15000	Po-210	0.00E+00	0.00E+00	2.64E-29	2.64E-29
E	15000	At-218	1.19E-12	2.13E-19	2.08E-19	4.21E-19
E	15000	Sr-90	3.88E-06	6.98E-13	6.80E-13	1.38E-12
E	15000	Y-90	5.83E-09	1.05E-15	1.02E-15	2.07E-15
E	15000	Cs-137	7.76E-06	1.40E-12	1.36E-12	2.76E-12
E	15000	Ba-137m	6.58E-06	1.18E-12	1.15E-12	2.34E-12
E	25000	Ra-226	4.07E-06	7.32E-13	9.63E-13	1.70E-12
E	25000	Rn-222	1.03E-08	0.00E+00	0.00E+00	0.00E+00
E	25000	Po-218	2.35E-09	4.23E-16	5.55E-16	9.78E-16
E	25000	Pb-214	1.81E-10	3.26E-17	4.28E-17	7.54E-17
E	25000	Bi-214	1.36E-11	2.44E-18	3.21E-18	5.65E-18
E	25000	Po-214	1.36E-11	2.44E-18	3.21E-18	5.65E-18
E	25000	Pb-210	0.00E+00	0.00E+00	1.85E-27	1.85E-27

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
E	25000	Bi-210	0.00E+00	0.00E+00	1.79E-29	1.79E-29
E	25000	Po-210	0.00E+00	0.00E+00	1.73E-31	1.73E-31
E	25000	At-218	4.66E-13	8.39E-20	1.10E-19	1.94E-19
E	25000	Sr-90	1.53E-06	2.75E-13	3.60E-13	6.35E-13
E	25000	Y-90	2.29E-09	4.12E-16	5.41E-16	9.54E-16
E	25000	Cs-137	3.05E-06	5.49E-13	7.21E-13	1.27E-12
E	25000	Ba-137m	2.59E-06	4.65E-13	6.11E-13	1.08E-12
E	35000	Ra-226	2.43E-06	4.37E-13	6.46E-13	1.08E-12
E	35000	Rn-222	6.93E-09	0.00E+00	0.00E+00	0.00E+00
E	35000	Po-218	1.40E-09	2.52E-16	3.73E-16	6.25E-16
E	35000	Pb-214	1.08E-10	1.95E-17	2.87E-17	4.82E-17
E	35000	Bi-214	8.10E-12	1.46E-18	2.15E-18	3.61E-18
E	35000	Po-214	8.10E-12	1.46E-18	2.15E-18	3.61E-18
E	35000	Pb-210	0.00E+00	0.00E+00	5.35E-28	5.35E-28
E	35000	Bi-210	0.00E+00	0.00E+00	4.58E-30	4.58E-30
E	35000	Po-210	0.00E+00	0.00E+00	3.92E-32	3.92E-32
E	35000	At-218	2.78E-13	5.00E-20	7.38E-20	1.24E-19
E	35000	Sr-90	9.10E-07	1.64E-13	2.42E-13	4.05E-13
E	35000	Y-90	1.37E-09	2.46E-16	3.63E-16	6.09E-16
E	35000	Cs-137	1.82E-06	3.28E-13	4.83E-13	8.11E-13
E	35000	Ba-137m	1.54E-06	2.78E-13	4.10E-13	6.87E-13
E	45000	Ra-226	1.59E-06	2.86E-13	4.70E-13	7.57E-13
E	45000	Rn-222	5.16E-09	0.00E+00	0.00E+00	0.00E+00
E	45000	Po-218	9.20E-10	1.66E-16	2.71E-16	4.37E-16
E	45000	Pb-214	7.09E-11	1.28E-17	2.09E-17	3.37E-17
E	45000	Bi-214	5.31E-12	9.57E-19	1.57E-18	2.52E-18
E	45000	Po-214	5.31E-12	9.57E-19	1.57E-18	2.52E-18
E	45000	Pb-210	0.00E+00	0.00E+00	2.10E-28	2.10E-28
E	45000	Bi-210	0.00E+00	0.00E+00	1.64E-30	1.64E-30
E	45000	Po-210	0.00E+00	0.00E+00	1.28E-32	1.28E-32
E	45000	At-218	1.82E-13	3.28E-20	5.38E-20	8.66E-20
E	45000	Sr-90	5.97E-07	1.07E-13	1.76E-13	2.83E-13
E	45000	Y-90	8.97E-10	1.61E-16	2.64E-16	4.26E-16
E	45000	Cs-137	1.19E-06	2.15E-13	3.52E-13	5.67E-13
E	45000	Ba-137m	1.01E-06	1.82E-13	2.98E-13	4.81E-13
E	55000	Ra-226	1.07E-06	1.92E-13	3.57E-13	5.49E-13
E	55000	Rn-222	4.08E-09	0.00E+00	0.00E+00	0.00E+00
E	55000	Po-218	6.18E-10	1.11E-16	2.06E-16	3.17E-16
E	55000	Pb-214	4.76E-11	8.57E-18	1.59E-17	2.44E-17
E	55000	Bi-214	3.57E-12	6.42E-19	1.19E-18	1.83E-18
E	55000	Po-214	3.57E-12	6.42E-19	1.19E-18	1.83E-18
E	55000	Pb-210	0.00E+00	0.00E+00	9.86E-29	9.86E-29
E	55000	Bi-210	0.00E+00	0.00E+00	7.16E-31	7.16E-31
E	55000	Po-210	0.00E+00	0.00E+00	5.20E-33	5.20E-33
E	55000	At-218	1.22E-13	2.20E-20	4.08E-20	6.28E-20
E	55000	Sr-90	4.01E-07	7.21E-14	1.34E-13	2.06E-13
E	55000	Y-90	6.02E-10	1.08E-16	2.01E-16	3.09E-16

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
E	55000	Cs-137	8.01E-07	1.44E-13	2.67E-13	4.11E-13
E	55000	Ba-137m	6.79E-07	1.22E-13	2.26E-13	3.49E-13
E	70000	Ra-226	5.71E-07	1.03E-13	2.48E-13	3.51E-13
E	70000	Rn-222	3.08E-09	0.00E+00	0.00E+00	0.00E+00
E	70000	Po-218	3.30E-10	5.94E-17	1.43E-16	2.03E-16
E	70000	Pb-214	2.54E-11	4.58E-18	1.10E-17	1.56E-17
E	70000	Bi-214	1.91E-12	3.43E-19	8.28E-19	1.17E-18
E	70000	Po-214	1.91E-12	3.43E-19	8.28E-19	1.17E-18
E	70000	Pb-210	0.00E+00	0.00E+00	3.94E-29	3.94E-29
E	70000	Bi-210	0.00E+00	0.00E+00	2.62E-31	2.62E-31
E	70000	Po-210	0.00E+00	0.00E+00	1.74E-33	1.74E-33
E	70000	At-218	6.54E-14	1.18E-20	2.84E-20	4.02E-20
E	70000	Sr-90	2.14E-07	3.85E-14	9.29E-14	1.31E-13
E	70000	Y-90	3.22E-10	5.79E-17	1.40E-16	1.98E-16
E	70000	Cs-137	4.28E-07	7.71E-14	1.86E-13	2.63E-13
E	70000	Ba-137m	3.63E-07	6.54E-14	1.58E-13	2.23E-13
ENE	250	Ra-226	1.06E-02	1.90E-09	1.24E-10	2.02E-09
ENE	250	Rn-222	1.15E-05	0.00E+00	0.00E+00	0.00E+00
ENE	250	Po-218	6.10E-06	1.10E-12	7.19E-14	1.17E-12
ENE	250	Pb-214	4.70E-07	8.46E-14	5.54E-15	9.02E-14
ENE	250	Bi-214	3.52E-08	6.34E-15	4.15E-16	6.76E-15
ENE	250	Po-214	3.52E-08	6.34E-15	4.15E-16	6.76E-15
ENE	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	250	At-218	1.21E-09	2.18E-16	1.42E-17	2.32E-16
ENE	250	Sr-90	3.96E-03	7.12E-10	4.66E-11	7.59E-10
ENE	250	Y-90	5.95E-06	1.07E-12	7.00E-14	1.14E-12
ENE	250	Cs-137	7.92E-03	1.42E-09	9.32E-11	1.52E-09
ENE	250	Ba-137m	6.71E-03	1.21E-09	7.91E-11	1.29E-09
ENE	750	Ra-226	1.38E-03	2.48E-10	4.02E-11	2.88E-10
ENE	750	Rn-222	1.59E-06	0.00E+00	0.00E+00	0.00E+00
ENE	750	Po-218	7.97E-07	1.43E-13	2.32E-14	1.67E-13
ENE	750	Pb-214	6.14E-08	1.11E-14	1.79E-15	1.28E-14
ENE	750	Bi-214	4.61E-09	8.29E-16	1.34E-16	9.63E-16
ENE	750	Po-214	4.61E-09	8.29E-16	1.34E-16	9.63E-16
ENE	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	750	At-218	1.58E-10	2.84E-17	4.60E-18	3.30E-17
ENE	750	Sr-90	5.17E-04	9.31E-11	1.51E-11	1.08E-10
ENE	750	Y-90	7.77E-07	1.40E-13	2.26E-14	1.62E-13
ENE	750	Cs-137	1.03E-03	1.86E-10	3.01E-11	2.16E-10
ENE	750	Ba-137m	8.77E-04	1.58E-10	2.55E-11	1.83E-10
ENE	1500	Ra-226	3.96E-04	7.13E-11	1.96E-11	9.09E-11
ENE	1500	Rn-222	4.78E-07	0.00E+00	0.00E+00	0.00E+00
ENE	1500	Po-218	2.29E-07	4.12E-14	1.13E-14	5.25E-14

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ENE	1500	Pb-214	1.76E-08	3.18E-15	8.73E-16	4.05E-15
ENE	1500	Bi-214	1.32E-09	2.38E-16	6.55E-17	3.04E-16
ENE	1500	Po-214	1.32E-09	2.38E-16	6.55E-17	3.04E-16
ENE	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	1500	At-218	4.54E-11	8.17E-18	2.25E-18	1.04E-17
ENE	1500	Sr-90	1.49E-04	2.67E-11	7.35E-12	3.41E-11
ENE	1500	Y-90	2.23E-07	4.02E-14	1.10E-14	5.12E-14
ENE	1500	Cs-137	2.97E-04	5.35E-11	1.47E-11	6.82E-11
ENE	1500	Ba-137m	2.52E-04	4.53E-11	1.25E-11	5.78E-11
ENE	2500	Ra-226	1.64E-04	2.94E-11	1.15E-11	4.10E-11
ENE	2500	Rn-222	2.04E-07	0.00E+00	0.00E+00	0.00E+00
ENE	2500	Po-218	9.45E-08	1.70E-14	6.66E-15	2.37E-14
ENE	2500	Pb-214	7.28E-09	1.31E-15	5.13E-16	1.82E-15
ENE	2500	Bi-214	5.46E-10	9.83E-17	3.85E-17	1.37E-16
ENE	2500	Po-214	5.46E-10	9.83E-17	3.85E-17	1.37E-16
ENE	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	2500	At-218	1.87E-11	3.37E-18	1.32E-18	4.69E-18
ENE	2500	Sr-90	6.13E-05	1.10E-11	4.32E-12	1.54E-11
ENE	2500	Y-90	9.21E-08	1.66E-14	6.49E-15	2.31E-14
ENE	2500	Cs-137	1.23E-04	2.21E-11	8.64E-12	3.07E-11
ENE	2500	Ba-137m	1.04E-04	1.87E-11	7.33E-12	2.60E-11
ENE	3500	Ra-226	9.36E-05	1.68E-11	8.08E-12	2.49E-11
ENE	3500	Rn-222	1.21E-07	0.00E+00	0.00E+00	0.00E+00
ENE	3500	Po-218	5.41E-08	9.73E-15	4.67E-15	1.44E-14
ENE	3500	Pb-214	4.17E-09	7.50E-16	3.60E-16	1.11E-15
ENE	3500	Bi-214	3.12E-10	5.62E-17	2.70E-17	8.32E-17
ENE	3500	Po-214	3.12E-10	5.62E-17	2.70E-17	8.32E-17
ENE	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	3500	At-218	1.07E-11	1.93E-18	9.26E-19	2.86E-18
ENE	3500	Sr-90	3.51E-05	6.32E-12	3.03E-12	9.35E-12
ENE	3500	Y-90	5.27E-08	9.49E-15	4.55E-15	1.40E-14
ENE	3500	Cs-137	7.02E-05	1.26E-11	6.06E-12	1.87E-11
ENE	3500	Ba-137m	5.95E-05	1.07E-11	5.14E-12	1.58E-11
ENE	4500	Ra-226	6.28E-05	1.13E-11	6.18E-12	1.75E-11
ENE	4500	Rn-222	8.40E-08	0.00E+00	0.00E+00	0.00E+00
ENE	4500	Po-218	3.63E-08	6.53E-15	3.57E-15	1.01E-14
ENE	4500	Pb-214	2.80E-09	5.04E-16	2.75E-16	7.79E-16
ENE	4500	Bi-214	2.10E-10	3.78E-17	2.06E-17	5.84E-17
ENE	4500	Po-214	2.10E-10	3.77E-17	2.06E-17	5.84E-17
ENE	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ENE	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ENE	4500	At-218	7.20E-12	1.30E-18	7.08E-19	2.00E-18
ENE	4500	Sr-90	2.36E-05	4.24E-12	2.32E-12	6.56E-12
ENE	4500	Y-90	3.54E-08	6.37E-15	3.48E-15	9.85E-15
ENE	4500	Cs-137	4.71E-05	8.48E-12	4.64E-12	1.31E-11
ENE	4500	Ba-137m	3.99E-05	7.19E-12	3.93E-12	1.11E-11
ENE	7500	Ra-226	2.75E-05	4.95E-12	3.56E-12	8.52E-12
ENE	7500	Rn-222	4.01E-08	0.00E+00	0.00E+00	0.00E+00
ENE	7500	Po-218	1.59E-08	2.86E-15	2.06E-15	4.93E-15
ENE	7500	Pb-214	1.23E-09	2.21E-16	1.59E-16	3.79E-16
ENE	7500	Bi-214	9.19E-11	1.65E-17	1.19E-17	2.84E-17
ENE	7500	Po-214	9.19E-11	1.65E-17	1.19E-17	2.84E-17
ENE	7500	Pb-210	0.00E+00	0.00E+00	5.09E-24	5.09E-24
ENE	7500	Bi-210	0.00E+00	0.00E+00	1.48E-25	1.48E-25
ENE	7500	Po-210	0.00E+00	0.00E+00	4.28E-27	4.28E-27
ENE	7500	At-218	3.15E-12	5.68E-19	4.07E-19	9.75E-19
ENE	7500	Sr-90	1.03E-05	1.86E-12	1.33E-12	3.19E-12
ENE	7500	Y-90	1.55E-08	2.79E-15	2.00E-15	4.79E-15
ENE	7500	Cs-137	2.06E-05	3.72E-12	2.67E-12	6.38E-12
ENE	7500	Ba-137m	1.75E-05	3.15E-12	2.26E-12	5.41E-12
ENE	15000	Ra-226	9.47E-06	1.71E-12	1.66E-12	3.37E-12
ENE	15000	Rn-222	1.59E-08	0.00E+00	0.00E+00	0.00E+00
ENE	15000	Po-218	5.48E-09	9.86E-16	9.60E-16	1.95E-15
ENE	15000	Pb-214	4.22E-10	7.60E-17	7.40E-17	1.50E-16
ENE	15000	Bi-214	3.16E-11	5.70E-18	5.54E-18	1.12E-17
ENE	15000	Po-214	3.16E-11	5.69E-18	5.54E-18	1.12E-17
ENE	15000	Pb-210	0.00E+00	0.00E+00	8.06E-26	8.06E-26
ENE	15000	Bi-210	0.00E+00	0.00E+00	1.36E-27	1.36E-27
ENE	15000	Po-210	0.00E+00	0.00E+00	2.30E-29	2.30E-29
ENE	15000	At-218	1.09E-12	1.95E-19	1.90E-19	3.86E-19
ENE	15000	Sr-90	3.55E-06	6.39E-13	6.23E-13	1.26E-12
ENE	15000	Y-90	5.34E-09	9.61E-16	9.35E-16	1.90E-15
ENE	15000	Cs-137	7.11E-06	1.28E-12	1.25E-12	2.52E-12
ENE	15000	Ba-137m	6.02E-06	1.08E-12	1.06E-12	2.14E-12
ENE	25000	Ra-226	3.87E-06	6.96E-13	8.99E-13	1.60E-12
ENE	25000	Rn-222	8.42E-09	0.00E+00	0.00E+00	0.00E+00
ENE	25000	Po-218	2.24E-09	4.02E-16	5.18E-16	9.21E-16
ENE	25000	Pb-214	1.72E-10	3.10E-17	3.99E-17	7.09E-17
ENE	25000	Bi-214	1.29E-11	2.33E-18	2.99E-18	5.32E-18
ENE	25000	Po-214	1.29E-11	2.33E-18	2.99E-18	5.32E-18
ENE	25000	Pb-210	0.00E+00	0.00E+00	2.99E-27	2.99E-27
ENE	25000	Bi-210	0.00E+00	0.00E+00	2.94E-29	2.94E-29
ENE	25000	Po-210	0.00E+00	0.00E+00	2.90E-31	2.90E-31
ENE	25000	At-218	4.43E-13	7.98E-20	1.03E-19	1.82E-19
ENE	25000	Sr-90	1.45E-06	2.61E-13	3.36E-13	5.97E-13
ENE	25000	Y-90	2.18E-09	3.92E-16	5.05E-16	8.97E-16
ENE	25000	Cs-137	2.90E-06	5.22E-13	6.72E-13	1.19E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ENE	25000	Ba-137m	2.46E-06	4.43E-13	5.70E-13	1.01E-12
ENE	35000	Ra-226	2.31E-06	4.16E-13	6.08E-13	1.02E-12
ENE	35000	Rn-222	5.59E-09	0.00E+00	0.00E+00	0.00E+00
ENE	35000	Po-218	1.34E-09	2.40E-16	3.50E-16	5.91E-16
ENE	35000	Pb-214	1.03E-10	1.85E-17	2.70E-17	4.55E-17
ENE	35000	Bi-214	7.72E-12	1.39E-18	2.02E-18	3.41E-18
ENE	35000	Po-214	7.72E-12	1.39E-18	2.02E-18	3.41E-18
ENE	35000	Pb-210	0.00E+00	0.00E+00	8.67E-28	8.67E-28
ENE	35000	Bi-210	0.00E+00	0.00E+00	7.54E-30	7.54E-30
ENE	35000	Po-210	0.00E+00	0.00E+00	6.56E-32	6.56E-32
ENE	35000	At-218	2.65E-13	4.77E-20	6.94E-20	1.17E-19
ENE	35000	Sr-90	8.67E-07	1.56E-13	2.27E-13	3.83E-13
ENE	35000	Y-90	1.30E-09	2.34E-16	3.41E-16	5.76E-16
ENE	35000	Cs-137	1.73E-06	3.12E-13	4.54E-13	7.66E-13
ENE	35000	Ba-137m	1.47E-06	2.64E-13	3.85E-13	6.50E-13
ENE	45000	Ra-226	1.53E-06	2.75E-13	4.46E-13	7.21E-13
ENE	45000	Rn-222	4.13E-09	0.00E+00	0.00E+00	0.00E+00
ENE	45000	Po-218	8.83E-10	1.59E-16	2.57E-16	4.16E-16
ENE	45000	Pb-214	6.80E-11	1.22E-17	1.98E-17	3.21E-17
ENE	45000	Bi-214	5.10E-12	9.18E-19	1.49E-18	2.40E-18
ENE	45000	Po-214	5.10E-12	9.18E-19	1.49E-18	2.40E-18
ENE	45000	Pb-210	0.00E+00	0.00E+00	3.40E-28	3.40E-28
ENE	45000	Bi-210	0.00E+00	0.00E+00	2.70E-30	2.70E-30
ENE	45000	Po-210	0.00E+00	0.00E+00	2.14E-32	2.14E-32
ENE	45000	At-218	1.75E-13	3.15E-20	5.10E-20	8.25E-20
ENE	45000	Sr-90	5.73E-07	1.03E-13	1.67E-13	2.70E-13
ENE	45000	Y-90	8.60E-10	1.55E-16	2.51E-16	4.05E-16
ENE	45000	Cs-137	1.15E-06	2.06E-13	3.34E-13	5.40E-13
ENE	45000	Ba-137m	9.71E-07	1.75E-13	2.83E-13	4.58E-13
ENE	55000	Ra-226	1.04E-06	1.88E-13	3.42E-13	5.29E-13
ENE	55000	Rn-222	3.24E-09	0.00E+00	0.00E+00	0.00E+00
ENE	55000	Po-218	6.03E-10	1.09E-16	1.97E-16	3.05E-16
ENE	55000	Pb-214	4.65E-11	8.37E-18	1.52E-17	2.35E-17
ENE	55000	Bi-214	3.49E-12	6.27E-19	1.14E-18	1.76E-18
ENE	55000	Po-214	3.48E-12	6.27E-19	1.14E-18	1.76E-18
ENE	55000	Pb-210	0.00E+00	0.00E+00	1.60E-28	1.60E-28
ENE	55000	Bi-210	0.00E+00	0.00E+00	1.18E-30	1.18E-30
ENE	55000	Po-210	0.00E+00	0.00E+00	8.69E-33	8.69E-33
ENE	55000	At-218	1.20E-13	2.15E-20	3.90E-20	6.06E-20
ENE	55000	Sr-90	3.91E-07	7.04E-14	1.28E-13	1.98E-13
ENE	55000	Y-90	5.88E-10	1.06E-16	1.92E-16	2.98E-16
ENE	55000	Cs-137	7.83E-07	1.41E-13	2.55E-13	3.96E-13
ENE	55000	Ba-137m	6.64E-07	1.19E-13	2.17E-13	3.36E-13
ENE	70000	Ra-226	5.90E-07	1.06E-13	2.42E-13	3.48E-13
ENE	70000	Rn-222	2.43E-09	0.00E+00	0.00E+00	0.00E+00
ENE	70000	Po-218	3.41E-10	6.14E-17	1.39E-16	2.01E-16
ENE	70000	Pb-214	2.63E-11	4.73E-18	1.07E-17	1.55E-17

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
ENE	70000	Bi-214	1.97E-12	3.55E-19	8.05E-19	1.16E-18
ENE	70000	Po-214	1.97E-12	3.55E-19	8.05E-19	1.16E-18
ENE	70000	Pb-210	0.00E+00	0.00E+00	6.39E-29	6.39E-29
ENE	70000	Bi-210	0.00E+00	0.00E+00	4.31E-31	4.31E-31
ENE	70000	Po-210	0.00E+00	0.00E+00	2.91E-33	2.91E-33
ENE	70000	At-218	6.76E-14	1.22E-20	2.76E-20	3.98E-20
ENE	70000	Sr-90	2.21E-07	3.98E-14	9.04E-14	1.30E-13
ENE	70000	Y-90	3.32E-10	5.98E-17	1.36E-16	1.96E-16
ENE	70000	Cs-137	4.43E-07	7.97E-14	1.81E-13	2.60E-13
ENE	70000	Ba-137m	3.75E-07	6.75E-14	1.53E-13	2.21E-13
NE	250	Ra-226	1.64E-02	2.95E-09	2.02E-10	3.15E-09
NE	250	Rn-222	1.78E-05	0.00E+00	0.00E+00	0.00E+00
NE	250	Po-218	9.47E-06	1.71E-12	1.17E-13	1.82E-12
NE	250	Pb-214	7.30E-07	1.31E-13	9.01E-15	1.40E-13
NE	250	Bi-214	5.47E-08	9.85E-15	6.75E-16	1.05E-14
NE	250	Po-214	5.47E-08	9.85E-15	6.75E-16	1.05E-14
NE	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	250	At-218	1.88E-09	3.38E-16	2.32E-17	3.61E-16
NE	250	Sr-90	6.15E-03	1.11E-09	7.58E-11	1.18E-09
NE	250	Y-90	9.23E-06	1.66E-12	1.14E-13	1.78E-12
NE	250	Cs-137	1.23E-02	2.21E-09	1.52E-10	2.36E-09
NE	250	Ba-137m	1.04E-02	1.88E-09	1.29E-10	2.00E-09
NE	750	Ra-226	2.17E-03	3.91E-10	6.59E-11	4.57E-10
NE	750	Rn-222	2.45E-06	0.00E+00	0.00E+00	0.00E+00
NE	750	Po-218	1.26E-06	2.26E-13	3.81E-14	2.64E-13
NE	750	Pb-214	9.68E-08	1.74E-14	2.93E-15	2.04E-14
NE	750	Bi-214	7.26E-09	1.31E-15	2.20E-16	1.53E-15
NE	750	Po-214	7.26E-09	1.31E-15	2.20E-16	1.53E-15
NE	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	750	At-218	2.49E-10	4.48E-17	7.55E-18	5.24E-17
NE	750	Sr-90	8.15E-04	1.47E-10	2.47E-11	1.71E-10
NE	750	Y-90	1.22E-06	2.20E-13	3.71E-14	2.58E-13
NE	750	Cs-137	1.63E-03	2.93E-10	4.94E-11	3.43E-10
NE	750	Ba-137m	1.38E-03	2.49E-10	4.19E-11	2.91E-10
NE	1500	Ra-226	6.32E-04	1.14E-10	3.23E-11	1.46E-10
NE	1500	Rn-222	7.37E-07	0.00E+00	0.00E+00	0.00E+00
NE	1500	Po-218	3.66E-07	6.58E-14	1.87E-14	8.45E-14
NE	1500	Pb-214	2.82E-08	5.07E-15	1.44E-15	6.51E-15
NE	1500	Bi-214	2.11E-09	3.80E-16	1.08E-16	4.88E-16
NE	1500	Po-214	2.11E-09	3.80E-16	1.08E-16	4.88E-16
NE	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NE	1500	At-218	7.25E-11	1.30E-17	3.70E-18	1.67E-17
NE	1500	Sr-90	2.37E-04	4.27E-11	1.21E-11	5.48E-11
NE	1500	Y-90	3.56E-07	6.41E-14	1.82E-14	8.23E-14
NE	1500	Cs-137	4.74E-04	8.54E-11	2.42E-11	1.10E-10
NE	1500	Ba-137m	4.02E-04	7.24E-11	2.06E-11	9.29E-11
NE	2500	Ra-226	2.63E-04	4.74E-11	1.91E-11	6.65E-11
NE	2500	Rn-222	3.15E-07	0.00E+00	0.00E+00	0.00E+00
NE	2500	Po-218	1.52E-07	2.74E-14	1.10E-14	3.84E-14
NE	2500	Pb-214	1.17E-08	2.11E-15	8.51E-16	2.96E-15
NE	2500	Bi-214	8.79E-10	1.58E-16	6.38E-17	2.22E-16
NE	2500	Po-214	8.79E-10	1.58E-16	6.38E-17	2.22E-16
NE	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	2500	At-218	3.02E-11	5.43E-18	2.19E-18	7.62E-18
NE	2500	Sr-90	9.87E-05	1.78E-11	7.16E-12	2.49E-11
NE	2500	Y-90	1.48E-07	2.67E-14	1.08E-14	3.75E-14
NE	2500	Cs-137	1.97E-04	3.55E-11	1.43E-11	4.99E-11
NE	2500	Ba-137m	1.67E-04	3.01E-11	1.21E-11	4.23E-11
NE	3500	Ra-226	1.52E-04	2.73E-11	1.35E-11	4.07E-11
NE	3500	Rn-222	1.86E-07	0.00E+00	0.00E+00	0.00E+00
NE	3500	Po-218	8.76E-08	1.58E-14	7.78E-15	2.35E-14
NE	3500	Pb-214	6.75E-09	1.22E-15	5.99E-16	1.81E-15
NE	3500	Bi-214	5.06E-10	9.11E-17	4.49E-17	1.36E-16
NE	3500	Po-214	5.06E-10	9.11E-17	4.49E-17	1.36E-16
NE	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	3500	At-218	1.74E-11	3.13E-18	1.54E-18	4.67E-18
NE	3500	Sr-90	5.68E-05	1.02E-11	5.05E-12	1.53E-11
NE	3500	Y-90	8.54E-08	1.54E-14	7.58E-15	2.29E-14
NE	3500	Cs-137	1.14E-04	2.05E-11	1.01E-11	3.06E-11
NE	3500	Ba-137m	9.64E-05	1.73E-11	8.56E-12	2.59E-11
NE	4500	Ra-226	1.02E-04	1.84E-11	1.03E-11	2.87E-11
NE	4500	Rn-222	1.29E-07	0.00E+00	0.00E+00	0.00E+00
NE	4500	Po-218	5.91E-08	1.06E-14	5.97E-15	1.66E-14
NE	4500	Pb-214	4.56E-09	8.20E-16	4.60E-16	1.28E-15
NE	4500	Bi-214	3.42E-10	6.15E-17	3.45E-17	9.60E-17
NE	4500	Po-214	3.41E-10	6.15E-17	3.45E-17	9.60E-17
NE	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NE	4500	At-218	1.17E-11	2.11E-18	1.18E-18	3.29E-18
NE	4500	Sr-90	3.84E-05	6.90E-12	3.87E-12	1.08E-11
NE	4500	Y-90	5.76E-08	1.04E-14	5.82E-15	1.62E-14
NE	4500	Cs-137	7.67E-05	1.38E-11	7.75E-12	2.16E-11
NE	4500	Ba-137m	6.50E-05	1.17E-11	6.57E-12	1.83E-11

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NE	7500	Ra-226	4.55E-05	8.19E-12	6.03E-12	1.42E-11
NE	7500	Rn-222	6.10E-08	0.00E+00	0.00E+00	0.00E+00
NE	7500	Po-218	2.63E-08	4.73E-15	3.55E-15	8.28E-15
NE	7500	Pb-214	2.03E-09	3.65E-16	2.73E-16	6.37E-16
NE	7500	Bi-214	1.52E-10	2.73E-17	2.04E-17	4.77E-17
NE	7500	Po-214	1.52E-10	2.73E-17	2.01E-17	4.74E-17
NE	7500	Pb-210	0.00E+00	0.00E+00	1.25E-21	1.25E-21
NE	7500	Bi-210	0.00E+00	0.00E+00	7.81E-23	7.81E-23
NE	7500	Po-210	0.00E+00	0.00E+00	4.87E-24	4.87E-24
NE	7500	At-218	5.21E-12	9.38E-19	6.88E-19	1.63E-18
NE	7500	Sr-90	1.71E-05	3.07E-12	2.25E-12	5.32E-12
NE	7500	Y-90	2.56E-08	4.61E-15	3.38E-15	8.00E-15
NE	7500	Cs-137	3.41E-05	6.14E-12	4.50E-12	1.06E-11
NE	7500	Ba-137m	2.89E-05	5.21E-12	3.82E-12	9.02E-12
NE	15000	Ra-226	1.58E-05	2.84E-12	2.86E-12	5.69E-12
NE	15000	Rn-222	2.36E-08	0.00E+00	0.00E+00	0.00E+00
NE	15000	Po-218	9.10E-09	1.64E-15	1.66E-15	3.30E-15
NE	15000	Pb-214	7.02E-10	1.26E-16	1.27E-16	2.54E-16
NE	15000	Bi-214	5.26E-11	9.47E-18	9.53E-18	1.90E-17
NE	15000	Po-214	5.26E-11	9.47E-18	9.51E-18	1.90E-17
NE	15000	Pb-210	0.00E+00	0.00E+00	2.36E-23	2.36E-23
NE	15000	Bi-210	0.00E+00	0.00E+00	8.57E-25	8.57E-25
NE	15000	Po-210	0.00E+00	0.00E+00	3.11E-26	3.11E-26
NE	15000	At-218	1.80E-12	3.25E-19	3.26E-19	6.51E-19
NE	15000	Sr-90	5.91E-06	1.06E-12	1.07E-12	2.13E-12
NE	15000	Y-90	8.87E-09	1.60E-15	1.60E-15	3.20E-15
NE	15000	Cs-137	1.18E-05	2.13E-12	2.14E-12	4.26E-12
NE	15000	Ba-137m	1.00E-05	1.80E-12	1.81E-12	3.61E-12
NE	25000	Ra-226	6.66E-06	1.20E-12	1.60E-12	2.79E-12
NE	25000	Rn-222	1.22E-08	0.00E+00	0.00E+00	0.00E+00
NE	25000	Po-218	3.85E-09	6.93E-16	9.19E-16	1.61E-15
NE	25000	Pb-214	2.97E-10	5.34E-17	7.04E-17	1.24E-16
NE	25000	Bi-214	2.23E-11	4.01E-18	5.27E-18	9.27E-18
NE	25000	Po-214	2.22E-11	4.00E-18	5.26E-18	9.27E-18
NE	25000	Pb-210	0.00E+00	0.00E+00	1.71E-24	1.71E-24
NE	25000	Bi-210	0.00E+00	0.00E+00	3.62E-26	3.62E-26
NE	25000	Po-210	0.00E+00	0.00E+00	7.65E-28	7.65E-28
NE	25000	At-218	7.63E-13	1.37E-19	1.81E-19	3.18E-19
NE	25000	Sr-90	2.50E-06	4.50E-13	5.91E-13	1.04E-12
NE	25000	Y-90	3.75E-09	6.76E-16	8.88E-16	1.56E-15
NE	25000	Cs-137	5.00E-06	9.00E-13	1.18E-12	2.08E-12
NE	25000	Ba-137m	4.24E-06	7.63E-13	1.00E-12	1.76E-12
NE	35000	Ra-226	3.99E-06	7.18E-13	1.09E-12	1.81E-12
NE	35000	Rn-222	8.00E-09	0.00E+00	0.00E+00	0.00E+00
NE	35000	Po-218	2.30E-09	4.15E-16	6.27E-16	1.04E-15
NE	35000	Pb-214	1.78E-10	3.20E-17	4.81E-17	8.01E-17
NE	35000	Bi-214	1.33E-11	2.40E-18	3.60E-18	6.00E-18

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NE	35000	Po-214	1.33E-11	2.40E-18	3.60E-18	6.00E-18
NE	35000	Pb-210	0.00E+00	0.00E+00	4.96E-25	4.96E-25
NE	35000	Bi-210	0.00E+00	0.00E+00	9.28E-27	9.28E-27
NE	35000	Po-210	0.00E+00	0.00E+00	1.74E-28	1.74E-28
NE	35000	At-218	4.57E-13	8.22E-20	1.24E-19	2.06E-19
NE	35000	Sr-90	1.50E-06	2.69E-13	4.04E-13	6.74E-13
NE	35000	Y-90	2.25E-09	4.04E-16	6.07E-16	1.01E-15
NE	35000	Cs-137	2.99E-06	5.38E-13	8.09E-13	1.35E-12
NE	35000	Ba-137m	2.54E-06	4.56E-13	6.86E-13	1.14E-12
NE	45000	Ra-226	2.66E-06	4.78E-13	8.09E-13	1.29E-12
NE	45000	Rn-222	5.84E-09	0.00E+00	0.00E+00	0.00E+00
NE	45000	Po-218	1.54E-09	2.76E-16	4.66E-16	7.42E-16
NE	45000	Pb-214	1.18E-10	2.13E-17	3.57E-17	5.70E-17
NE	45000	Bi-214	8.87E-12	1.60E-18	2.68E-18	4.27E-18
NE	45000	Po-214	8.87E-12	1.60E-18	2.68E-18	4.27E-18
NE	45000	Pb-210	0.00E+00	0.00E+00	1.95E-25	1.95E-25
NE	45000	Bi-210	0.00E+00	0.00E+00	3.33E-27	3.33E-27
NE	45000	Po-210	0.00E+00	0.00E+00	5.68E-29	5.68E-29
NE	45000	At-218	3.04E-13	5.48E-20	9.18E-20	1.47E-19
NE	45000	Sr-90	9.96E-07	1.79E-13	3.01E-13	4.80E-13
NE	45000	Y-90	1.50E-09	2.69E-16	4.52E-16	7.21E-16
NE	45000	Cs-137	1.99E-06	3.59E-13	6.01E-13	9.60E-13
NE	45000	Ba-137m	1.69E-06	3.04E-13	5.10E-13	8.14E-13
NE	55000	Ra-226	1.85E-06	3.33E-13	6.28E-13	9.61E-13
NE	55000	Rn-222	4.56E-09	0.00E+00	0.00E+00	0.00E+00
NE	55000	Po-218	1.07E-09	1.92E-16	3.61E-16	5.54E-16
NE	55000	Pb-214	8.24E-11	1.48E-17	2.78E-17	4.26E-17
NE	55000	Bi-214	6.18E-12	1.11E-18	2.08E-18	3.19E-18
NE	55000	Po-214	6.18E-12	1.11E-18	2.08E-18	3.19E-18
NE	55000	Pb-210	0.00E+00	0.00E+00	9.19E-26	9.19E-26
NE	55000	Bi-210	0.00E+00	0.00E+00	1.46E-27	1.46E-27
NE	55000	Po-210	0.00E+00	0.00E+00	2.31E-29	2.31E-29
NE	55000	At-218	2.12E-13	3.81E-20	7.13E-20	1.09E-19
NE	55000	Sr-90	6.94E-07	1.25E-13	2.33E-13	3.58E-13
NE	55000	Y-90	1.04E-09	1.88E-16	3.51E-16	5.38E-16
NE	55000	Cs-137	1.39E-06	2.50E-13	4.67E-13	7.17E-13
NE	55000	Ba-137m	1.18E-06	2.12E-13	3.96E-13	6.08E-13
NE	70000	Ra-226	1.10E-06	1.98E-13	4.55E-13	6.53E-13
NE	70000	Rn-222	3.38E-09	0.00E+00	0.00E+00	0.00E+00
NE	70000	Po-218	6.36E-10	1.15E-16	2.61E-16	3.76E-16
NE	70000	Pb-214	4.90E-11	8.83E-18	2.01E-17	2.89E-17
NE	70000	Bi-214	3.68E-12	6.62E-19	1.51E-18	2.17E-18
NE	70000	Po-214	3.68E-12	6.62E-19	1.51E-18	2.17E-18
NE	70000	Pb-210	0.00E+00	0.00E+00	3.68E-26	3.68E-26
NE	70000	Bi-210	0.00E+00	0.00E+00	5.34E-28	5.34E-28
NE	70000	Po-210	0.00E+00	0.00E+00	7.75E-30	7.75E-30
NE	70000	At-218	1.26E-13	2.27E-20	5.17E-20	7.44E-20

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NE	70000	Sr-90	4.13E-07	7.43E-14	1.69E-13	2.43E-13
NE	70000	Y-90	6.20E-10	1.12E-16	2.54E-16	3.66E-16
NE	70000	Cs-137	8.26E-07	1.49E-13	3.38E-13	4.87E-13
NE	70000	Ba-137m	7.00E-07	1.26E-13	2.87E-13	4.13E-13
NNE	250	Ra-226	2.39E-02	4.29E-09	2.96E-10	4.59E-09
NNE	250	Rn-222	2.58E-05	0.00E+00	0.00E+00	0.00E+00
NNE	250	Po-218	1.38E-05	2.48E-12	1.71E-13	2.65E-12
NNE	250	Pb-214	1.06E-06	1.91E-13	1.32E-14	2.04E-13
NNE	250	Bi-214	7.97E-08	1.43E-14	9.90E-16	1.53E-14
NNE	250	Po-214	7.97E-08	1.43E-14	9.90E-16	1.53E-14
NNE	250	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	250	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	250	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	250	At-218	2.73E-09	4.92E-16	3.40E-17	5.26E-16
NNE	250	Sr-90	8.95E-03	1.61E-09	1.11E-10	1.72E-09
NNE	250	Y-90	1.34E-05	2.42E-12	1.67E-13	2.59E-12
NNE	250	Cs-137	1.79E-02	3.22E-09	2.22E-10	3.44E-09
NNE	250	Ba-137m	1.52E-02	2.73E-09	1.88E-10	2.92E-09
NNE	750	Ra-226	3.19E-03	5.74E-10	9.68E-11	6.71E-10
NNE	750	Rn-222	3.56E-06	0.00E+00	0.00E+00	0.00E+00
NNE	750	Po-218	1.84E-06	3.32E-13	5.59E-14	3.88E-13
NNE	750	Pb-214	1.42E-07	2.56E-14	4.31E-15	2.99E-14
NNE	750	Bi-214	1.06E-08	1.92E-15	3.23E-16	2.24E-15
NNE	750	Po-214	1.06E-08	1.92E-15	3.23E-16	2.24E-15
NNE	750	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	750	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	750	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	750	At-218	3.65E-10	6.58E-17	1.11E-17	7.69E-17
NNE	750	Sr-90	1.20E-03	2.15E-10	3.63E-11	2.52E-10
NNE	750	Y-90	1.80E-06	3.23E-13	5.45E-14	3.78E-13
NNE	750	Cs-137	2.39E-03	4.30E-10	7.26E-11	5.03E-10
NNE	750	Ba-137m	2.03E-03	3.65E-10	6.15E-11	4.26E-10
NNE	1500	Ra-226	9.34E-04	1.68E-10	4.76E-11	2.16E-10
NNE	1500	Rn-222	1.07E-06	0.00E+00	0.00E+00	0.00E+00
NNE	1500	Po-218	5.40E-07	9.72E-14	2.75E-14	1.25E-13
NNE	1500	Pb-214	4.16E-08	7.49E-15	2.12E-15	9.61E-15
NNE	1500	Bi-214	3.12E-09	5.61E-16	1.59E-16	7.20E-16
NNE	1500	Po-214	3.12E-09	5.61E-16	1.59E-16	7.20E-16
NNE	1500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	1500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	1500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	1500	At-218	1.07E-10	1.93E-17	5.45E-18	2.47E-17
NNE	1500	Sr-90	3.50E-04	6.30E-11	1.78E-11	8.09E-11
NNE	1500	Y-90	5.26E-07	9.47E-14	2.68E-14	1.22E-13
NNE	1500	Cs-137	7.00E-04	1.26E-10	3.57E-11	1.62E-10
NNE	1500	Ba-137m	5.94E-04	1.07E-10	3.03E-11	1.37E-10
NNE	2500	Ra-226	3.90E-04	7.03E-11	2.82E-11	9.84E-11

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NNE	2500	Rn-222	4.59E-07	0.00E+00	0.00E+00	0.00E+00
NNE	2500	Po-218	2.26E-07	4.06E-14	1.63E-14	5.69E-14
NNE	2500	Pb-214	1.74E-08	3.13E-15	1.25E-15	4.38E-15
NNE	2500	Bi-214	1.30E-09	2.35E-16	9.40E-17	3.29E-16
NNE	2500	Po-214	1.30E-09	2.35E-16	9.40E-17	3.29E-16
NNE	2500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	2500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	2500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	2500	At-218	4.47E-11	8.05E-18	3.23E-18	1.13E-17
NNE	2500	Sr-90	1.46E-04	2.64E-11	1.06E-11	3.69E-11
NNE	2500	Y-90	2.20E-07	3.96E-14	1.59E-14	5.55E-14
NNE	2500	Cs-137	2.93E-04	5.27E-11	2.11E-11	7.38E-11
NNE	2500	Ba-137m	2.48E-04	4.47E-11	1.79E-11	6.26E-11
NNE	3500	Ra-226	2.25E-04	4.06E-11	1.99E-11	6.05E-11
NNE	3500	Rn-222	2.71E-07	0.00E+00	0.00E+00	0.00E+00
NNE	3500	Po-218	1.30E-07	2.35E-14	1.15E-14	3.49E-14
NNE	3500	Pb-214	1.00E-08	1.81E-15	8.85E-16	2.69E-15
NNE	3500	Bi-214	7.53E-10	1.36E-16	6.63E-17	2.02E-16
NNE	3500	Po-214	7.53E-10	1.36E-16	6.63E-17	2.02E-16
NNE	3500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	3500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	3500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	3500	At-218	2.58E-11	4.65E-18	2.28E-18	6.93E-18
NNE	3500	Sr-90	8.46E-05	1.52E-11	7.45E-12	2.27E-11
NNE	3500	Y-90	1.27E-07	2.29E-14	1.12E-14	3.41E-14
NNE	3500	Cs-137	1.69E-04	3.04E-11	1.49E-11	4.53E-11
NNE	3500	Ba-137m	1.43E-04	2.58E-11	1.26E-11	3.84E-11
NNE	4500	Ra-226	1.53E-04	2.75E-11	1.53E-11	4.27E-11
NNE	4500	Rn-222	1.87E-07	0.00E+00	0.00E+00	0.00E+00
NNE	4500	Po-218	8.82E-08	1.59E-14	8.83E-15	2.47E-14
NNE	4500	Pb-214	6.80E-09	1.22E-15	6.80E-16	1.90E-15
NNE	4500	Bi-214	5.10E-10	9.17E-17	5.10E-17	1.43E-16
NNE	4500	Po-214	5.10E-10	9.17E-17	5.10E-17	1.43E-16
NNE	4500	Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	4500	Bi-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	4500	Po-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NNE	4500	At-218	1.75E-11	3.15E-18	1.75E-18	4.90E-18
NNE	4500	Sr-90	5.72E-05	1.03E-11	5.73E-12	1.60E-11
NNE	4500	Y-90	8.60E-08	1.55E-14	8.61E-15	2.41E-14
NNE	4500	Cs-137	1.14E-04	2.06E-11	1.15E-11	3.21E-11
NNE	4500	Ba-137m	9.70E-05	1.75E-11	9.71E-12	2.72E-11
NNE	7500	Ra-226	6.84E-05	1.23E-11	8.93E-12	2.12E-11
NNE	7500	Rn-222	8.86E-08	0.00E+00	0.00E+00	0.00E+00
NNE	7500	Po-218	3.95E-08	7.11E-15	5.43E-15	1.25E-14
NNE	7500	Pb-214	3.05E-09	5.48E-16	4.25E-16	9.73E-16
NNE	7500	Bi-214	2.28E-10	4.11E-17	3.26E-17	7.37E-17
NNE	7500	Po-214	2.28E-10	4.11E-17	3.00E-17	7.11E-17

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NNE	7500	Pb-210	0.00E+00	0.00E+00	3.00E-20	3.00E-20
NNE	7500	Bi-210	0.00E+00	0.00E+00	3.05E-21	3.05E-21
NNE	7500	Po-210	0.00E+00	0.00E+00	3.10E-22	3.10E-22
NNE	7500	At-218	7.83E-12	1.41E-18	1.02E-18	2.43E-18
NNE	7500	Sr-90	2.56E-05	4.61E-12	3.34E-12	7.95E-12
NNE	7500	Y-90	3.85E-08	6.93E-15	5.02E-15	1.19E-14
NNE	7500	Cs-137	5.13E-05	9.23E-12	6.68E-12	1.59E-11
NNE	7500	Ba-137m	4.35E-05	7.82E-12	5.66E-12	1.35E-11
NNE	15000	Ra-226	2.37E-05	4.27E-12	4.27E-12	8.53E-12
NNE	15000	Rn-222	3.39E-08	0.00E+00	0.00E+00	0.00E+00
NNE	15000	Po-218	1.37E-08	2.47E-15	2.53E-15	4.99E-15
NNE	15000	Pb-214	1.06E-09	1.90E-16	1.93E-16	3.84E-16
NNE	15000	Bi-214	7.92E-11	1.43E-17	1.44E-17	2.87E-17
NNE	15000	Po-214	7.92E-11	1.43E-17	1.42E-17	2.84E-17
NNE	15000	Pb-210	0.00E+00	0.00E+00	9.18E-22	9.18E-22
NNE	15000	Bi-210	0.00E+00	0.00E+00	5.43E-23	5.43E-23
NNE	15000	Po-210	0.00E+00	0.00E+00	3.21E-24	3.21E-24
NNE	15000	At-218	2.72E-12	4.89E-19	4.86E-19	9.75E-19
NNE	15000	Sr-90	8.89E-06	1.60E-12	1.59E-12	3.19E-12
NNE	15000	Y-90	1.34E-08	2.40E-15	2.39E-15	4.80E-15
NNE	15000	Cs-137	1.78E-05	3.20E-12	3.18E-12	6.38E-12
NNE	15000	Ba-137m	1.51E-05	2.71E-12	2.70E-12	5.41E-12
NNE	25000	Ra-226	1.02E-05	1.83E-12	2.42E-12	4.25E-12
NNE	25000	Rn-222	1.73E-08	0.00E+00	0.00E+00	0.00E+00
NNE	25000	Po-218	5.88E-09	1.06E-15	1.43E-15	2.49E-15
NNE	25000	Pb-214	4.53E-10	8.15E-17	1.08E-16	1.89E-16
NNE	25000	Bi-214	3.40E-11	6.11E-18	7.98E-18	1.41E-17
NNE	25000	Po-214	3.40E-11	6.11E-18	7.91E-18	1.40E-17
NNE	25000	Pb-210	0.00E+00	0.00E+00	9.06E-23	9.06E-23
NNE	25000	Bi-210	0.00E+00	0.00E+00	3.12E-24	3.12E-24
NNE	25000	Po-210	0.00E+00	0.00E+00	1.08E-25	1.08E-25
NNE	25000	At-218	1.17E-12	2.10E-19	2.71E-19	4.81E-19
NNE	25000	Sr-90	3.81E-06	6.87E-13	8.88E-13	1.57E-12
NNE	25000	Y-90	5.73E-09	1.03E-15	1.33E-15	2.36E-15
NNE	25000	Cs-137	7.63E-06	1.37E-12	1.78E-12	3.15E-12
NNE	25000	Ba-137m	6.47E-06	1.16E-12	1.51E-12	2.67E-12
NNE	35000	Ra-226	6.08E-06	1.09E-12	1.66E-12	2.75E-12
NNE	35000	Rn-222	1.13E-08	0.00E+00	0.00E+00	0.00E+00
NNE	35000	Po-218	3.52E-09	6.33E-16	9.70E-16	1.60E-15
NNE	35000	Pb-214	2.71E-10	4.88E-17	7.33E-17	1.22E-16
NNE	35000	Bi-214	2.03E-11	3.66E-18	5.46E-18	9.11E-18
NNE	35000	Po-214	2.03E-11	3.66E-18	5.43E-18	9.09E-18
NNE	35000	Pb-210	0.00E+00	0.00E+00	2.63E-23	2.63E-23
NNE	35000	Bi-210	0.00E+00	0.00E+00	8.02E-25	8.02E-25
NNE	35000	Po-210	0.00E+00	0.00E+00	2.44E-26	2.44E-26
NNE	35000	At-218	6.97E-13	1.25E-19	1.86E-19	3.12E-19
NNE	35000	Sr-90	2.28E-06	4.11E-13	6.10E-13	1.02E-12

ESTIMATED RADIONUCLIDE CONCENTRATIONS
AT VARIOUS LOCATIONS IN THE ENVIRONMENT
AT TIME T = 500. SECONDS

Wind Toward	Distance (meters)	Nuclide	Air Conc (pCi/m3)	Dry Depo Rate (pCi/cm2/s)	Wet Depo Rate (pCi/cm2/s)	Ground Depo Rate (pCi/cm2/s)
NNE	35000	Y-90	3.43E-09	6.17E-16	9.16E-16	1.53E-15
NNE	35000	Cs-137	4.56E-06	8.21E-13	1.22E-12	2.04E-12
NNE	35000	Ba-137m	3.87E-06	6.96E-13	1.03E-12	1.73E-12
NNE	45000	Ra-226	4.06E-06	7.31E-13	1.24E-12	1.97E-12
NNE	45000	Rn-222	8.17E-09	0.00E+00	0.00E+00	0.00E+00
NNE	45000	Po-218	2.35E-09	4.22E-16	7.18E-16	1.14E-15
NNE	45000	Pb-214	1.81E-10	3.26E-17	5.45E-17	8.71E-17
NNE	45000	Bi-214	1.36E-11	2.44E-18	4.06E-18	6.51E-18
NNE	45000	Po-214	1.36E-11	2.44E-18	4.05E-18	6.49E-18
NNE	45000	Pb-210	0.00E+00	0.00E+00	1.04E-23	1.04E-23
NNE	45000	Bi-210	0.00E+00	0.00E+00	2.88E-25	2.88E-25
NNE	45000	Po-210	0.00E+00	0.00E+00	8.01E-27	8.01E-27
NNE	45000	At-218	4.65E-13	8.38E-20	1.39E-19	2.23E-19
NNE	45000	Sr-90	1.52E-06	2.74E-13	4.55E-13	7.29E-13
NNE	45000	Y-90	2.29E-09	4.12E-16	6.83E-16	1.10E-15
NNE	45000	Cs-137	3.05E-06	5.48E-13	9.10E-13	1.46E-12
NNE	45000	Ba-137m	2.58E-06	4.65E-13	7.71E-13	1.24E-12
NNE	55000	Ra-226	2.84E-06	5.12E-13	9.63E-13	1.47E-12
NNE	55000	Rn-222	6.34E-09	0.00E+00	0.00E+00	0.00E+00
NNE	55000	Po-218	1.64E-09	2.96E-16	5.58E-16	8.54E-16
NNE	55000	Pb-214	1.27E-10	2.28E-17	4.24E-17	6.52E-17
NNE	55000	Bi-214	9.50E-12	1.71E-18	3.17E-18	4.88E-18
NNE	55000	Po-214	9.50E-12	1.71E-18	3.16E-18	4.87E-18
NNE	55000	Pb-210	0.00E+00	0.00E+00	4.89E-24	4.89E-24
NNE	55000	Bi-210	0.00E+00	0.00E+00	1.26E-25	1.26E-25
NNE	55000	Po-210	0.00E+00	0.00E+00	3.26E-27	3.26E-27
NNE	55000	At-218	3.26E-13	5.87E-20	1.08E-19	1.67E-19
NNE	55000	Sr-90	1.07E-06	1.92E-13	3.55E-13	5.47E-13
NNE	55000	Y-90	1.60E-09	2.88E-16	5.33E-16	8.21E-16
NNE	55000	Cs-137	2.13E-06	3.84E-13	7.10E-13	1.09E-12
NNE	55000	Ba-137m	1.81E-06	3.26E-13	6.02E-13	9.27E-13
NNE	70000	Ra-226	1.73E-06	3.11E-13	7.01E-13	1.01E-12
NNE	70000	Rn-222	4.68E-09	0.00E+00	0.00E+00	0.00E+00
NNE	70000	Po-218	9.98E-10	1.80E-16	4.05E-16	5.85E-16
NNE	70000	Pb-214	7.69E-11	1.38E-17	3.09E-17	4.47E-17
NNE	70000	Bi-214	5.76E-12	1.04E-18	2.31E-18	3.35E-18
NNE	70000	Po-214	5.76E-12	1.04E-18	2.30E-18	3.34E-18
NNE	70000	Pb-210	0.00E+00	0.00E+00	1.96E-24	1.96E-24
NNE	70000	Bi-210	0.00E+00	0.00E+00	4.64E-26	4.64E-26
NNE	70000	Po-210	0.00E+00	0.00E+00	1.10E-27	1.10E-27
NNE	70000	At-218	1.98E-13	3.56E-20	7.91E-20	1.15E-19
NNE	70000	Sr-90	6.47E-07	1.17E-13	2.59E-13	3.75E-13
NNE	70000	Y-90	9.72E-10	1.75E-16	3.89E-16	5.64E-16
NNE	70000	Cs-137	1.29E-06	2.33E-13	5.18E-13	7.51E-13
NNE	70000	Ba-137m	1.10E-06	1.98E-13	4.39E-13	6.36E-13

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Population Assessment
Mar 10, 2013 06:46 pm

Facility: Sand Point
Address:
City: Seattle
State: WA Zip:

Source Category:
Source Type: Area
Emission Year: 2010

Comments: Max values for all radionuclides for 2000 cubic yd
See above

Dataset Name: Sand Point
Dataset Date: 3/10/2013 6:43:00 PM
Wind File: C:\Program Files\CAP88-PC30\WindLib\24233.WND
Population File: C:\Program Files\CAP88-PC30\Poplib\Sand Point.pop

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)	Collective Population (person-rem/y)
INGESTION	1.08E-01	7.22E-04
INHALATION	3.01E-02	1.67E-04
AIR IMMERSION	1.00E-04	5.57E-07
GROUND SURFACE	1.64E-01	9.40E-04
INTERNAL	1.38E-01	8.89E-04
EXTERNAL	1.65E-01	9.41E-04
TOTAL	3.03E-01	1.83E-03

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclides	Selected Individual (mrem/y)	Collective Population (person-rem/y)
Ra-226	4.83E-04	2.76E-06
Rn-222	1.10E-10	6.25E-13
Po-218	6.61E-07	3.78E-09
Pb-214	1.84E-02	1.05E-04
Bi-214	1.10E-01	6.30E-04
Po-214	6.05E-06	3.46E-08
Pb-210	2.97E-03	1.83E-05
Bi-210	2.50E-05	1.44E-07
Po-210	2.42E-04	1.52E-06
At-218	5.58E-08	3.19E-10
Sr-90	7.88E-02	4.95E-04
Y-90	3.17E-03	1.81E-05
Cs-137	5.63E-02	3.75E-04
Ba-137m	3.22E-02	1.84E-04
TOTAL	3.03E-01	1.83E-03

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
Esophagu	2.06E-09	1.60E-10
Stomach	7.85E-09	6.09E-10
Colon	2.58E-08	2.03E-09
Liver	3.25E-09	2.53E-10
LUNG	3.76E-08	2.80E-09
Bone	1.73E-09	1.42E-10
Skin	1.17E-09	8.72E-11
Breast	9.36E-09	7.16E-10
Ovary	2.68E-09	2.08E-10
Bladder	5.02E-09	3.91E-10
Kidneys	1.20E-09	9.36E-11
Thyroid	6.19E-10	4.77E-11
Leukemia	4.12E-08	3.38E-09
Residual	2.88E-08	2.23E-09
Total	1.68E-07	1.31E-08

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
INGESTION	5.89E-08	5.09E-09
INHALATION	2.31E-08	1.66E-09
AIR IMMERSION	5.45E-11	3.92E-12
GROUND SURFACE	8.63E-08	6.39E-09
INTERNAL	8.20E-08	6.75E-09
EXTERNAL	8.63E-08	6.39E-09
TOTAL	1.68E-07	1.31E-08

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
Ra-226	2.63E-10	1.94E-11
Rn-222	5.99E-17	4.40E-18
Po-218	3.62E-13	2.68E-14
Pb-214	9.79E-09	7.25E-10
Bi-214	5.85E-08	4.33E-09
Po-214	3.32E-12	2.46E-13
Pb-210	9.86E-10	7.88E-11
Bi-210	6.41E-12	4.97E-13
Po-210	9.28E-11	7.55E-12
At-218	2.65E-14	1.96E-15
Sr-90	4.92E-08	3.98E-09
Y-90	3.83E-10	2.84E-11
Cs-137	3.17E-08	2.69E-09
Ba-137m	1.74E-08	1.29E-09
TOTAL	1.68E-07	1.31E-08

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	3.0E-01	4.4E-02	1.4E-02	6.7E-03	4.2E-03	3.1E-03	1.8E-03
NNW	6.5E-02	9.7E-03	3.4E-03	1.8E-03	1.3E-03	1.0E-03	7.4E-04
NW	7.7E-02	1.1E-02	3.9E-03	2.0E-03	1.4E-03	1.1E-03	7.8E-04
WNW	5.5E-02	8.3E-03	2.9E-03	1.6E-03	1.1E-03	9.3E-04	6.9E-04
W	3.5E-02	5.3E-03	2.0E-03	1.1E-03	8.8E-04	7.6E-04	6.1E-04
WSW	2.3E-02	3.6E-03	1.4E-03	9.1E-04	7.3E-04	6.5E-04	5.6E-04
SW	7.2E-02	1.1E-02	3.6E-03	1.9E-03	1.3E-03	1.1E-03	7.6E-04
SSW	1.2E-01	1.8E-02	5.9E-03	2.9E-03	2.0E-03	1.5E-03	9.8E-04
S	1.7E-01	2.5E-02	8.1E-03	3.9E-03	2.6E-03	1.9E-03	1.2E-03
SSE	6.8E-02	9.9E-03	3.4E-03	1.8E-03	1.3E-03	1.0E-03	7.3E-04
SE	5.2E-02	7.6E-03	2.7E-03	1.5E-03	1.1E-03	8.8E-04	6.7E-04
ESE	6.2E-02	9.1E-03	3.1E-03	1.7E-03	1.2E-03	9.7E-04	7.1E-04
E	7.7E-02	1.1E-02	3.7E-03	1.9E-03	1.3E-03	1.1E-03	7.6E-04
ENE	6.6E-02	9.7E-03	3.3E-03	1.8E-03	1.2E-03	1.0E-03	7.3E-04
NE	1.0E-01	1.5E-02	5.1E-03	2.6E-03	1.7E-03	1.4E-03	9.1E-04
NNE	0.0E+00	2.2E-02	7.3E-03	3.6E-03	2.4E-03	1.8E-03	1.1E-03

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	9.8E-04	7.2E-04	6.3E-04	5.8E-04	5.5E-04	5.2E-04
NNW	5.8E-04	5.2E-04	5.0E-04	4.9E-04	4.9E-04	4.8E-04
NW	5.9E-04	5.3E-04	5.1E-04	5.0E-04	4.9E-04	4.8E-04
WNW	5.6E-04	5.1E-04	5.0E-04	4.9E-04	4.8E-04	4.8E-04
W	5.2E-04	5.0E-04	4.9E-04	4.8E-04	4.8E-04	4.7E-04
WSW	5.1E-04	4.9E-04	4.8E-04	4.8E-04	4.8E-04	4.7E-04
SW	5.9E-04	5.2E-04	5.1E-04	4.9E-04	4.9E-04	4.8E-04
SSW	6.8E-04	5.7E-04	5.3E-04	5.2E-04	5.0E-04	4.9E-04
S	7.6E-04	6.1E-04	5.6E-04	5.4E-04	5.2E-04	5.0E-04
SSE	5.7E-04	5.2E-04	5.0E-04	4.9E-04	4.9E-04	4.8E-04
SE	5.5E-04	5.1E-04	4.9E-04	4.9E-04	4.8E-04	4.8E-04
ESE	5.6E-04	5.1E-04	5.0E-04	4.9E-04	4.8E-04	4.8E-04
E	5.8E-04	5.2E-04	5.0E-04	4.9E-04	4.9E-04	4.8E-04
ENE	5.7E-04	5.2E-04	5.0E-04	4.9E-04	4.9E-04	4.8E-04
NE	6.4E-04	5.5E-04	5.2E-04	5.1E-04	5.0E-04	4.9E-04
NNE	7.3E-04	6.0E-04	5.5E-04	5.3E-04	5.1E-04	5.0E-04

COLLECTIVE EFFECTIVE DOSE EQUIVALENT (person rem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	3.0E-04	4.4E-05	1.4E-05	6.7E-06	4.2E-06	3.4E-05	1.8E-06
NNW	6.5E-05	9.7E-06	3.4E-06	1.8E-06	1.3E-06	1.0E-06	7.4E-07
NW	7.7E-05	1.1E-05	3.9E-06	2.0E-06	1.4E-06	1.1E-06	7.8E-07
WNW	5.5E-05	8.3E-06	2.9E-06	1.6E-06	1.1E-06	9.3E-07	6.9E-07
W	3.5E-05	5.3E-06	2.0E-06	1.1E-06	8.8E-07	7.6E-07	6.1E-07
WSW	2.3E-05	3.6E-06	1.4E-06	9.1E-07	7.3E-07	6.5E-07	5.6E-07
SW	7.2E-05	1.1E-05	3.6E-06	1.9E-06	1.3E-06	1.1E-06	7.6E-07
SSW	1.2E-04	1.8E-05	5.9E-06	2.9E-06	2.0E-06	1.5E-06	9.8E-07
S	1.7E-04	2.5E-05	8.1E-06	3.9E-06	2.6E-06	1.9E-06	1.2E-06
SSE	6.8E-05	9.9E-06	3.4E-06	1.8E-06	1.3E-06	1.0E-06	7.3E-07
SE	5.2E-05	7.6E-06	2.7E-06	1.5E-06	1.1E-06	8.8E-07	6.7E-07
ESE	6.2E-05	9.1E-06	3.1E-06	1.7E-06	1.2E-06	9.7E-07	7.1E-07
E	7.7E-05	1.1E-05	3.7E-06	1.9E-06	1.3E-06	1.1E-06	7.6E-07
ENE	6.6E-05	9.7E-06	3.3E-06	1.8E-06	1.2E-06	1.0E-06	7.3E-07
NE	1.0E-04	1.5E-05	5.1E-06	2.6E-06	1.7E-06	1.4E-06	9.1E-07
NNE	0.0E+00	2.2E-05	7.3E-06	3.6E-06	2.4E-06	1.8E-06	1.1E-06

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	9.8E-07	7.2E-07	6.3E-07	5.8E-07	5.5E-07	5.2E-07
NNW	5.8E-07	5.2E-07	5.0E-07	4.9E-07	4.9E-07	4.8E-07
NW	5.9E-07	5.3E-07	5.1E-07	5.0E-07	4.9E-07	4.8E-07
WNW	5.6E-07	5.1E-07	5.0E-07	4.9E-07	4.8E-07	4.8E-07
W	5.2E-07	5.0E-07	4.9E-07	4.8E-07	4.8E-07	4.7E-07
WSW	5.1E-07	4.9E-07	4.8E-07	4.8E-07	4.8E-07	4.7E-07
SW	5.9E-07	5.2E-07	5.1E-07	4.9E-07	4.9E-07	4.8E-07
SSW	6.8E-07	5.7E-07	5.3E-07	5.7E-06	5.0E-07	4.9E-07
S	7.6E-07	6.1E-07	5.6E-07	5.4E-07	5.2E-07	5.0E-07
SSE	5.7E-07	5.2E-07	5.0E-07	4.9E-07	4.9E-07	4.8E-07
SE	5.5E-07	5.1E-07	4.9E-07	4.9E-07	4.8E-07	4.8E-07
ESE	5.6E-07	5.1E-07	5.0E-07	4.9E-07	4.8E-07	4.8E-07
E	5.8E-07	5.2E-07	5.0E-07	4.9E-07	4.9E-07	4.8E-07
ENE	5.7E-07	5.2E-07	5.0E-07	4.9E-07	4.9E-07	4.8E-07
NE	6.4E-07	5.5E-07	5.2E-07	5.1E-07	5.0E-07	4.9E-07
NNE	7.3E-07	6.0E-07	5.5E-07	5.3E-07	5.1E-07	5.0E-07

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	1.7E-07	2.4E-08	7.9E-09	3.7E-09	2.3E-09	1.7E-09	9.7E-10
NNW	3.6E-08	5.4E-09	1.9E-09	9.7E-10	6.9E-10	5.6E-10	4.0E-10
NW	4.3E-08	6.3E-09	2.1E-09	1.1E-09	7.6E-10	6.1E-10	4.3E-10
WNW	3.1E-08	4.6E-09	1.6E-09	8.5E-10	6.2E-10	5.1E-10	3.8E-10
W	1.9E-08	2.9E-09	1.1E-09	6.3E-10	4.8E-10	4.1E-10	3.3E-10
WSW	1.3E-08	2.0E-09	8.0E-10	4.9E-10	4.0E-10	3.6E-10	3.0E-10
SW	4.0E-08	5.9E-09	2.0E-09	1.0E-09	7.2E-10	5.8E-10	4.1E-10
SSW	6.9E-08	9.9E-09	3.3E-09	1.6E-09	1.1E-09	8.3E-10	5.4E-10
S	9.6E-08	1.4E-08	4.5E-09	2.2E-09	1.4E-09	1.1E-09	6.5E-10
SSE	3.8E-08	5.5E-09	1.9E-09	9.7E-10	6.9E-10	5.6E-10	4.0E-10
SE	2.9E-08	4.2E-09	1.5E-09	8.0E-10	5.8E-10	4.8E-10	3.6E-10
ESE	3.4E-08	5.0E-09	1.7E-09	9.1E-10	6.5E-10	5.3E-10	3.9E-10
E	4.3E-08	6.1E-09	2.1E-09	1.1E-09	7.3E-10	5.9E-10	4.1E-10
ENE	3.6E-08	5.4E-09	1.8E-09	9.6E-10	6.8E-10	5.5E-10	4.0E-10
NE	5.7E-08	8.3E-09	2.8E-09	1.4E-09	9.5E-10	7.5E-10	4.9E-10
NNE	0.0E+00	1.2E-08	4.0E-09	2.0E-09	1.3E-09	9.9E-10	6.1E-10

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	5.4E-10	3.9E-10	3.4E-10	3.1E-10	3.0E-10	2.8E-10
NNW	3.1E-10	2.8E-10	2.7E-10	2.7E-10	2.6E-10	2.6E-10
NW	3.2E-10	2.9E-10	2.7E-10	2.7E-10	2.6E-10	2.6E-10
WNW	3.0E-10	2.8E-10	2.7E-10	2.6E-10	2.6E-10	2.6E-10
W	2.8E-10	2.7E-10	2.6E-10	2.6E-10	2.6E-10	2.6E-10
WSW	2.7E-10	2.6E-10	2.6E-10	2.6E-10	2.6E-10	2.6E-10
SW	3.2E-10	2.8E-10	2.7E-10	2.7E-10	2.6E-10	2.6E-10
SSW	3.7E-10	3.1E-10	2.9E-10	2.8E-10	2.7E-10	2.7E-10
S	4.1E-10	3.3E-10	3.0E-10	2.9E-10	2.8E-10	2.7E-10
SSE	3.1E-10	2.8E-10	2.7E-10	2.7E-10	2.6E-10	2.6E-10
SE	3.0E-10	2.7E-10	2.7E-10	2.6E-10	2.6E-10	2.6E-10
ESE	3.1E-10	2.8E-10	2.7E-10	2.6E-10	2.6E-10	2.6E-10
E	3.2E-10	2.8E-10	2.7E-10	2.7E-10	2.6E-10	2.6E-10
ENE	3.1E-10	2.8E-10	2.7E-10	2.7E-10	2.6E-10	2.6E-10
NE	3.5E-10	3.0E-10	2.8E-10	2.8E-10	2.7E-10	2.6E-10
NNE	4.0E-10	3.2E-10	3.0E-10	2.9E-10	2.8E-10	2.7E-10

COLLECTIVE FATAL CANCER RATE (deaths/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	2.2E-09	3.2E-10	1.0E-10	4.8E-11	3.0E-11	2.4E-10	1.3E-11
NNW	4.7E-10	7.0E-11	2.4E-11	1.3E-11	8.9E-12	7.3E-12	5.2E-12
NW	5.6E-10	8.2E-11	2.8E-11	1.4E-11	9.9E-12	7.9E-12	5.5E-12
WNW	4.0E-10	5.9E-11	2.1E-11	1.1E-11	8.0E-12	6.6E-12	4.9E-12
W	2.5E-10	3.8E-11	1.4E-11	8.1E-12	6.2E-12	5.3E-12	4.3E-12
WSW	1.6E-10	2.6E-11	1.0E-11	6.4E-12	5.2E-12	4.6E-12	3.9E-12
SW	5.2E-10	7.6E-11	2.6E-11	1.3E-11	9.4E-12	7.6E-12	5.4E-12
SSW	8.9E-10	1.3E-10	4.2E-11	2.1E-11	1.4E-11	1.1E-11	6.9E-12
S	1.2E-09	1.8E-10	5.8E-11	2.8E-11	1.8E-11	1.4E-11	8.4E-12
SSE	4.9E-10	7.1E-11	2.4E-11	1.3E-11	8.9E-12	7.2E-12	5.2E-12
SE	3.7E-10	5.5E-11	1.9E-11	1.0E-11	7.5E-12	6.2E-12	4.7E-12
ESE	4.5E-10	6.5E-11	2.2E-11	1.2E-11	8.4E-12	6.9E-12	5.0E-12
E	5.5E-10	7.9E-11	2.7E-11	1.4E-11	9.5E-12	7.6E-12	5.4E-12
ENE	4.7E-10	6.9E-11	2.4E-11	1.2E-11	8.8E-12	7.2E-12	5.2E-12
NE	7.3E-10	1.1E-10	3.6E-11	1.8E-11	1.2E-11	9.7E-12	6.4E-12
NNE	0.0E+00	1.6E-10	5.2E-11	2.5E-11	1.7E-11	1.3E-11	7.9E-12

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	6.9E-12	5.0E-12	4.4E-12	4.1E-12	3.9E-12	3.7E-12
NNW	4.1E-12	3.7E-12	3.5E-12	3.5E-12	3.4E-12	3.4E-12
NW	4.2E-12	3.7E-12	3.6E-12	3.5E-12	3.4E-12	3.4E-12
WNW	3.9E-12	3.6E-12	3.5E-12	3.4E-12	3.4E-12	3.3E-12
W	3.7E-12	3.5E-12	3.4E-12	3.4E-12	3.3E-12	3.3E-12
WSW	3.5E-12	3.4E-12	3.4E-12	3.3E-12	3.3E-12	3.3E-12
SW	4.1E-12	3.7E-12	3.5E-12	3.5E-12	3.4E-12	3.4E-12
SSW	4.8E-12	4.0E-12	3.8E-12	4.0E-11	3.5E-12	3.4E-12
S	5.4E-12	4.3E-12	3.9E-12	3.8E-12	3.6E-12	3.5E-12
SSE	4.0E-12	3.6E-12	3.5E-12	3.4E-12	3.4E-12	3.4E-12
SE	3.8E-12	3.5E-12	3.5E-12	3.4E-12	3.4E-12	3.3E-12
ESE	4.0E-12	3.6E-12	3.5E-12	3.4E-12	3.4E-12	3.4E-12
E	4.1E-12	3.7E-12	3.5E-12	3.5E-12	3.4E-12	3.4E-12
ENE	4.0E-12	3.6E-12	3.5E-12	3.4E-12	3.4E-12	3.4E-12
NE	4.5E-12	3.9E-12	3.7E-12	3.6E-12	3.5E-12	3.4E-12
NNE	5.1E-12	4.2E-12	3.9E-12	3.7E-12	3.6E-12	3.5E-12

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

G E N E R A L D A T A

Non-Radon Population Assessment
Mar 10, 2013 06:46 pm

Facility: Sand Point
Address:
City: Seattle
State: WA Zip:

Source Category:
Source Type: Area
Emission Year: 2010

Comments: Max values for all radionuclides for 2000 cubic yd
See above

Dataset Name: Sand Point
Dataset Date: 3/10/2013 6:43:00 PM
Wind File: C:\Program Files\CAP88-PC30\WindLib\24233.WND
Population File: C:\Program Files\CAP88-PC30\Poplib\Sand Point.pop

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	Clearance Type	Particle Size (microns)	Scavenging Coefficient (per second)	Dry Deposition Velocity (m/s)
Ra-226	M	1	1.00E-05	1.80E-03
Rn-222	G	0	0.00E+00	0.00E+00
Po-218	M	1	1.00E-05	1.80E-03
Pb-214	M	1	1.00E-05	1.80E-03
Bi-214	M	1	1.00E-05	1.80E-03
Po-214	M	1	1.00E-05	1.80E-03
Pb-210	M	1	1.00E-05	1.80E-03
Bi-210	M	1	1.00E-05	1.80E-03
Po-210	M	1	1.00E-05	1.80E-03
At-218	M	1	1.00E-05	1.80E-03
Sr-90	M	1	1.00E-05	1.80E-03
Y-90	M	1	1.00E-05	1.80E-03
Cs-137	F	1	1.00E-05	1.80E-03
Ba-137m	M	1	1.00E-05	1.80E-03

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

	DECAY CONSTANT (PER DAY)			TRANSFER COEFFICIENT	
Nuclide	Radio-active (1)	Surface	Water	Milk (2)	Meat (3)
Ra-226	1.19E-06	5.48E-05	0.00E+00	1.00E-03	2.00E-03
Rn-222	1.81E-01	5.48E-05	0.00E+00	0.00E+00	0.00E+00
Po-218	3.27E+02	5.48E-05	0.00E+00	4.00E-04	5.00E-03
Pb-214	3.72E+01	5.48E-05	0.00E+00	3.00E-04	8.00E-04
Bi-214	5.02E+01	5.48E-05	0.00E+00	1.00E-03	2.00E-03
Po-214	3.64E+08	5.48E-05	0.00E+00	4.00E-04	5.00E-03
Pb-210	8.51E-05	5.48E-05	0.00E+00	3.00E-04	8.00E-04
Bi-210	1.38E-01	5.48E-05	0.00E+00	1.00E-03	2.00E-03
Po-210	5.01E-03	5.48E-05	0.00E+00	4.00E-04	5.00E-03
At-218	2.99E+04	5.48E-05	0.00E+00	1.00E-02	1.00E-02
Sr-90	6.52E-05	5.48E-05	0.00E+00	2.00E-03	1.00E-02
Y-90	2.60E-01	5.48E-05	0.00E+00	6.00E-05	2.00E-03
Cs-137	6.32E-05	5.48E-05	0.00E+00	1.00E-02	5.00E-02
Ba-137m	3.91E+02	5.48E-05	0.00E+00	5.00E-04	2.00E-04

FOOTNOTES:

(1) Fraction of animal's daily intake of nuclide which appears in each L of milk (days/L)

(2) Fraction of animal's daily intake of nuclide which appears in each kg of meat (days/kg)

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

	CONCENTRATION UPTAKE FACTOR		GI UPTAKE FRACTION	
Nuclide	Forage (1)	Edible (2)	Inhalation	Ingestion
Ra-226	2.00E-01	4.00E-02	2.00E-01	2.00E-01
Rn-222	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Po-218	1.00E-01	1.00E-03	1.00E-01	1.00E-01
Pb-214	1.00E-01	4.00E-03	2.00E-01	2.00E-01
Bi-214	5.00E-01	1.00E-01	5.00E-02	5.00E-02
Po-214	1.00E-01	1.00E-03	1.00E-01	1.00E-01
Pb-210	1.00E-01	4.00E-03	2.00E-01	2.00E-01
Bi-210	5.00E-01	1.00E-01	5.00E-02	5.00E-02
Po-210	1.00E-01	1.00E-03	1.00E-01	1.00E-01
At-218	9.00E-01	2.00E-01	1.00E+00	1.00E+00
Sr-90	4.00E+00	3.00E-01	3.00E-01	3.00E-01
Y-90	1.00E-01	2.00E-03	1.00E-04	1.00E-04
Cs-137	1.00E+00	2.00E-01	1.00E+00	1.00E+00
Ba-137m	1.00E-01	1.00E-02	2.00E-01	2.00E-01

FOOTNOTES: (1) Concentration factor for uptake of nuclide from soil for pasture and forage (in pCi/kg dry weight per pCi/kg dry soil)

(2) Concentration factor for uptake of nuclide from soil by edible parts of crops (in pCi/kg wet weight per pCi/kg dry soil)

DECAY CHAIN ACTIVITIES

Nuclide	Stack	Activity at 500. seconds	Activity at 100.00 years
Ra-226	1	2.4000E-02	1.1060E-02
Rn-222	1	2.5160E-05	1.0730E-02
Po-218	1	1.3870E-05	1.0730E-02
Pb-214	1	1.0690E-06	1.0730E-02
Bi-214	1	8.0150E-08	1.0730E-02
Po-214	1	8.0140E-08	1.0730E-02
Pb-210	1	0.0000E+00	9.5810E-05
Bi-210	1	0.0000E+00	8.9550E-05
Po-210	1	0.0000E+00	2.7030E-05
At-218	1	2.7500E-09	2.1460E-06
Sr-90	1	9.0000E-03	4.1200E-03
Y-90	1	1.3520E-05	4.0380E-03
Cs-137	1	1.8000E-02	8.2410E-03
Ba-137m	1	1.5260E-02	7.7960E-03

NUMBER OF BEEF CATTLE

	Distance (meters)						
Direction	250	750	1500	2500	3500	4500	7500
N	0	1	3	6	8	10	83
NNW	0	1	3	6	8	10	83
NW	0	1	3	6	8	10	83
WNW	0	1	3	6	8	10	83
W	0	1	3	6	8	10	83
WSW	0	1	3	6	8	10	83
SW	0	1	3	6	8	10	83
SSW	0	1	3	6	8	10	83
S	0	1	3	6	8	10	83
SSE	0	1	3	6	8	10	83
SE	0	1	3	6	8	10	83
ESE	0	1	3	6	8	10	83
E	0	1	3	6	8	10	83
ENE	0	1	3	6	8	10	83
NE	0	1	3	6	8	10	83
NNE	0	1	3	6	8	10	83

	Distance (meters)					
Direction	15000	25000	35000	45000	55000	70000
N	331	552	772	993	1214	3090
NNW	331	552	772	993	1214	3090
NW	331	552	772	993	1214	3090
WNW	331	552	772	993	1214	3090
W	331	552	772	993	1214	3090
WSW	331	552	772	993	1214	3090
SW	331	552	772	993	1214	3090
SSW	331	552	772	993	1214	3090
S	331	552	772	993	1214	3090
SSE	331	552	772	993	1214	3090
SE	331	552	772	993	1214	3090
ESE	331	552	772	993	1214	3090
E	331	552	772	993	1214	3090
ENE	331	552	772	993	1214	3090
NE	331	552	772	993	1214	3090
NNE	331	552	772	993	1214	3090

NUMBER OF MILK CATTLE

	Distance (meters)						
Direction	250	750	1500	2500	3500	4500	7500
N	0	0	1	1	2	3	22
NNW	0	0	1	1	2	3	22
NW	0	0	1	1	2	3	22
WNW	0	0	1	1	2	3	22
W	0	0	1	1	2	3	22
WSW	0	0	1	1	2	3	22
SW	0	0	1	1	2	3	22
SSW	0	0	1	1	2	3	22
S	0	0	1	1	2	3	22
SSE	0	0	1	1	2	3	22
SE	0	0	1	1	2	3	22
ESE	0	0	1	1	2	3	22
E	0	0	1	1	2	3	22
ENE	0	0	1	1	2	3	22
NE	0	0	1	1	2	3	22
NNE	0	0	1	1	2	3	22

	Distance (meters)					
Direction	15000	25000	35000	45000	55000	70000
N	88	147	206	265	324	825
NNW	88	147	206	265	324	825
NW	88	147	206	265	324	825
WNW	88	147	206	265	324	825
W	88	147	206	265	324	825
WSW	88	147	206	265	324	825
SW	88	147	206	265	324	825
SSW	88	147	206	265	324	825
S	88	147	206	265	324	825
SSE	88	147	206	265	324	825
SE	88	147	206	265	324	825
ESE	88	147	206	265	324	825
E	88	147	206	265	324	825
ENE	88	147	206	265	324	825
NE	88	147	206	265	324	825
NNE	88	147	206	265	324	825

AREA OF VEGETABLE CROP PRODUCTION (M**2)

	Distance (meters)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
NNW	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
NW	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
WNW	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
W	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
WSW	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
SW	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
SSW	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
S	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
SSE	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
SE	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
ESE	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
E	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
ENE	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
NE	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05
NNE	0.0E+00	7.7E+03	3.1E+04	5.1E+04	7.1E+04	9.2E+04	7.7E+05

	Distance (meters)					
Direction	15000	25000	35000	45000	55000	70000
N	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
NNW	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
NW	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
WNW	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
W	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
WSW	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
SW	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
SSW	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
S	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
SSE	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
SE	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
ESE	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
E	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
ENE	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
NE	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07
NNE	3.1E+06	5.1E+06	7.1E+06	9.2E+06	1.1E+07	2.9E+07

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

HUMAN INHALATION RATE	
Cubic centimeters/hr	9.17E+05
SOIL PARAMETERS	
Effective surface density (kg/sq m, dry weight) (Assumes 15 cm plow layer)	2.15E+02
BUILDUP TIMES	
For activity in soil (years)	1.00E+02
For radionuclides deposited on ground/water (days)	3.65E+02
DELAY TIMES	
Ingestion of pasture grass by animals (hr)	0.00E+00
Ingestion of stored feed by animals (hr)	2.16E+03
Ingestion of leafy vegetables by man (hr)	3.36E+02
Ingestion of produce by man (hr)	3.36E+02
Transport time from animal feed-milk-man (day)	2.00E+00
Time from slaughter to consumption (day)	2.00E+01
WEATHERING	
Removal rate constant for physical loss (per hr)	2.90E-03
CROP EXPOSURE DURATION	
Pasture grass (hr)	7.20E+02
Crops/leafy vegetables (hr)	1.44E+03
AGRICULTURAL PRODUCTIVITY	
Grass-cow-milk-man pathway (kg/sq m)	2.80E-01
Produce/leafy veg for human consumption (kg/sq m)	7.16E-01
FALLOUT INTERCEPTION FRACTIONS	
Vegetables	2.00E-01
Pasture	5.70E-01
GRAZING PARAMETERS	
Fraction of year animals graze on pasture	4.00E-01
Fraction of daily feed that is pasture grass when animal grazes on pasture	4.30E-01

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

ANIMAL FEED CONSUMPTION FACTORS	
Contaminated feed/forage (kg/day, dry weight)	1.56E+01
DAIRY PRODUCTIVITY	
Milk production of cow (L/day)	1.10E+01
MEAT ANIMAL SLAUGHTER PARAMETERS	
Muscle mass of animal at slaughter (kg)	2.00E+02
Fraction of herd slaughtered (per day)	3.81E-03
DECONTAMINATION	
Fraction of radioactivity retained after washing for leafy vegetables and produce	5.00E-01
FRACTIONS GROWN IN GARDEN OF INTEREST	
Produce ingested	1.00E+00
Leafy vegetables ingested	1.00E+00
INGESTION RATIOS:	
IMMEDIATE SURROUNDING AREA/TOTAL WITHIN AREA	
Vegetables	8.00E-02
Meat	1.00E-02
Milk	0.00E+00
MINIMUM INGESTION FRACTIONS FROM OUTSIDE AREA (Actual fractions of food types from outside area can be greater than the minimum fractions listed below.)	
Vegetables	0.00E+00
Meat	0.00E+00
Milk	0.00E+00
HUMAN FOOD UTILIZATION FACTORS	
Produce ingestion (kg/y)	1.76E+02
Milk ingestion (L/y)	1.12E+02
Meat ingestion (kg/y)	8.50E+01
Leafy vegetable ingestion (kg/y)	1.80E+01
SWIMMING PARAMETERS	
Fraction of time spent swimming	0.00E+00
Dilution factor for water (cm)	1.00E+00

♀

COMPLY: V1.6. 7/ 2/2013 6:53

40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

REPORT ON COMPLIANCE WITH

THE CLEAN AIR ACT LIMITS FOR RADIONUCLIDE EMISSIONS

FROM THE COMPLY CODE - V1.6.

Prepared by:

TetraTech EC
Sand Point
Seattle Washington

Erik Abkemeier
757-944-0921

Prepared for:

U.S. Environmental Protection Agency
Office of Radiation and Indoor Air
Washington, DC 20460

♀

COMPLY: V1.6. 7/ 2/2013 6:53

Sand Point Shed

SCREENING LEVEL 4

DATA ENTERED:

Nuclide		Release Rate (curies/YEAR)
RA-226	W	2.400E-05
CS-137	D	1.800E-05
SR-90	Y	9.000E-06

Release height 2 meters.

Building height 0 meters.

Stack diameter 2.00 meters.

Distance from the source to the receptor is 5 meters.

Default volumetric flow rate from the stack used (0.3 cu m/sec).

Default mean wind speed used (2.0 m/sec).

Distance from the SOURCE to the FARM producing VEGETABLES is 500 meters.

Distance from the SOURCE to the FARM producing MILK is 500 meters.

Distance from the SOURCE to the FARM producing MEAT is 500 meters.

Default air temperature used (55.0 degrees F).

Default stack temperature used (55.0 degrees F).

NOTES:

Input parameters outside the "normal" range:

Building is unusually SHORT.
Release height is unusually LOW.

♀

COMPLY: V1.6. 7/ 2/2013 6:53

RESULTS:

Effective dose equivalent: 1.7 mrem/yr.

*** Comply at level 4.

This facility is in COMPLIANCE.

It may or may not be EXEMPT from reporting to the EPA.

You may contact your regional EPA office for more information.

SHED FIN

********** END OF COMPLIANCE REPORT **********

♀

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

S Y N O P S I S R E P O R T

Non-Radon Population Assessment
Mar 10, 2013 06:46 pm

Facility: Sand Point
Address:
City: Seattle
State: WA Zip:

Source Category:
Source Type: Area
Emission Year: 2010

Comments: Max values for all radionuclides for 2000 cubic yd
See above

Effective Dose Equivalent (mrem/year)
3.03E-01

At This Location: 250 Meters North

Dataset Name: Sand Point
Dataset Date: 3/10/2013 6:43:00 PM
Wind File: C:\Program Files\CAP88-PC30\WindLib\24233.WN
Population File: C:\Program Files\CAP88-PC30\Poplib\Sand Poin

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 250 Meters North
Lifetime Fatal Cancer Risk: 1.68E-07

FREQUENCY DISTRIBUTION OF LIFETIME FATAL CANCER RISKS

Risk Range	# of People	# of People in This Risk Range or Higher	Deaths/Year in This Risk Range	Deaths/Year in This Risk Range or Higher
1.0E+00 TO 1.0E-01	0	0	0.00E+00	0.00E+00
1.0E-01 TO 1.0E-02	0	0	0.00E+00	0.00E+00
1.0E-02 TO 1.0E-03	0	0	0.00E+00	0.00E+00
1.0E-03 TO 1.0E-04	0	0	0.00E+00	0.00E+00
1.0E-04 TO 1.0E-05	0	0	0.00E+00	0.00E+00
1.0E-05 TO 1.0E-06	0	0	0.00E+00	0.00E+00
LESS THAN 1.0E-06	227	227	1.31E-08	1.31E-08

RADIONUCLIDE EMISSIONS DURING THE YEAR 2010

Nuclide	Type	Size	Source #1 Ci/y	TOTAL Ci/y
Ra-226	M	1	2.4E-02	2.4E-02
Rn-222	G	0	0.0E+00	0.0E+00
Po-218	M	1	0.0E+00	0.0E+00
Pb-214	M	1	0.0E+00	0.0E+00
At-218	M	1	0.0E+00	0.0E+00
Bi-214	M	1	0.0E+00	0.0E+00
Po-214	M	1	0.0E+00	0.0E+00
Pb-210	M	1	0.0E+00	0.0E+00
Bi-210	M	1	0.0E+00	0.0E+00
Po-210	M	1	0.0E+00	0.0E+00
Sr-90	M	1	9.0E-03	9.0E-03
Y-90	M	1	0.0E+00	0.0E+00
Cs-137	F	1	1.8E-02	1.8E-02
Ba-137m	M	1	0.0E+00	0.0E+00

SITE INFORMATION

Temperature:	10	degrees C
Precipitation:	100	cm/y
Humidity:	8	g/cu m
Mixing Height:	1000	m

SOURCE INFORMATION

Source Number: 1

Source Height (m): 2.00
Area (sq m): 1.00

Plume Rise Pasquill Cat:	A	B	C	D	E	F	G
Zero:	0.00	0.00	0.00	0.00	0.00	0.00	0.00

AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	0.080	0.000	0.010
Fraction From Assessment Area:	0.920	1.000	0.990
Fraction Imported:	0.000	0.000	0.000

Beef Cattle Density: 5.62E-02
Milk Cattle Density: 1.50E-02
Land Fraction Cultivated for Vegetable Crops: 5.20E-02

POPULATION DATA

Direction	Distance (m) 250	750	1500	2500	3500	4500	7500
N	1	1	1	1	1	11	1
NNW	1	1	1	1	1	1	1
NW	1	1	1	1	1	1	1
WNW	1	1	1	1	1	1	1
W	1	1	1	1	1	1	1
WSW	1	1	1	1	1	1	1
SW	1	1	1	1	1	1	1
SSW	1	1	1	1	1	1	1
S	1	1	1	1	1	1	1
SSE	1	1	1	1	1	1	1
SE	1	1	1	1	1	1	1
ESE	1	1	1	1	1	1	1
E	1	1	1	1	1	1	1
ENE	1	1	1	1	1	1	1
NE	1	1	1	1	1	1	1
NNE	0	1	1	1	1	1	1

Direction	Distance (m) 15000	25000	35000	45000	55000	70000
N	1	1	1	1	1	1
NNW	1	1	1	1	1	1
NW	1	1	1	1	1	1
WNW	1	1	1	1	1	1
W	1	1	1	1	1	1
WSW	1	1	1	1	1	1
SW	1	1	1	1	1	1
SSW	1	1	1	11	1	1
S	1	1	1	1	1	1
SSE	1	1	1	1	1	1
SE	1	1	1	1	1	1
ESE	1	1	1	1	1	1
E	1	1	1	1	1	1
ENE	1	1	1	1	1	1
NE	1	1	1	1	1	1
NNE	1	1	1	1	1	1

VFC-TSP

ENVIRONMENTAL TISCH

Manufacturer of Air Pollution Monitoring Equipment

TE-5170DV

Volumetric Flow Controlled (VFC) Air Sampler

Volumetric Flow Controlled Total Suspended Particulate High Volume Air Sampling System includes:

- anodized aluminum shelter
- 8" x 10" stainless steel filter holder with stagnation pressure tap
- blower motor assembly
- continuous flow/pressure recorder
- 30" water manometer
- volumetric flow controller with look up table, digital timer, and digital elapsed time indicator
- 110v/60hz or 220v/50hz

Meets EPA Code of Federal Regulation, Appendix B to Part 50

Specifications

Flow rate:	42–45 cfm continuous
Filter media:	Glass fiber filter 8" x 10" (TE-G653)
Flow control:	Volumetric flow controller (TE-10557TSP)
Motor blower:	2-stage vacuum 1.0 hp: 110v/60hz (TE-115923) 220v/50hz (TE-116111)
Water manometer:	30" water manometer (TE-5030) Flow/pressure recorder (TE-5009)
Timer:	Digital timer programmer with digital elapsed time indicator (TE-302) Sample delay 0–11 Days
Motor specifications:	110v/60hz—Part TE-115923 double ball bearing, thru-flow discharge 220v/50hz—Part TE-116111 ball/sleeve bearing, thru-flow discharge Start up amps: 20 Amps Running amps: 8 Amps

Shipping information

(two cartons)

Size/weight:	45.5" x 22.5" x 20"/50 lbs 28" x 21" x 20"/30 lbs

TE-5170V

High Volume VFC Monitor in Ambient Air

Volumetric Flow Controlled Total Suspended Particulate High Volume Air Sampling System includes:

- anodized aluminum shelter
- 8" x 10" stainless steel filter holder with stagnation pressure tap
- blower motor assembly
- continuous flow/pressure recorder
- elapsed time indicator (TE-5012)
- 30" water manometer
- volumetric flow controller with look up table
- 7-day mechanical timer
- 110v/60hz or 220v/50hz

Meets EPA Code of Federal Regulation, Appendix B to Part 50

Same as TE-5170DV except:

Timer:	7-day mechanical timer (TE-5007)

Tisch Environmental, Inc. 145 South Miami Ave. Village of Cleves OH 45002 USA
Phone 513.467.9000 Toll Free 877.263.7610 Fax 513.467.9009 Website www.tisch-env.com

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

W E A T H E R D A T A

Non-Radon Population Assessment
Mar 10, 2013 06:46 pm

Facility: Sand Point
Address:
City: Seattle
State: WA Zip:

Source Category:
Source Type: Area
Emission Year: 2010

Comments: Max values for all radionuclides for 2000 cubic yd
See above

Dataset Name: Sand Point
Dataset Date: 3/10/2013 6:43:00 PM
Wind File: C:\Program Files\CAP88-PC30\WindLib\24233.WND
Population File: C:\Program Files\CAP88-PC30\Poplib\Sand Point.pop

HARMONIC AVERAGE WIND SPEEDS (WIND TOWARDS)

	Pasquill Stability Class							
Dir	A	B	C	D	E	F	G	Wind Freq
N	1.890	1.760	2.470	3.580	2.830	1.350	0.000	0.221
NNW	2.570	1.580	2.170	3.000	2.770	1.440	0.000	0.038
NW	0.000	1.590	2.450	3.050	2.840	1.480	0.000	0.043
WNW	0.000	1.110	2.510	3.250	2.980	1.450	0.000	0.031
W	0.000	1.390	2.410	2.980	3.040	1.410	0.000	0.018
WSW	0.000	1.700	2.160	3.060	3.190	1.560	0.000	0.011
SW	2.570	1.610	2.680	3.260	3.620	1.670	0.000	0.039
SSW	2.570	2.420	3.260	3.770	3.840	1.790	0.000	0.079
S	1.890	2.510	3.700	4.150	3.800	1.590	0.000	0.125
SSE	1.810	2.420	3.300	3.380	3.310	1.440	0.000	0.037
SE	1.850	2.380	3.180	2.240	2.660	1.300	0.000	0.026
ESE	1.890	2.490	2.990	2.090	2.670	1.170	0.000	0.033
E	1.390	2.520	2.700	2.070	2.670	1.030	0.000	0.038
ENE	1.990	2.290	2.750	2.690	2.810	1.070	0.000	0.039
NE	1.890	2.350	2.870	3.740	2.970	1.150	0.000	0.084
NNE	1.990	2.110	2.950	4.090	3.030	1.190	0.000	0.137

ARITHMETIC AVERAGE WIND SPEEDS (WIND TOWARDS)

	Pasquill Stability Class						
Dir	A	B	C	D	E	F	G
N	2.300	2.600	3.240	4.680	2.980	1.880	0.000
NNW	2.570	2.250	2.880	3.810	2.890	1.960	0.000
NW	0.000	2.170	3.130	3.790	2.990	2.010	0.000
WNW	0.000	1.720	2.930	4.190	3.170	1.970	0.000
W	0.000	1.920	3.020	4.010	3.240	1.930	0.000
WSW	0.000	2.310	3.080	3.990	3.420	2.070	0.000
SW	2.570	2.330	3.280	4.180	3.840	2.150	0.000
SSW	2.570	3.080	3.830	4.660	4.020	2.230	0.000
S	2.300	3.190	4.240	5.100	3.990	2.090	0.000
SSE	2.240	3.220	4.130	4.610	3.550	1.960	0.000
SE	2.270	3.110	3.930	3.150	2.720	1.820	0.000
ESE	2.300	3.150	3.750	2.930	2.730	1.640	0.000
E	1.920	3.120	3.530	2.990	2.730	1.410	0.000
ENE	2.350	3.030	3.520	3.850	2.950	1.490	0.000
NE	2.300	3.160	3.730	4.920	3.150	1.620	0.000
NNE	2.350	3.000	3.910	5.330	3.240	1.670	0.000

FREQUENCIES OF STABILITY CLASSES (WIND TOWARDS)

	Pasquill Stability Class						
Dir	A	B	C	D	E	F	G
N	0.0006	0.0139	0.0455	0.7601	0.1008	0.0791	0.0000
NNW	0.0005	0.0118	0.0477	0.6477	0.1767	0.1156	0.0000
NW	0.0000	0.0094	0.0381	0.6385	0.1631	0.1509	0.0000
WNW	0.0000	0.0055	0.0293	0.6593	0.1481	0.1578	0.0000
W	0.0000	0.0121	0.0440	0.6001	0.1859	0.1579	0.0000
WSW	0.0000	0.0186	0.0470	0.5239	0.2057	0.2048	0.0000
SW	0.0005	0.0194	0.0794	0.4357	0.2550	0.2100	0.0000
SSW	0.0003	0.0245	0.0997	0.4400	0.2647	0.1708	0.0000
S	0.0010	0.0345	0.1362	0.4761	0.2282	0.1240	0.0000
SSE	0.0030	0.0689	0.1581	0.4114	0.1682	0.1904	0.0000
SE	0.0023	0.1589	0.2511	0.3097	0.0960	0.1820	0.0000
ESE	0.0039	0.1486	0.3071	0.3212	0.0840	0.1352	0.0000
E	0.0029	0.1707	0.2404	0.3867	0.0699	0.1294	0.0000
ENE	0.0041	0.0982	0.1644	0.5619	0.0787	0.0928	0.0000
NE	0.0015	0.0502	0.1075	0.7266	0.0589	0.0552	0.0000
NNE	0.0012	0.0255	0.0766	0.7953	0.0578	0.0435	0.0000
TOTAL	0.0012	0.0413	0.1016	0.6092	0.1358	0.1110	0.0000

ADDITIONAL WEATHER INFORMATION

Average Air Temperature: 10.0 degrees C
283.16 K
Precipitation: 100.0 cm/y
Humidity: 8.0 g/cu m
Lid Height: 1000 meters
Surface Roughness Length: 0.010 meters
Height Of Wind Measurements: 10.0 meters
Average Wind Speed: 4.002 m/s

Vertical Temperature Gradients:
STABILITY E 0.073 k/m
STABILITY F 0.109 k/m
STABILITY G 0.146 k/m

ATTACHMENT 6

TASK-SPECIFIC PLAN FOR BUILDINGS 2, 12, AND 27 SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

This page intentionally left blank.

U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

ATTACHMENT 6

FINAL

TASK-SPECIFIC PLAN FOR BUILDINGS 2, 12, AND 27 SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS
July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION AT FORMER NAVAL STATION PUGET SOUND SEATTLE, WASHINGTON

Prepared by:

TETRA TECH EC, INC.
1230 Columbia Street, Suite 750
San Diego, California 92101-8536

Daryl DeLong
Technical Lead

Lee Boreen
Project Manager

Erik Abkemeier, CHP, PE, CSP, CHMM
Radiation Safety Officer

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

PAGE

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

µR/hr	microroentgens per hour
µR/min	microroentgens per minute
APP	Accident Prevention Plan
BRAC	Base Realignment and Closure
cpm	counts per minute
Cs-137	cesium-137
DCGL	derived concentration guideline level
$DCGL_W$	wide-area DCGL
DFW	definable feature of work
DoD	Department of Defense
DQO	data quality objective
EBS	Environmental Baseline Survey
EE/CA	Engineering Evaluation/Cost Analysis
FSS	Final Status Survey
LBGR	lower boundary of the gray region
LLRW	low-level radioactive waste
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
$MDCR_{Surveyor}$	minimum detectable count rate calculated assuming a surveyor efficiency
MDER	minimum detectable exposure rate
mrem/y	millirems per year
NaI	sodium iodide
NAS	Naval Air Station
NAVFAC NW	Naval Facilities Engineering Command Northwest
NAVSTA PS	Naval Station Puget Sound
Navy	Department of the Navy
NOAA	National Oceanic and Atmospheric Administration
pCi/g	picocuries per gram
R	roentgen

ABBREVIATIONS AND ACRONYMS
(Continued)

Ra-226	radium-226
RASO	Radiological Affairs Support Office
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
RSOR	Radiation Safety Officer Representative
SOP	Standard Operating Procedure
Sr-90	strontium-90
SSHP	Site Safety and Health Plan
TSP	Task-specific Plan
TtEC	Tetra Tech EC, Inc.

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2, 12, AND 27 SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

This Task-specific Plan (TSP) provides details for conducting the Final Status Surveys (FSSs) of areas outside Buildings 2, 12, and 27 at former Naval Station Puget Sound (NAVSTA PS). The surveys will be conducted in accordance with the general approach and methodologies that are provided in the Radiological Removal Action Work Plan to which this TSP is attached, and associated Standard Operating Procedures (SOPs) (Attachment 4 to the Radiological Removal Action Work Plan). The survey activities will conform to the requirements of the Radiation Protection Plan (RPP) (Attachment 8 to the Radiological Removal Action Work Plan) and Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) (TtEC 2013) prepared for the site. No exceptions to the Radiological Removal Action Work Plan, SOPs, the RPP, or the APP/SSHP are noted.

The remedial activities and FSS are being performed to address elevated radiological activity identified in the soil and storm drains outside Buildings 2, 12, and 27. The FSS presented in this TSP has been designed as a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NUREG-1575; DoD et al. 2000) survey.

1.0 SITE DESCRIPTIONS AND HISTORICAL SUMMARY

Former NAVSTA PS is located approximately 6 miles northeast of downtown Seattle on the western shore of Lake Washington in Seattle, Washington (Figures 1-1 and 1-2). It is bounded by residential areas to the west and south and Lake Washington to the north and east.

Former NAVSTA PS was initially named Naval Air Station (NAS) Seattle at Sand Point. Portions of the facility were built in 1925 on land donated by King County and served as a Naval Air Reserve Training facility until December 7, 1941. Many of the major buildings were built prior to World War II, including Building 2 and Building 27. Additions were constructed and remodeling took place in later years, including an addition to the southern portion of Building 27 in 1944 (South Shed) and the remodeling of an instrument shop in Building 2 in 1941 (1941 Instrument Shop).

During World War II, NAS Seattle supported air transport and ship outfitting personnel for the Alaskan and Western Pacific theaters of operation. Transport squadron personnel operated cargo flights to Alaska and the Aleutian Islands, supplying air stations such as Sitka, Kodiak, Dutch Harbor, Adak, and Attu. Outfitting personnel handled the preparation of escort carriers and seaplane tenders built in Tacoma and Vancouver, Washington. In 1945, at the peak of its activity, NAS Seattle supported more than 4,600 Department of the Navy (Navy) (including Marine Corps) and civilian personnel. After the war, NAS Seattle was designated a Naval Reserve Air Station. From 1945 to 1970, the station maintained Naval Reserve squadrons for

supplementing active duty forces, both in the continental United States and abroad. Aviation activities officially ceased on June 30, 1970, and NAS Seattle was decommissioned.

On July 1, 1970, NAS Seattle was designated Naval Support Activity Seattle. Three years after the Navy stopped its air activities, the facility was divided into three parts. The National Oceanic and Atmospheric Administration (NOAA) received 100 acres, including one third of the runways and 3,500 feet of waterfront. The city of Seattle received the southeast portion, including approximately 1 mile of waterfront that later became Warren G. Magnuson Park in 1977. The Navy retained the remainder. From 1970 to April 1982, the Base provided logistic services such as supplies, billeting, and administration to the 13th Naval District, Department of Defense (DoD), and other federal agencies. In April 1982, Naval Support Activity Seattle was designated Naval Station Seattle. In October 1986, Naval Station Seattle was designated NAVSTA PS as a result of the station's decreasing support role in the Pacific fleet activities.

In June 1991, the Base Realignment and Closure (BRAC) Commission of the DoD announced the closure of NAVSTA PS. In accordance with recommendations of the 1991 BRAC Commission, the Navy closed NAVSTA PS in September 1995. A disestablishment ceremony was held on September 28, 1995, to commemorate the closing.

Subsequent to closure, the Navy conducted environmental investigations and cleanup of portions of the facility. The condition of the property was described in the Environmental Baseline Survey (EBS) report (URS 1996). The EBS described the significant operations and existing conditions at specific buildings and areas at former NAVSTA PS that were addressed in past environmental investigations. The EBS identified areas with potential environmental concern where storage or release of hazardous substances had occurred. No radiological contamination was identified in the EBS report. After completion of these actions, as well as the appropriate National Environmental Policy Act actions, the Navy initiated transfer of the former NAVSTA PS property to several government agencies in accordance with the BRAC closure plan.

Due to a long history of use of the facility by the Navy, and because of the potential that the environmental investigations conducted did not identify all environmental hazards that pose a threat to human health and the environment, the transfer deed between the Navy and the city of Seattle included an environmental covenant that allowed the city to seek action by the Navy to address contamination that was not identified in the EBS report.

Seattle Parks and Recreation personnel reviewed historical drawings and identified rooms labeled "Instrument Shop" and "Radium Room," which implied that radioactive materials may have been used or stored in these areas of the buildings. Buildings 2 and 27 are both former aircraft hangars. Airplane maintenance and storage activities of the era typically included the

use of self-luminescent radium paint for the maintenance and repair of aircraft instruments and parts.

As a result, the Navy initiated a radiological remedial investigation at former NAVSTA PS. The survey results are presented in the Radiological Remedial Investigation Report (Shaw 2011). Radiological contamination (in the form of radium-226 [Ra-226]) above the radiological remedial investigation project release criteria was found in and around the 1939 and 1941 Instrument Shops in Building 2 and within the Building 27 South Shed (an addition to the south face of the original Building 27 hangar structure) and two adjoining Building 27 stair towers. Radiological contamination above the radiological remedial investigation project release criteria was also found in storm drain lines associated with these buildings and in soil adjacent to these buildings and nearby Building 12.

The former Radium Room sink piping that penetrated the concrete floor of the Welding Shop on the first floor of the Building 27 South Shed is connected to the storm drain line that runs south out of the building and west to catch basin CB-3. The line from catch basin CB-3 connects to manhole MH-141 and continues through manholes MH-137 and MH-160 to discharge into Lake Washington. Of the sludge samples collected within this storm drain line, only samples collected from catch basin CB-3 were found to contain radiological contamination (Ra-226) exceeding radiological remedial investigation project release criteria. Drain pipes from former sinks located near the center of the South Shed are connected to the storm drain line that traverses south to catch basin CB-1. Catch basin CB-1 connects to an adjacent 24-inch storm line that runs north to manhole MH-136 and through MH-160 to Lake Washington. Of the sludge samples collected within this storm line, only samples collected from catch basin CB-1 were found at levels exceeding radiological remedial investigation project release criteria.

A drain pipe from a former sink in the Building 2 1941 Former Instrument Shop was found to contain sludge with radiological contamination exceeding radiological remedial investigation project release criteria. This drain discharged to the storm drain line that parallels the west side of Building 2 at manhole MH-134. Sample results from the sediment pit near manhole MH-134 indicate the presence of cesium-137 (Cs-137) in three samples at 3 picocuries per gram (pCi/g), 5.56 pCi/g, and 6.03 pCi/g. None of the sludge samples collected from manholes east of Building 2 (manholes MH-162, MH-134, and MH-135) or from manholes located under and north of Building 27 (manholes MH-136, MH-1005, and MH-160) were found to have radiological contamination exceeding radiological remedial investigation project release criteria.

Results of gamma walkover surveys and soil sampling indicate that soil containing Ra-226 concentrations exceeding the radiological remedial investigation project release criterion is present in historically unpaved (nontarmac) areas south and west of Building 27. The vertical extent of this soil appears to be limited to a layer of soil typically 1 to 2 feet thick within the 3 to 5 feet of soil above groundwater depending on elevation and whether the area received fill from

past construction of the NOAA overpass. Results of gamma walkover surveys and soil sampling indicate that soil containing Ra-226 concentrations exceeding radiological remedial investigation project release criterion is present in limited areas along the north side of Building 12 and the south and east sides of Building 2. The vertical extent of this soil appears to be limited to a thin layer of soil typically less than 2 feet below ground surface. A single discrete item (radioactive button) was found and removed from the soil along the east side of Building 2. The source of the contamination in soils surrounding Buildings 2, 12, and 27 appears to be the historical release of mop (cleaning) water containing Ra-226 from past cleaning activities. The mop water may have been poured outside the buildings in discrete areas. Contamination may have migrated from these areas due to rainfall and/or construction activities.

Based on the findings of the radiological remedial investigation, an Engineering Evaluation/Cost Analysis (EE/CA) was initiated to develop and evaluate removal action alternatives with the intent that the selected alternative would be implemented as a non-time-critical removal action. However, to expedite the removal action, the lead agency (Naval Facilities Engineering Command Northwest [NAVFAC NW]) decided to forego further development of the EE/CA and perform a time-critical removal action. An Action Memorandum (Shaw 2013), in which the appropriate removal action was documented based on regulatory and public comments, was prepared to present the written decision.

2.0 REMEDIAL ACTIONS

During previous investigations around Buildings 2, 12, and 27, gamma walkover surveys and soil samples identified Ra-226 contamination above the radiological remedial investigation project release criterion. The investigations also identified isolated occurrences of contamination from Cs-137 and strontium-90 (Sr-90) in drain lines that may also extend to others areas. This section describes the methods necessary to remove contaminated soil and storm drains from the vicinity of Buildings 2, 12, and 27.

2.1 Release Criteria for Remedial Actions

The release criteria for soil and sludge surveys are listed in Table 2-1. Remedial actions will continue until contamination levels are below the listed values.

2.2 Removal of Contaminated Soils and Piping

Soil and storm drain removal efforts will focus on those areas identified in the Radiological Remedial Investigation Report as needing further action based on the results of gamma walkover surveys and soil/sludge sample analyses. These areas are shown on Figures 2-1 through 2-3 (Potential Soil Contamination Areas) and Figure 2-4 (Storm Drains Designated for Removal). The removal approach will be as detailed in Section 12.8 of the Radiological Removal Action Work Plan and as discussed below. In the event that a discrete radioactive item is discovered during a survey, soil will be excavated a minimum of 1 foot around the device, and the excavated

soil and the sidewalls and bottom of the excavated area will be sampled and characterized. The discrete radioactive item will be characterized through use of a portable gamma spectroscopy device and segregated in a container designated for discrete radioactive items only. Excavated soils and storm drain components will be containerized and turned over to the government-designated low-level radioactive waste (LLRW) contractor for characterization and disposal. Tools and equipment used to remove the impacted soil will be surveyed in accordance with Standard Operating Procedure NAVSTA PS-Tt-009, Release of Material and Equipment from Radiologically Controlled Areas.

2.3 Remedial Action Support Survey

Following soil removal in identified areas, remedial action support surveys will be performed. These surveys involve collecting additional biased samples in the areas where the soils were removed. A sample typically will also be collected at the boundary of the excavation approximately every 3 feet and in the area immediately surrounding previously identified contaminated materials. If the remedial action support survey indicates that contamination above the release criteria still exists, these results will be used as characterization data to proceed with removing additional material as described in Section 2.4. Once soil sample analysis identifies no activity above the release criteria, remediation is complete and the area is ready for an FSS.

2.4 Characterization Survey

The intent of characterization is to fully delineate the extent of contamination to minimize the total amount of waste generated during excavation activities. Characterization surrounding identified areas of elevated activity will be achieved by performing additional scoping/ characterization gamma walkover surveys and collecting samples as directed by the Tetra Tech EC, Inc. (TtEC) Project Radiation Safety Officer Representative (RSOR)—in consultation with the Navy's Radiological Affairs Support Office (RASO) and NAVFAC NW—and analyzing them for the radionuclides of concern. These data will define the extent of the remedial action and will promptly be provided to the Radiation Safety Officer (RSO). Concurrence of the RASO is required before remedial actions are taken.

Additional soil borings may be collected in an effort to characterize certain areas, as directed by the RASO and NAVFAC NW, to supplement the soil boring data previously collected. During the radiological remedial investigation, 66 potential soil boring locations were identified for the purpose of collecting and analyzing soil samples to define the magnitude and extent of radiological contamination. Soil from 24 of the 66 boring locations identified was analyzed during the radiological remedial investigation. As part of the radiological removal action, the remaining 42 boring locations, shown on Figure 3-1 of the Radiological Removal Action Work Plan, will be investigated. Some boring locations may be eliminated and some may be added based on conditions encountered in the field. Further information regarding soil borings is provided in Section 12.7 of the Radiological Removal Action Work Plan.

2.5 Storm Drain Removal

The term "storm drain" refers to the conveyance piping, as well as the associated catch basins and/or manholes. Removal efforts will focus on those storm drains identified on Figure 2-4.

2.5.1 Excavation Approach

The general approach to removing the storm drain lines is specified in Section 12.8 of the Radiological Removal Action Work Plan. Storm drains will be removed to the depth of the pipe plus an additional 12 inches.

2.5.2 Postexcavation Survey Units

After scanning and sampling an excavation area, the area will be digitally rendered, and sampling locations will be selected using a random start and triangular pattern in the most current version of Visual Sample Plan (Gilbert et al. 2001). Each survey unit will be subject to a Class 1 survey, with a maximum area of 2,000 square meters (m^2), per Table 5-1 of the Radiological Removal Action Work Plan. The FSS process for excavation areas is discussed below.

3.0 FINAL STATUS SURVEY

The FSS will be sufficient to recommend unrestricted release of the site if no residual contamination is detected.

3.1 Release Criteria

The purpose of this section is to provide guidance for excavation footprint surveys of the Building 2, 12, and 27 soil and storm drain removal areas. These surveys will be performed to assess whether residual radioactivity above the established release criteria, as defined in Table 2-1, is present in the area. By using conservative assumptions for the dose limit, the source term, and the exposure pathway scenario, the results are conservative release criteria that are protective of the public at the 15 millirems per year (mrem/y) dose limit exclusive of background sources of radiation; however, all areas above any release criterion will be remediated according to Section 2.0 of this TSP.

The results from this survey will be tested statistically using the unity rule presented in the MARSSIM (NUREG-1575; DoD et al. 2000) to ensure that the net residual activity in each survey unit is less than the 15 mrem/y limit.

3.2 Reference Area

The reference (background) area for this survey will be selected after field mobilization in consultation with the RSOR, the RASO, and NAVFAC NW. Any reference area must be an area that is not identified as impacted. The RSOR, the RASO, and NAVFAC NW may choose an

alternate background location and/or multiple background locations once survey activities have started based on any additional materials encountered.

3.3 Investigation Levels

The investigation levels for all alpha and beta contamination surveys will be set at the release criteria listed in Table 2-1. The investigation level for gamma scan surveys will be three standard deviations (sigma) above the mean gamma readings measured in the reference area.

3.4 Survey Units

After all radioactive materials have been removed from the identified outside areas, the resulting excavations will be surveyed and sampled as Class 1 survey units. These areas will be encompassed by Class 2 survey units bounding the Class 1 survey units to verify that the characterization of the size of the Class 1 survey units is accurate.

Four areas associated with Building 27 identified during the remedial investigation will be combined to form a single Class 1 survey unit. Two areas associated with Building 2 will be combined to form a single Class 1 survey unit, and two areas associated with Building 12 will be combined to form a single Class 1 survey unit. Additional Class 1 survey units will be established in areas around storm drain excavation areas, in total areas not exceeding 2,000 m^2 per survey unit. Due to the potential to expand the boundaries of the described survey units, no predetermined survey unit layouts were provided—survey units may be redesigned, reconfigured, or modified as needed based on the final field measurements. The final survey unit layout will be reported with the final report.

In the examples below, reference area data from another Navy project were used because background data were not available at the time this TSP was prepared.

3.4.1 Establishing the Number of Measurements

Since radionuclide-specific measurements will not be performed, *N* is calculated in the manner specified for the Wilcoxon Rank-Sum test (Equation 6-2 from the Radiological Removal Action Work Plan):

Equation 6-2 from the Radiological Removal Action Work Plan

$$N = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{3\left(P_r - 0.5\right)^2}\left(1.2\right)$$

Where:

$Z_{1-\alpha}$ = 1.645 Type I decision error level

$Z_{1-\beta}$ = 1.645 Type II decision error level

P_r = random measurement probability, which is based on relative shift discussed in Section 3.4.4

(1.2) = factor for oversampling to account for missing or unusable data

The second term in the equation increases the number of data points by 20 percent. The 20 percent value was selected to account for a reasonable amount of uncertainty in the parameters used to calculate *N* and still allow flexibility to account for some lost or unusable data. While this 20 percent factor helps in meeting the data quality objectives (DQOs) provided in Table 5-1, it is not required during the data quality assessment to demonstrate compliance with the stated objectives of the statistical tests. The actual number of measurements required for each survey unit will be calculated for the final report.

P_r in Equation 6-2 is based on the relative shift. The relative shift is equal to Δ/σ, where Δ is equal to the derived concentration guideline level (DCGL)–lower boundary of the gray region (LBGR) and σ is an estimate of the standard deviation of the measured values in a survey unit.

3.4.2 LBGR Determination

The LBGR is the net median concentration of the contaminant in the survey unit. Since this value is unknown, MARSSIM (NUREG-1575; DoD et al. 2000) suggests using a value for the LBGR of one half the DCGL for planning purposes. Once the median concentration activity in the survey unit is established (as expressed in a gross alpha and gross beta measurement), this value will be used as a ratio to the lowest DCGL for the decay method to determine the LBGR. Equation 7-7 from the Radiological Removal Action Work Plan provides the method used to determine the LBGR:

Equation 7-7 from the Radiological Removal Action Work Plan

$$LBGR = \frac{C_1}{DCGL_1} + \frac{C_2}{DCGL_2} + \frac{C_3}{DCGL_3} + \ldots + \frac{C_i}{DCGL_i} \leq 1$$

Where:

C_i = concentration of radionuclide "i"

$DCGL_i$ = DCGL of radionuclide "i"

For planning purposes, the LBGR will administratively be set to one half the DCGL, or a value of 0.5.

3.4.3 Standard Deviation

Likewise, there is no estimate of the standard deviation of the contaminant in the survey unit, especially if no contaminant is initially expected. Therefore, σ will be assigned the value of the standard deviation of the adjusted measurement values in the survey unit as shown in Equation 7-8 from the Radiological Removal Action Work Plan:

Equation 7-8 from the Radiological Removal Action Work Plan

$$\sigma = \sqrt{\left(\frac{\sigma_{C1}}{DCGL_1}\right)^2 + \left(\frac{\sigma_{C2}}{DCGL_2}\right)^2 + \ldots + \left(\frac{\sigma_{Ci}}{DCGL_i}\right)^2}$$

Where:

σ_{Ci} = standard deviation from radionuclide "i"

$DCGL_i$ = DCGL of radionuclide "i"

For planning purposes, σ will be estimated to be 0.5. During the FSS, this value will be revised using the actual radionuclide concentrations from the survey data.

3.4.4 Relative Shift

The relative shift is equal to Δ/σ, where Δ is equal to [$DCGL_W$–LBGR] and σ is an estimate of the standard deviation of the measured values in a survey unit (or for planning purposes, from the background area on another Navy facility). The relative shift can be calculated as shown in Equation 6-1 from the Radiological Removal Action Work Plan:

Equation 6-1 from the Radiological Removal Action Work Plan

$$\frac{\Delta}{\sigma} = \frac{DCGL_W - LBGR}{\sigma} = \frac{1 - 0.5}{0.2} = 2.5$$

Using this Δ/σ value of 2.5, P_r was determined to be 0.961428.

3.4.5 Unity Rule

As stated in Section 4.3.3 and Appendix I.11 of MARSSIM (NUREG-1575; DoD et al. 2000), the unity rule will be used since multiple radionuclides (with different decay methods) are expected to be present. As stated in Appendix I.11.1, the DCGL is set at 1.0 (the total fraction of all radionuclides that might exceed the release criteria from Table 2-1).

Therefore, *N* is calculated using Equation 6-2 from the Radiological Removal Action Work Plan:

Where:

Type I decision error level: 1.645 (corresponding to a 5% error)
Type II decision error level: 1.645 (corresponding to a 5% error)
Random measurement probability: 0.961428

$$16.95 = \left\{ \frac{(1.645 + 1.645)^2}{3(0.961428 - 0.5)^2} \right\} (1.2)$$

N for surveys is calculated as a minimum of 16.95 total data collection locations. Rounding this number up to an even number would equate to 9 from each survey unit and 9 from the reference area, for a total of 18. However, to preclude the need for additional sampling due to a possible area of elevated activity, and to ensure that the density of measurements in each survey unit is adequate, this number will be further increased to a minimum of 10 readings from the survey unit and 20 from the reference area.

To maintain the potential for use as an FSS, data collected will be continuously analyzed to determine the relationship between each survey unit and the reference area.

3.4.6 Triangular Grid Layout

Systematic sampling and measurement locations for Class 1 and Class 2 survey units will be spread out using a triangular grid method, using a random start point, as described in Section 5.4.2 of the Radiological Removal Action Work Plan. The final layout will be determined using the most current version of Visual Sample Plan.

3.5 Field Instrumentation Measurements

3.5.1 Gamma Scan Measurements

One hundred percent of all survey units will be scanned with a Ludlum Model 2350-1 data logger equipped with a Ludlum Model 44-10 sodium iodide (NaI) scintillation detector. The gamma scans will be performed in accordance with NAVSTA PS-Tt-003, Radiation and Contamination Surveys. Areas exceeding investigation level (Section 3.3) will be investigated further. The intent of the gamma scan surveys is to determine whether residual contamination may be present.

All gamma scan surveys will be data-logged for inclusion in the survey report. Scans will be performed at a rate of approximately 0.5 meter per second with the detector held approximately 10 centimeters (4 inches) above the ground and moved back and forth across the travel path while scanning to produce a serpentine scan pattern. Backgrounds used for gamma scan measurement will be commensurate with the materials encountered throughout each survey unit.

3.5.1.1 Minimum Detectable Count Rate for Gamma Surveys (2-inch by 2-inch NaI Probe)

The minimum detectable count rate (MDCR) is the minimum detectable number of net source counts in the scan interval, for an ideal observer, that can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in *d'*), as shown in Equation 8-5 from the Radiological Removal Action Work Plan:

Equation 8-5 from the Radiological Removal Action Work Plan

$$MDCR = d' \sqrt{b_i} \left(\frac{60}{i} \right)$$

Where:

MDCR	=	minimum detectable count rate
d'	=	index of sensitivity (α and β errors) = 3.28
b_i	=	number of background counts in scan time interval = 96.77 counts
i	=	scan or observation interval = 1 second

For this calculation, an estimated background count rate of 5,806 counts per minute (cpm) is used. It should be noted that a typical source will remain under the NaI probe for 1 second during the scan; therefore, the average number of background counts in the observation interval is 96.77 [$b_i = 5{,}806 \times (1/60)$]. The required rate of true positives is 95 percent, and the rate of false positives is 5 percent. From Table 6.5 of MARSSIM (DoD et al. 2000), the value of *d'*, representing this performance goal, is 3.28. Using these inputs, the MDCR for this TSP is 1,936 cpm.

3.5.1.2 MDC for Gamma Scans of Surface Areas

The scan minimum detectable concentration (MDC) (in pCi/g) for land areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions). To establish the scan MDC, the relationship between the detector's net count rate to net exposure rate must be established first. This is accomplished by determining the MDCR and then applying a surveyor efficiency factor *p* to get the $MDCR_{Surveyor}$ as shown in Equation 8-9 from the Radiological Removal Action Work Plan:

Equation 8-9 from the Radiological Removal Action Work Plan

$$MDCR_{Surveyor} = MDCR / \sqrt{p}$$

The $MDCR_{Surveyor}$ is calculated using a surveyor efficiency (p) of 0.7 and the MDCR of 1,936 cpm as follows:

$$MDCR_{Surveyor} = 1936 \Big/ \sqrt{0.7} = 2{,}314 cpm$$

The $MDCR_{Surveyor}$ is then converted into the corresponding minimum detectable exposure rate (MDER) by use of a calibration constant specific to the detector being used and the radionuclide of concern. For example, when used with the Ludlum Model 2350-1, the calibration records for the Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector provide a calibration constant that can be used to determine the ratio of cpm to microroentgens per hour (µR/hr), as shown in Equation 8-10 from the Radiological Removal Action Work Plan:

Equation 8-10 from the Radiological Removal Action Work Plan

$$MDER\ (\mu R / hr) \quad = \quad \frac{MDCR_{Surveyor} * 6 \times 10^{7}}{cc}$$

Where:

$MDCR_{Surveyor}$	=	as calculated in Equation 8-9 from the Radiological Removal Action Work Plan
6×10^{7}	=	a conversion factor accounting for differences in time and activity units ([µR-min]/[R-hr])
cc	=	calibration constant ([counts]/[R])

In this case, MDER is calculated as follows:

$$MDER\ (\mu R / hr) \quad = \quad \frac{2314 * 6 \times 10^{7}}{cc} = 2.57 \text{ microR/hr}$$

Where:

$MDCR_{Surveyor}$	=	2,314 cpm
6×10^{7}	=	a conversion factor accounting for differences in time and activity units ([µR-min]/[R-hr])
cc	=	5.4×10^{10} ([counts]/[R])

Next, the relationship between the radionuclide concentration and exposure rate is established. This is accomplished by modeling (using MicroShield) to determine the net exposure rate produced by the radionuclide at a distance above the ground. The factors considered in modeling include:

- Dose point above the surface
- Density of material in grams per cubic centimeter
- DCGL of the radionuclide of concern in pCi/g
- Depth of detection for the DCGL
- Circular dimension of the cylindrical area of detector capability (m^2)

The concentration of the radionuclide of concern (scan MDC) necessary to yield the MDER may be calculated by taking the ratio of the MDER to the exposure rate calculated by MicroShield or Monte Carlo *N*-Particle code, as shown in Equation 8-11 from the Radiological Removal Action Work Plan:

Equation 8-11 from the Radiological Removal Action Work Plan

$$Scan\ MDC\,(pCi/g) = \frac{DCGL\ pCi/g * MDER\,\mu R/hr}{Microshield\ Exposure\ Rate\,\mu R/hr}$$

For Ra-226, the scan MDC to yield the MDER may be calculated by taking the ratio of the MDER to the exposure rate calculated by Microshield using the following input parameters:

- Dose point of 4 inches above the soil was used.
- Density of 1.6 grams per cubic centimeter (g/cm^3) was used for soil.
- An Ra-226 concentration of 1.0 pCi/g was used.
- Depth of the area of elevated activity was 15 centimeters.
- Circular dimension of the cylindrical area of elevated activity was 0.25 m^2.

$$Scan\ MDC\,(pCi/g) = \frac{DCGL\ pCi/g * MDER\,\mu R/hr}{Microshield\ Exposure\ Rate\,\mu R/hr} = 3.48\ \text{pCi/g}$$

Where:

DCGL = 1.0 pCi/g
MDER = 2.57 microR/hr
Microshield Exposure Rate = 0.7384 microR/hr

3.5.2 Static Measurements

Static measurements will be collected at systematic and biased locations for gamma in all survey units. For remedial action support or characterization surveys, the area surveyed will have a static measurement density approximating 20 measurements per 1,000 m^2 of area in each area that was remediated or characterized.

3.5.2.1 Gamma Static Measurements

Static gamma measurements will be collected at the specified systematic locations in each survey unit. Additional biased measurements may be collected if elevated gamma scan survey results identify measurements above the investigation level. Note that all static gamma measurements exceeding investigation levels should have corresponding notes on the survey sheets annotating the investigative action taken (e.g., sample taken or surveyed with different instrument type).

The gamma and exposure rate measurements will be performed in accordance with SOP NAVSTA PS-Tt-003, Radiation and Contamination Surveys. All static gamma measurements will be data-logged for inclusion in the survey report.

For gamma surveys, the MDCR is calculated in cpm. Equation 8-12 from the Radiological Removal Action Work Plan is used to calculate the MDCR:

Equation 8-12 from the Radiological Removal Action Work Plan

$$MDCR = \frac{3 + 4.65\sqrt{R_B T_B}}{T_B}$$

Where:

$3 + 4.65$	=	constant factor provided in MARSSIM
R_B	=	background count rate (cpm) = 5,806
T_B	=	background counting time (minute) = 1

Using the inputs observed in the reference area (listed above) in Equation 8-12, the calculated MDCR for the Ludlum Model 2350-1 is 357.32 cpm.

3.6 Equipment and Materials

The radiological survey of equipment and material will be conducted in accordance with SOP NAVSTA PS-Tt-009, Release of Materials and Equipment from Radiologically Controlled Areas. Survey and swipe sampling data will be compared to the release criteria listed in Table 2-1. Materials identified as having contamination present above the levels specified in Table 2-1 will be packaged for subsequent decontamination, or for storage and disposal as LLRW.

3.7 Soil Sampling

Soil samples will be collected at the surveillance locations determined in Section 3.4. Solid soil samples will be collected at the systematic and biased (when used) sampling locations and analyzed by gamma spectroscopy.

One hundred percent of final systematic solid samples will be analyzed by gamma spectroscopy including analysis of Ra-226 through in-growth of bismuth-214 approaching secular equilibrium, and for total strontium/Sr-90 in accordance with the Sampling and Analysis Plan (Attachment 1 to the Radiological Removal Action Work Plan).

3.8 Media Samples

Swipe samples will be collected during equipment and material surveys, and from other components where soil or sludge is not present. Where sufficient material is present, media samples (e.g., dust or sediment) will also be collected from drainage systems and other low-lying locations identified in the field where contaminants might accumulate. Additional samples may also be collected based on scan survey results. Samples will be collected using SOP NAVSTA PS-Tt-006, Sampling Procedures for Radiological Surveys.

Alpha/beta radiation analyses will be performed using a low background gas-flow proportional counter or Ludlum Model 2929 (or equivalent) swipe counter. Gamma radiation analyses will be performed by gamma spectroscopy.

3.9 Actions If Additional Activity Is Discovered

If areas of elevated activity are observed during the survey, additional characterization and remediation will be performed, as described in Section 2.0. Each new area will be subject to an FSS as described previously in this TSP. Any additional areas will be mapped and submitted with the final report.

4.0 SITE REPORT

Results of the survey that demonstrate that the net residual dose of the Buildings 2, 12, and 27 contaminated soil and storm drain areas is less than 15 mrem/y will be presented in a FSS Report. Any conclusion, other than a recommendation for unrestricted release, will be presented in a characterization report. Further surveys and remedial activities will be accomplished under this TSP only with modification and the consent of the TtEC RSOR in consultation with RASO. The final survey unit dimensions and locations will be presented in the final report.

5.0 QUALITY CONTROL

The DQOs for the survey are provided in Table 5-1.

Definable features of work (DFWs) establish the measures required to verify both the quality of work performed and compliance with project requirements. The DFW for this task is radiological surveys and associated sample results. A description of this DFW and the associated phases of quality control is presented in Table 5-2.

6.0 ENVIRONMENTAL PROTECTION

Environmental protection-driven requirements addressed in the Radiological Removal Action Work Plan apply. No additional requirements are necessary.

7.0 REFERENCES

Department of Defense (DoD), Department of Energy, Nuclear Regulatory Commission (NRC), and U.S. Environmental Protection Agency (EPA). 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) NUREG-1575. August.

Gilbert, R.O., J.R. Davidson, J.E. Wilson, and B.A. Pulsipher. 2001. Visual Sample Plan (VSP) Models and Code Verification. PNNL-13450, Pacific Northwest National Laboratory, Richland, Washington.

Shaw (Shaw Environmental & Infrastructure, Inc.). 2011. Final Radiological Remedial Investigation Report, Former Naval Station Puget Sound, Seattle, Washington. May.

———————. 2013. Final Action Memorandum. Former Naval Station Puget Sound, Seattle, Washington. May.

TtEC (Tetra Tech EC, Inc.). 2013. Accident Prevention Plan/Site Safety and Health Plan, Radiological Materials Time-Critical Removal Action. Former Naval Station Puget Sound, Seattle, Washington. July.

URS (URS Consultants, Inc.). 1996. Environmental Baseline Survey, Naval Station Puget Sound, Seattle, Washington. January.

TABLES

This page intentionally left blank.

TABLE 2-1

PRIMARY RADIATION PROPERTIES AND RELEASE CRITERIA FOR RADIONUCLIDES OF CONCERN

Radionuclide	Primary Radiation Properties		Release Criteria		
			Materials and Equipment Wastes		
	Half-life (years)	Type	Total Surface Activity[a]	Removable Activity[a]	Dose Based Release Criteria[b, c, d] (pCi/g)
Cesium-137	30.17	Beta Gamma	5,000	1,000	25.63
Radium-226	1,600	Alpha Gamma	100	20	1.07
Strontium-90	28.8	Beta	1,000	200	9.45

Notes:

[a] Units are disintegrations per minute per 100 square centimeters.

[b] Release criteria are taken from the Final Action Memorandum (Shaw 2013) (values do not include background).

[c] The resulting dose is based on 15 mrem/year using RESRAD Version 6.5.

[d] Release criteria for soil/sediment is the summation of the dose-based concentration guideline (15 mrem/year) and the mean background. A background investigation and establishment of site background levels will be conducted prior to implementation of the time-critical removal action.

Abbreviations and Acronyms:

pCi/g – picocuries per gram

This page intentionally left blank.

TABLE 5-1

SUMMARY OF DATA QUALITY OBJECTIVES

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
Statement of Problem	**Decisions**	**Inputs to the Decisions**	**Boundaries of the Study**	**Decision Rules**	**Limits on Decision Errors**	**Optimize the Sampling Design**
Buildings 2, 12, and 27 soils are listed as areas impacted by radiological activities. The radionuclides of concern are Cs-137, Ra-226, and Sr-90. Whether the site-specific release criteria for these isotopes have been met or whether remediation is warranted must be determined.	The primary use of the data expected to result from completion of this TSP is to support the Final Status Surveys of Buildings 2, 12, and 27 soils. Therefore, the decision to be made can be stated as, "Do the results of the survey meet the release criteria?"	Radiological surveys required to support the Final Status Surveys of Buildings 2, 12, and 27 soils will include: • 100 percent gamma scan surveys of three Class 1 survey units • 100 percent gamma scan of drain line excavation survey units • A minimum of 10 systematic gamma, exposure rate, and media samples collected in each Class 1 survey unit • Additional biased measurements and samples to be collected if investigation levels are exceeded during review of the associated gamma scan data	The boundaries of the Buildings 2, 12, and 27 soils are shown on Figure 1-2. The spatial boundaries are consistent with future work on the immediate area.	If the results of the survey meet the release criteria, then the data will be used to support a Final Status Survey. Otherwise, the data will be used for characterization.	Limits on decision errors are set at 5 percent, unless double sampling is determined to be necessary, when the alpha error is reduced to 2.5 percent, as specified in the Radiological Removal Action Work Plan.	Operational details for the radiological survey process have been developed. The theoretical assumptions are based on guidelines contained in MARSSIM. Specific assumptions regarding types of radiation measurements, instrument detection capabilities, quantities, and locations of data to be collected, and investigation levels are contained in this TSP and the Radiological Removal Action Work Plan.

Abbreviations and Acronyms:
Cs-137 – cesium-137
MARSSIM – Multi-Agency Radiation Survey and Site Investigation Manual
Ra-226 – radium-226
Sr-90 – strontium-90
TSP – Task-specific Plan

This page intentionally left blank.

TABLE 5-2

DEFINABLE FEATURES OF WORK FOR RADIOLOGICAL SURVEYS

ACTIVITY	PREPARATORY (Prior to initiating survey activity)	DONE	INITIAL (At outset of survey activity)	DONE	FOLLOW-UP (Ongoing during survey activity)	DONE
Radiological surveys	• Verify that an approved TSP is in place. • Verify that the Remedial Project Manager is notified about mobilization. • Verify that an approved RWP is available and has been read and signed by assigned personnel. • Verify that Radiological Removal Action Work Plan, Site Safety and Health Plan, TSP, and AHAs have been reviewed. • Verify that assigned personnel are trained and qualified. • Verify that personnel have been given an emergency notification procedure. • Verify that workers assigned dosimetry have completed NRC Form 4. • Verify that the relevant SOPs and/or manufacturers' instructions are available and have been reviewed for equipment to be used for radiological surveys. • Verify that equipment is on-site and is in working order (initial daily check).		• Verify that radiological instruments are as specified in the Radiological Removal Action Work Plan and TSP. • Inspect training records. • Verify that a qualified RCT and SSHO are present at active work areas. • Verify that site activities are being photographed. • Verify that the reference area measurements have been obtained using the procedure described in the Radiological Removal Action Work Plan, which states that the same survey methodology and instruments used to collect the background data will be used to perform measurements within survey units. • Verify that daily checks were performed on all portable survey instruments. • Verify that radiological instrument calibrations and setup are current. • Verify that required dosimetry is being worn. • Verify that field logbooks, proper forms, and chain-of-custody documents are in use. • Verify that samples and measurements are being collected in accordance with the TSP, the Radiological Removal Action Work Plan, and relevant SOPs. • Verify that sample handling and analyses are in accordance with the Radiological Removal Action Work Plan and applicable SOPs.		• Verify that the site is properly posted and secured, if necessary. • Conduct ongoing inspection of material and equipment. • Verify that a qualified RCT and SSHO are present at active work areas. • Verify that daily instrument checks and background measurements were obtained and documented. • Verify that survey and sample analysis results are documented. • Verify that personnel have read and signed the revised RWP, if revision is required. • Inspect sample chain-of-custody and survey log for completeness. • Verify that survey and analytical activities conform to the TSP. • Verify that survey instruments are recalibrated after repairs or modifications. • Verify that site activities are being photographed. • Verify that survey documentation is reviewed by the RTS.	

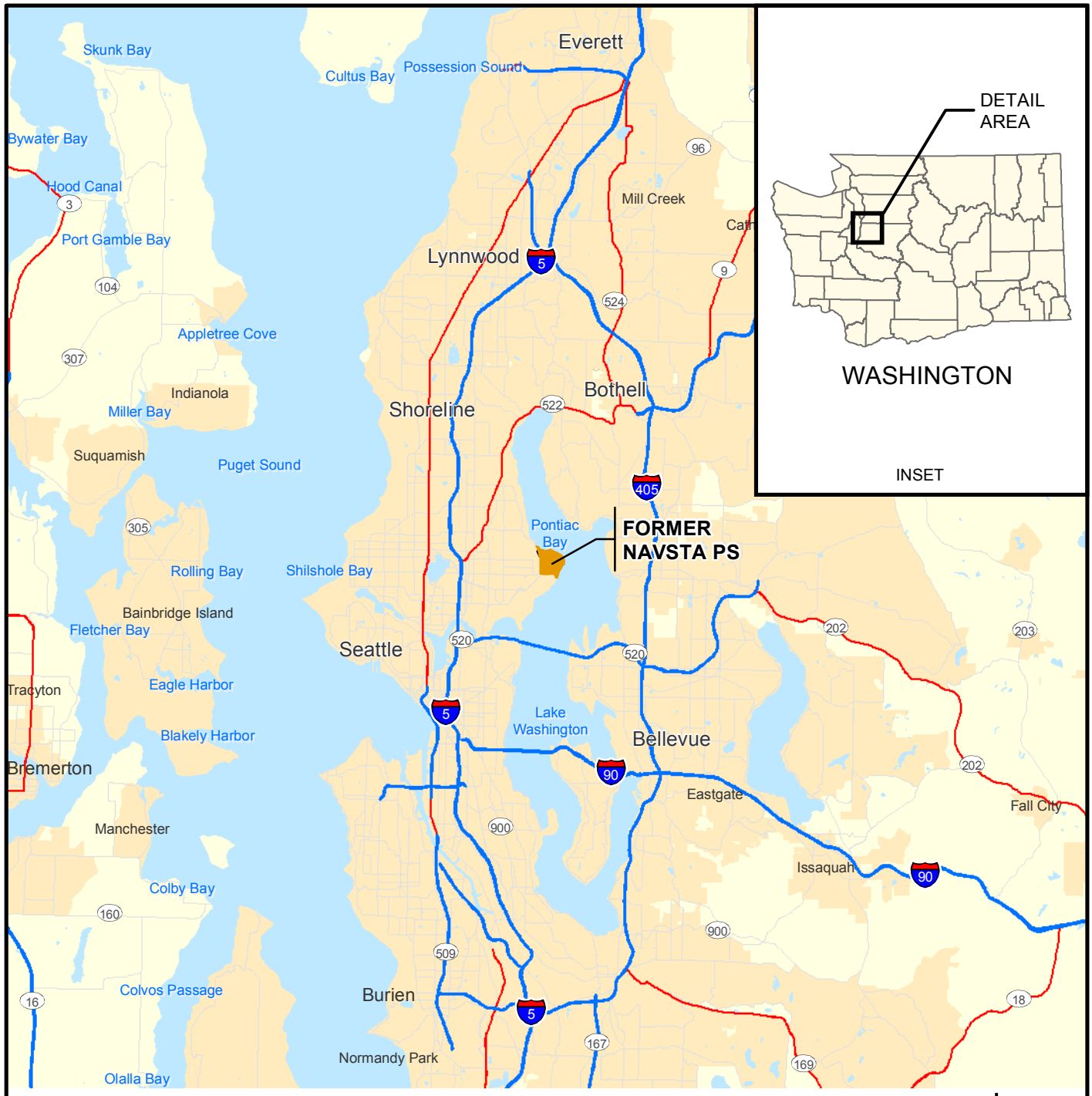
Abbreviations and Acronyms:

AHA – Activity Hazard Analysis
NRC – Nuclear Regulatory Commission
RCT – Radiological Control Technician
RTS – Radiological Task Supervisor
RWP – Radiation Work Permit
SOP– Standard Operating Procedure
SSHP – Site Safety and Health Officer
TSP – Task-specific Plan

This page intentionally left blank.

FIGURES

This page intentionally left blank.



LEGEND

- STATE HIGHWAY
- INTERSTATE HIGHWAY
- WATER

2.5 0 2.5 5 Miles

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR BUILDINGS 2, 12, AND 27
SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

FIGURE 1-1

REGIONAL LOCATION MAP

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7702.mxd

TETRA TECH EC, INC.

LEGEND

PROJECT SITE

1,000 0 1,000 Feet

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR BUILDINGS 2, 12, AND 27
SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

FIGURE 1-2

SITE LOCATION MAP

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7703.mxd

TETRA TECH EC, INC.

LOCATION MAP

LEGEND

- ▲ SOIL CHARACTERIZATION BORING

CPM

- 3586 - 5600
- 5601 - 7600
- 4601 - 9600
- 9601 - 11600
- 11601 - 187277
- POTENTIAL SOIL CONTAMINATION AREA

SCALE
0 10 20 FEET

SOURCE: SHAW E&I, Inc, SEATTLE WASHINGTON

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2, 12, AND 27
SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

FIGURE 2-1

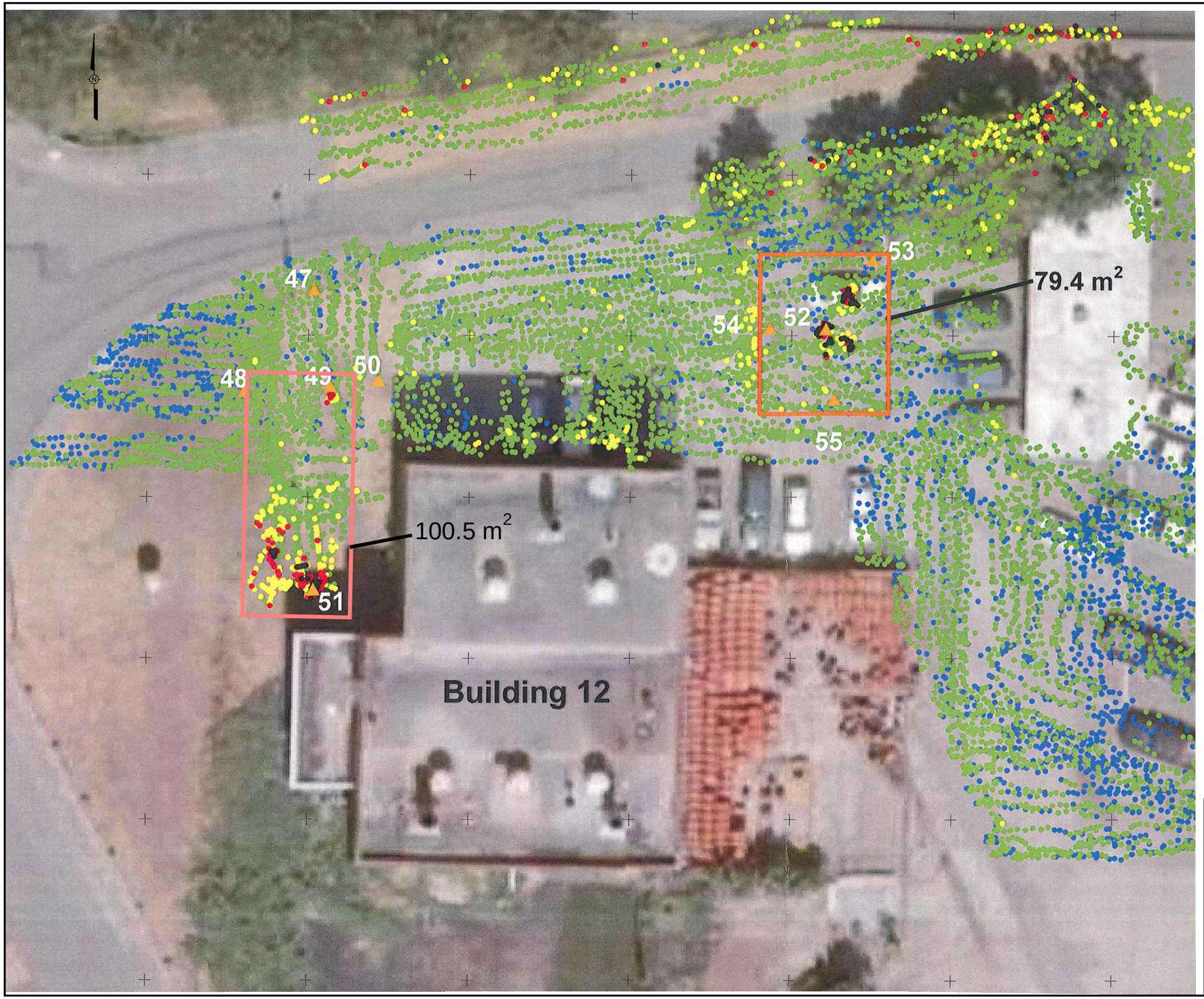
BUILDING 2 POTENTIAL SOIL CONTAMINATION AREA

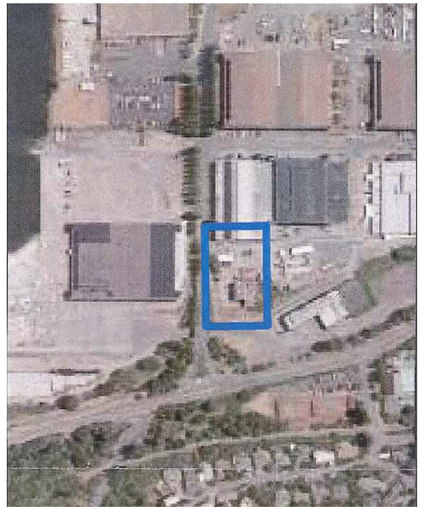
FORMER NAVAL STATION PUGET SOUND, SEATTLE, WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

P:\CAD PROJECT FILES\SAND POINT NAVAL STATION PUGET SOUND CAD FILES\BUILDING 27 FIGURE 2-1_2-3.DWG
PLOT/UPDATE: DEC 06 2012 08:55:06





LOCATION MAP

LEGEND

- SOIL CHARACTERIZATION BORING

CPM

- 3586 - 5600
- 5601 - 7600
- 4601 - 9600
- 9601 - 11600
- 11601 - 187277
- POTENTIAL SOIL CONTAMINATION AREA

SCALE
0 10 20 FEET

SOURCE: SHAW E&I, Inc, SEATTLE WASHINGTON

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2, 12, AND 27
SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

FIGURE 2-2

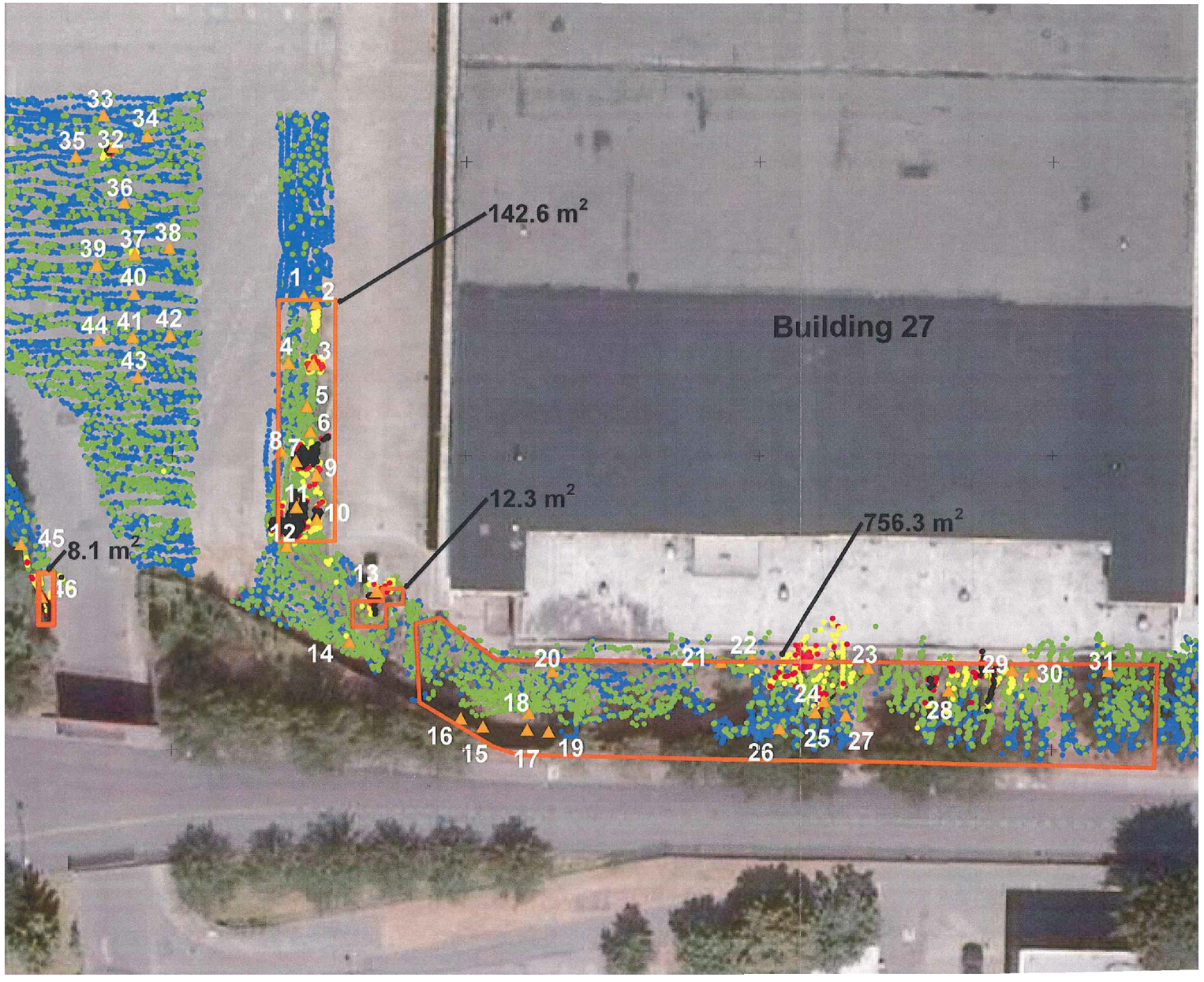
BUILDING 12 POTENTIAL SOIL CONTAMINATION AREA

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

P:\CAD PROJECT FILES\SAND POINT NAVAL STATION PUGET SOUND CAD FILES\BUILDING 27 FIGURE 2-1_2-3.DWG
PLOT/UPDATE: DEC 06 2012 08:55:06



LOCATION MAP

LEGEND

- SOIL CHARACTERIZATION BORING

CPM

- 3586 - 5600
- 5601 - 7600
- 4601 - 9600
- 9601 - 11600
- 11601 - 187277
- POTENTIAL SOIL CONTAMINATION AREA

SCALE
0 20 40 FEET

SOURCE: SHAW E&I, Inc, SEATTLE WASHINGTON

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2, 12, AND 27
SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

FIGURE 2-3

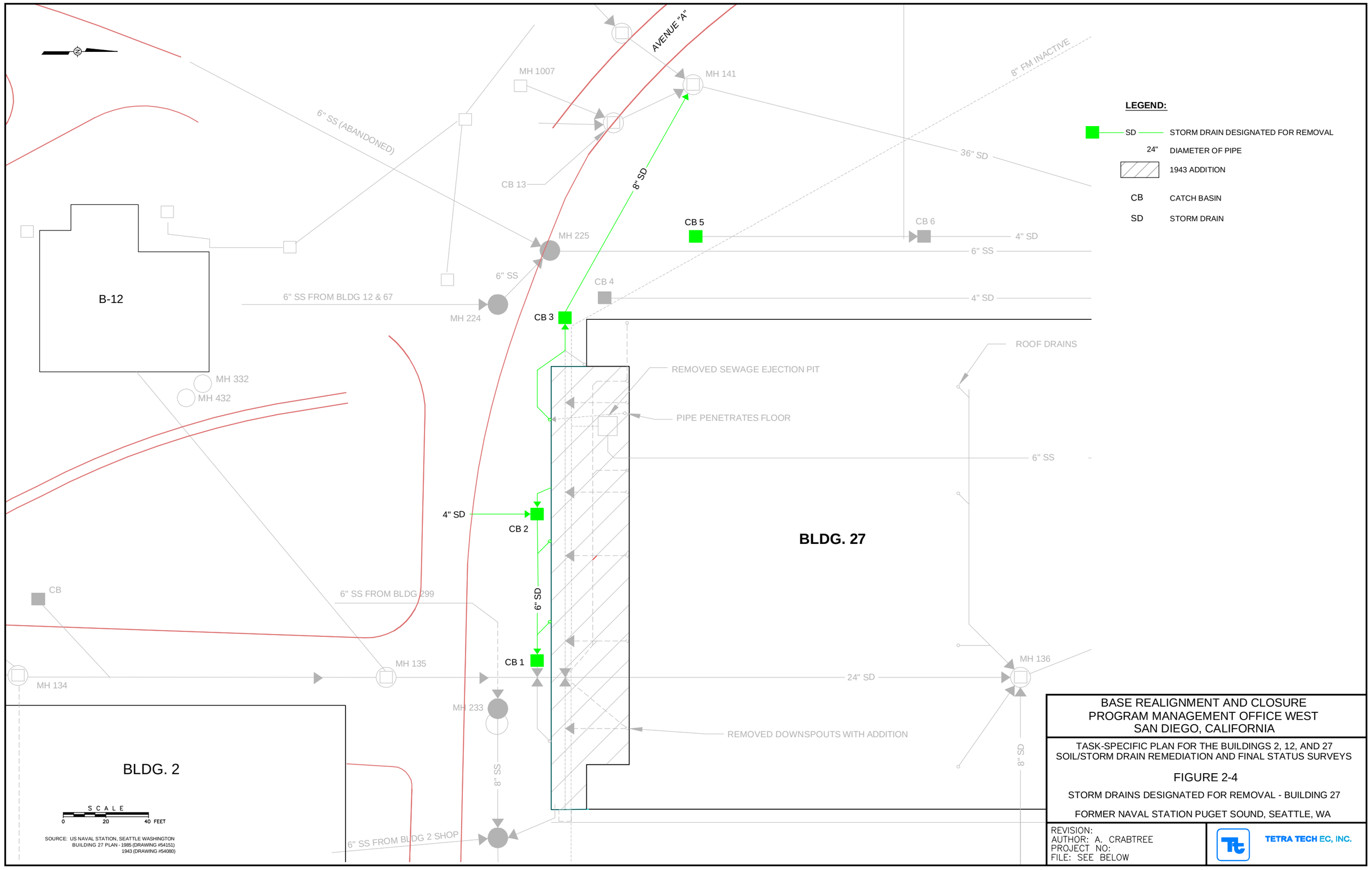
BUILDING 27 POTENTIAL SOIL CONTAMINATION AREA

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

P:\CAD PROJECT FILES\SAND POINT NAVAL STATION PUGET SOUND CAD FILES\BUILDING 27 FIGURE 2-1_2-3.DWG
PLOT/UPDATE: DEC 11 2012 13:40:54



BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2, 12, AND 27
SOIL/STORM DRAIN REMEDIATION AND FINAL STATUS SURVEYS

FIGURE 2-4

STORM DRAINS DESIGNATED FOR REMOVAL - BUILDING 27

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

P:\CAD PROJECT FILES\SAND POINT NAVAL STATION PUGET SOUND CAD FILES\BUILDING 27 FIGURE 2-4.DWG
PLOT/UPDATE: DEC 11 2012 13:38:24

ATTACHMENT 7

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 AND 27 REMEDIAL ACTION SUPPORT AND FINAL STATUS SURVEYS

This page intentionally left blank.

U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

ATTACHMENT 7

FINAL

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 AND 27 REMEDIAL ACTION SUPPORT AND FINAL STATUS SURVEYS
July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION AT FORMER NAVAL STATION PUGET SOUND SEATTLE, WASHINGTON

Prepared by:

TETRA TECH EC, INC.
1230 Columbia Street, Suite 750
San Diego, California 92101-8536

Daryl DeLong
Technical Lead

Lee Boreen
Project Manager

Erik Abkemeier, CHP, PE, CSP, CHMM
Radiation Safety Officer

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

PAGE

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

APP	Accident Prevention Plan
BRAC	Base Realignment and Closure
cm^2	square centimeter
cm/s	centimeters per second
cpm	counts per minute
Cs-137	cesium-137
DCGL	derived concentration guideline level
$DCGL_W$	wide-area DCGL
DFW	definable feature of work
DoD	Department of Defense
dpm	disintegrations per minute
DQO	data quality objective
EBS	Environmental Baseline Survey
EE/CA	Engineering Evaluation/Cost Analysis
FSS	Final Status Survey
HEPA	high-efficiency particulate air
LBGR	lower boundary of the gray region
LLRW	low-level radioactive waste
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
$MDCR_{SURVEYOR}$	minimum detectable count rate calculated assuming a surveyor efficiency
mrem/y	millirems per year
NaI	sodium iodide
NAS	Naval Air Station
NAVFAC NW	Naval Facilities Engineering Command Northwest
NAVSTA PS	Naval Station Puget Sound
Navy	Department of the Navy
NOAA	National Oceanic and Atmospheric Administration
Ra-226	radium-226

ABBREVIATIONS AND ACRONYMS
(Continued)

RASO	Radiological Affairs Support Office
RASS	Remedial Action Support Survey
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
RSOR	Radiation Safety Officer Representative
Shaw	Shaw Environmental & Infrastructure, Inc.
SOP	Standard Operating Procedure
Sr-90	strontium-90
SSHP	Site Safety and Health Plan
TSP	Task-specific Plan
TtEC	Tetra Tech EC, Inc.

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 AND 27 REMEDIAL ACTION SUPPORT AND FINAL STATUS SURVEYS

This Task-specific Plan (TSP) provides details for conducting the Remedial Action Support Survey (RASS) and Final Status Survey (FSS) of the interior areas of Buildings 2 and 27 at former Naval Station Puget Sound (NAVSTA PS). The surveys will be conducted in accordance with the general approach and methodologies provided in the Radiological Removal Action Work Plan, to which the TSP is attached, and associated Standard Operating Procedures (SOPs) (Attachment 4 to the Radiological Removal Action Work Plan). The survey activities will conform to the requirements of the Radiation Protection Plan (RPP) (Attachment 8 to the Radiological Removal Action Work Plan) and Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) (TtEC 2013) prepared for the site. No exceptions to the Radiological Removal Action Work Plan, SOPs, RPP or APP/SSHP are noted.

The RASS and FSS are being performed to address areas of elevated radiological activity identified in the interior portions of Buildings 2 and 27. The FSS presented in this TSP has been designed as a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NUREG-1575; DoD et al. 2000) survey.

1.0 SITE DESCRIPTIONS AND HISTORICAL SUMMARY

Former NAVSTA PS is located approximately 6 miles northeast of downtown Seattle on the western shore of Lake Washington in Seattle, Washington (Figures 1-1 and 1-2). It is bounded by residential areas to the west and south and Lake Washington to the north and east.

Former NAVSTA PS was initially named Naval Air Station (NAS) Seattle at Sand Point. Portions of the facility were built in 1925 on land donated by King County and served as a Naval Air Reserve Training facility until December 7, 1941. Many of the major buildings were built prior to World War II, including Building 2 and Building 27. Additions were constructed and remodeling took place in later years, including an addition to the southern portion of Building 27 in 1944 (South Shed) and the remodeling of an instrument shop in Building 2 in 1941 (1941 Instrument Shop).

During World War II, NAS Seattle supported air transport and ship outfitting personnel for the Alaskan and Western Pacific theaters of operation. Transport squadron personnel operated cargo flights to Alaska and the Aleutian Islands, supplying air stations such as Sitka, Kodiak, Dutch Harbor, Adak, and Attu. Outfitting personnel handled the preparation of escort carriers and seaplane tenders built in Tacoma and Vancouver, Washington. In 1945, at the peak of its activity, NAS Seattle supported more than 4,600 Department of the Navy (Navy) (including Marine Corps) and civilian personnel. After the war, NAS Seattle was designated a Naval

Reserve Air Station. From 1945 to 1970, the station maintained Naval Reserve squadrons for supplementing active duty forces, both in the continental United States and abroad. Aviation activities officially ceased on June 30, 1970, and NAS Seattle was decommissioned.

On July 1, 1970, NAS Seattle was designated Naval Support Activity Seattle. Three years after the Navy stopped its air activities, the facility was divided into three parts. The National Oceanic and Atmospheric Administration (NOAA) received 100 acres, including one third of the runways and 3,500 feet of waterfront. The city of Seattle received the southeast portion, including approximately 1 mile of waterfront that later became Warren G. Magnuson Park in 1977. The Navy retained the remainder. From 1970 to April 1982, the Base provided logistic services such as supplies, billeting, and administration to the 13th Naval District, Department of Defense (DoD), and other federal agencies. In April 1982, Naval Support Activity Seattle was designated Naval Station Seattle. In October 1986, Naval Station Seattle was designated NAVSTA PS as a result of the station's decreasing support role in the Pacific fleet activities.

In June 1991, the Base Realignment and Closure (BRAC) Commission of the DoD announced the closure of NAVSTA PS. In accordance with recommendations of the 1991 BRAC Commission, the Navy closed NAVSTA PS in September 1995. A disestablishment ceremony was held on September 28, 1995, to commemorate the closing of the Base.

Subsequent to closure, the Navy conducted environmental investigations and cleanup of portions of the facility. The condition of the property was described in the Environmental Baseline Survey (EBS) report (URS 1996). The EBS described the significant operations and existing conditions at specific buildings and areas at former NAVSTA PS that were addressed in past environmental investigations. The EBS identified areas with potential environmental concern where storage or release of hazardous substances had occurred. No radiological contamination was identified in the EBS report. After completion of these actions, as well as the appropriate National Environmental Policy Act actions, the Navy initiated transfer of the former NAVSTA PS property to several government agencies in accordance with the BRAC closure plan.

Due to a long history of use of the facility by the Navy, and because of the potential that the environmental investigations conducted did not identify all environmental hazards that pose a threat to human health and the environment, the transfer deed between the Navy and the city of Seattle included an environmental covenant that allowed the city to seek action by the Navy to address contamination that was not identified in the EBS report.

Seattle Parks and Recreation personnel reviewed historical drawings and identified rooms labeled "Instrument Shop" and "Radium Room," which implied that radioactive materials may have been used or stored in these areas of the buildings. Buildings 2 and 27 are both former aircraft hangars. Airplane maintenance and storage activities of the era typically included the

use of self-luminescent radium paint for the maintenance and repair of aircraft instruments and parts.

As a result, the Navy initiated a radiological remedial investigation at former NAVSTA PS. The survey results are presented in the Radiological Remedial Investigation Report (Shaw 2011). Radiological contamination (in the form of radium-226 [Ra-226]) above the radiological remedial investigation project release criteria was found in and around the 1939 and 1941 Instrument Shops in Building 2 and within the Building 27 South Shed (an addition to the south face of the original Building 27 hangar structure) and two adjoining Building 27 stair towers. Small amounts of cesium-137 (Cs-137) and strontium-90 (Sr-90) were identified in several of the samples from B2 and B27 drain systems that could have resulted from aircraft maintenance operations.

Based on the findings of the radiological remedial investigation, an Engineering Evaluation/Cost Analysis (EE/CA) was initiated to develop and evaluate removal action alternatives, with the intent that the selected alternative would be implemented as a non-time-critical removal action. However, to expedite the removal action, the lead agency (Naval Facilities Engineering Command Northwest [NAVFAC NW]) decided to forego further development of the EE/CA and perform a time-critical removal action. An Action Memorandum (Shaw 2013), in which the appropriate removal action was documented based on regulatory and public comments, was prepared to present the written decision.

1.1 Building 2 History

Building 2, located west of the NOAA facilities, housed the Marine Corps Reserve motorpool and offices. The building, constructed in 1938, was an active air hangar until the NAS was decommissioned in 1970. Airplane maintenance and storage activities at Building 2 (also called Hangar 2) may have involved the use of self-luminescent radium paint for the maintenance and repair of aircraft instruments and parts.

Building 2 comprises two former hangar spaces. The ground level of the building has a concrete floor and steel framing and most recently was used as a recreation facility. The northern portion of the building is used for storage, offices, and restrooms. There are unoccupied areas on the second floor of the building, including two former instrument shops. The second floor is accessible by staircases. Figure 1-3 shows the locations of the 1939 and 1941 Instrument Shops.

During the radiological remedial investigation performed by Shaw Environmental & Infrastructure, Inc. (Shaw) in 2010, MARSSIM Class 1 surveys of portions of the floors and Class 2 surveys of the walls found radiological contamination above the release criteria (Shaw 2011) with contamination levels up to 7,161 disintegrations per minute (dpm)/ 100 square centimeters (cm^2) α and 16,580 dpm/100 cm^2 β noted on both the floors and the walls. Radiological contamination above radiological remedial investigation project release criteria

within Building 2 was limited to the 1939 Instrument Shop, the 1941 Instrument Shop, the area immediately adjacent to (south and east) the 1941 Instrument Shop, and the 1941 Instrument Shop ventilation system.

The area of radiological contamination above project release criteria was limited to three 1-meter squares and a small area of the south wall in the 1939 Instrument Shop. The extent of radiological contamination above radiological remedial investigation project release criteria on the 1941 Instrument Shop floor was more substantial than the contamination in the 1939 Instrument Shop and extends up to 6 meters laterally south and 5 meters east of the 1941 Instrument Shop footprint. Only one measurement on the northern brick wall of the 1941 Instrument Shop exceeded radiological remedial investigation project release criteria. This appears to be the location of the former sink. The drain pipe from the former sink was found to contain sludge with contamination exceeding radiological remedial investigation project release criteria. This drain discharged to the storm line that parallels the west side of Building 2 at manhole MH-134. The aboveground portion of the drain pipe was removed. The remainder of the drain pipe is still buried beneath the concrete floor slab.

With the exception of the 1941 Instrument Shop ventilation system, no radiological contamination above radiological remedial investigation project release criteria was found on the ceiling or ceiling vents in areas surveyed. The ventilation system exhaust ducts (accessed from the attic) are contaminated at levels exceeding radiological remedial investigation project release criteria. Given that the 1941 Instrument Shop ventilation is a closed-loop system, there is a potential that contamination exceeding radiological remedial investigation project release criteria extends to other areas of the ventilation system.

According to the Radiological Remedial Investigation Report (Shaw 2011), the source of radiological contamination likely originated from activities within the 1939 and 1941 Instrument Shops, and in the case of the 1941 Instrument Shop, may have been spread to an area south during cleanup activities (mopping).

1.2 Building 27 History

Building 27 was originally constructed as a hangar for the Navy in 1937. The northern portion of Building 27 comprises the former hangar space and a North Shed area. It has a concrete floor and steel framing. Structures (towers) with stairs are present on each corner of Building 27. The southeast and southwest towers are four stories high and provide access to the second floor and roof tops. At the south end of the building are two enclosed floors of storage rooms, offices, and restrooms (South Shed). The South Shed was added in 1944 (Drawing 54080 [Navy 1943]). A shared wall separates the hangar from the South Shed.

Building 27 was vacant at the start of the field activities conducted by Shaw in April 2010, except for use of the lower floor of the South Shed and portions of the hangar for storage. In May 2010, a tenant of the Seattle Parks and Recreation began renovation of the northern hangar area of Building 27 into an indoor sports facility.

The second floor of Building 27 South Shed is accessible by staircases in the towers on both the east and west sides. Stairs once present near the central portion of the South Shed (quarter deck) have since been removed. One set of stairs led outside to the south and one set led to the hangar to the north. A site drawing dated November 1943 (Drawing 54080 [Navy 1943]) indicates that an instrument shop on the second floor, including a radium room, may have been used for handling radioactive materials. Drawings dated 1975 (Drawing 54141 [Navy 1975]) and 1985 (Drawing 54151 [Navy 1985]) indicate that the building had undergone renovation, during which the Radium Room was reconfigured and renamed the S-1 Work Space. Figure 1-3 presents both the 1943 and 1985 room configurations.

The S-1 Work Space now contains a wall of mailboxes on the south wall. On the north wall, a sink had been removed, but the open drain pipe and capped water supply pipes remained. During the radiological remedial investigation, the drain pipe was removed from the second floor north wall to the ground floor concrete slab. Below the slab, the drain pipe remains and continues on to discharge into storm drain catch basin CB-3, which was found to have Ra-226 exceeding the radiological remedial investigation project release criterion. A ventilation duct located in the ceiling has been abandoned, but the penetration measuring approximately 2 feet square remains through the ceiling space above into the heating, ventilating, and air conditioning penthouse located on the roof. The floor was covered with a layer of particleboard and 9-inch-square floor tiles that, along with the mastic, were composed of asbestos-containing materials.

During a radiological remedial investigation by Shaw in 2010, MARSSIM Class 1 surveys of portions of the floors and Class 2 surveys of the walls were performed, and contamination was found above the radiological remedial investigation project release criteria (Shaw 2011); contamination levels up to 21,844 dpm/100 cm^2 α and 634,000 dpm/100 cm^2 β were noted on both the floors and the walls. Radiological contamination above radiological remedial investigation project release criteria within Building 27 is limited to the South Shed and the two adjoining towers (southwest and southeast towers). Radiological contamination above radiological remedial investigation project release criteria was found in the wood flooring that was exposed when the remodeled flooring was removed in nearly all the rooms on the second floor of the South Shed. The migration of radiological contamination into the wood subfloor below the tongue and groove wood flooring appears to have been impeded by a layer of roofing-type tar paper found between the wood floor and subfloor, with the exception of floor penetrations (i.e., former steam piping) or areas where former walls had been removed and the roofing paper did not originally exist.

At penetrations and former wall locations (where the walls were removed), radiological contamination appears to have migrated to the subfloor, and in the three locations where the subfloor had been removed (Radium Room and two locations in the Safety Chief Room), radiological contamination had migrated to the floor joists. Radiological contamination above radiological remedial investigation project release criteria on the first floor was limited to the concrete floor of the Welding Shop near the slab penetration location of the removed Radium Room drain pipe and one site consistent with dripping from a ceiling penetration into the second floor. Radiological contamination above radiological remedial investigation project release criteria was found on the second floor and the metal stairs of the southwest tower and on the first floor and the metal stairs of the southeast tower.

Radiological contamination above radiological remedial investigation project release criteria was found on one ceiling vent into the attic of the South Shed. No radiological contamination above radiological remedial investigation project release criteria was found on the ceiling or roof of the South Shed.

According to the Radiological Remedial Investigation Report (Shaw 2011), the radiological contamination likely originated from activities within the instrument shop and appears to have been spread throughout the building during cleaning activities (mopping).

2.0 REMEDIAL ACTIONS

During previous investigations inside Buildings 2 and 27, elevated alpha and beta measurements identified the presence of radiological contamination (Ra-226) above the radiological remedial investigation project release criteria. This section describes the methods necessary to remove contamination from inside Buildings 2 and 27.

2.1 Release Criteria for Remedial Actions

The release criteria for the Buildings 2 and 27 surveys are listed in Table 2-1. Remedial actions will continue until contamination levels are below those listed in Table 2-1.

2.2 Remediation of Previously Identified Areas of Contamination

Several areas inside Buildings 2 and 27 will require remedial actions. Depending on the contaminated media, several options are available to remediate the contaminated areas.

Remedial actions will comply with the appropriate SOPs for radiological posting, airborne monitoring, radiological and contamination surveys, and decontamination of equipment, tools, and materials, as provided in Attachment 4 to the Radiological Removal Action Work Plan. The following sections briefly describe the methodologies available to remediate contaminated media/areas. Remedial actions will be coordinated and controlled using a Radiation Work Permit.

Results from the remedial actions will be submitted to the Navy's Radiological Affairs Support Office (RASO) and NAVFAC NW for review prior to beginning the FSS.

2.2.1 Remediation of Fiberboard, Drywall, Wood Floors, Ceiling Paneling, Plaster, and Wood Paneling

Areas identified in the Radiological Remedial Investigation Report (Shaw 2011) to be above the release criteria will be remediated. Radiological surveys performed during the remedial investigation identified areas of contamination that were marked. These areas will be scan surveyed using a Ludlum 2350-1 data logger with a 44-10 detector and a Ludlum 2360 data logger with a 43-37 and/or 43-68 detector to verify the location and extent of contamination. Previously identified areas may expand, and new areas of contamination may be identified as a result of gamma scan surveys performed as part of the remedial action. Remediation of fiberboard, drywall, wood floors, ceiling paneling, plaster surfaces, and wood paneling will be completed by removing an area larger than the contaminated area by cutting or by using another appropriate method determined by the Project Superintendent. (***Note:*** A task-specific Radiation Work Permit with Navy concurrence will be required prior to commencing work involving the common wall between Arena Sports and the Building 27 shed to ensure that all potential exposure pathways to the general public are adequately controlled.) Surveys will be conducted inside the void space exposed by removal of the materials to ensure that contamination did not spread to areas behind walls, below floors, or above ceilings.

All remediated materials will be disposed of as low-level radioactive waste (LLRW).

2.2.2 Remediation of Concrete and Other Hard Surfaces

Remediation of concrete and other hard surfaces may be accomplished either by cutting and removing an area larger than the contaminated surface or by scabbling/chipping the area/material.

Scabbling/chipping may be used to remove the material that is fixing the activity to the surface, or remove a very thin layer of the surface material. It is important to note that decontamination methods for fixed contamination can and do result in the creation of removable surface contamination. This creates a condition that may generate airborne radioactive materials. To protect the public and workers' health and safety, the activities will be controlled in such a manner that airborne radioactivity is minimized, and air sampling will be performed during these operations to properly evaluate any resultant airborne radioactivity in accordance with the Washington State Department of Health approved site-specific Air Emissions Plan (Attachment 5 to the Radiological Removal Action Work Plan).

The surface residual radioactivity will be removed by mechanically abrading the surface of the affected area. During abrading activities, a high-efficiency particulate air (HEPA) vacuum will be used as a ventilation sweep over the remediation area, as necessary. The progress of the

remediation will be checked periodically by a Radiological Control Technician scanning with a Ludlum Model 2360 connected to a model 43-68 gas-flow proportional detector (or equivalent). Large area wipes will also be collected throughout the remediation process to ensure removable contamination is not being spread into clean areas.

Remediation will continue until a survey indicates that the activity is less than the levels listed in Table 2-1. When the survey indicates that the remediation is complete, a HEPA vacuum will be used to remove any loose material. The area around the remediation will be surveyed to ensure contamination has not spread from the immediate remediation area. Debris will be placed into an LLRW container for disposal. Once the remediation has been completed and decontamination has been verified to have been successful by performing follow-up surveys in accordance with SOP NAVSTA PS-Tt-003, Radiation and Contamination Surveys, the area may be subject to an FSS (Section 3.0).

2.2.3 Remediation of Ventilation Systems

All previously contaminated portions of ventilation systems in Buildings 2 and 27, including the Building 27 rooftop penthouse air handling unit, will be disassembled to ensure that all surface area is accessible, cleaned using a HEPA vacuum to remove any loose materials and dusts, and then surveyed as materials and equipment in accordance with SOP NAVSTA PS-Tt-009. Photographs will be taken at every survey point to correspond to the appropriate swipe and static measurement result.

If contamination is still found in the ventilation system, affected portions will be removed and disposed of as LLRW, as directed by the RASO and NAVFAC NW.

Further discussion of ventilation systems is provided in Section 3.8.

2.2.4 Piping Removal

As indicated in Section 1.1, a drain pipe from a second floor sink in Building 2 was removed to the level of the ground floor slab. The remainder of this drain pipe, which is beneath the ground floor slab and leads to storm drain manhole MH-134, requires removal.

As indicated in Section 1.2, another drain pipe was removed between the ground floor slab level and the ceiling above in Building 27. The remainder of the drain pipe, which is beneath the ground floor slab and leads to storm drain catch basin CB-3, requires removal.

These drain pipes will be removed, and an FSS of the pipe removal and trench area will be required. This will be performed using the procedures provided in Section 12.8 of the Radiological Removal Action Work Plan.

Hard surfaces will be saw cut and removed in the area above the proposed excavation boundary. The overlying materials, which are expected to be primarily concrete, will be placed immediately adjacent to the work area on plastic. The disposition of these materials will be determined based on the results from the surveys of the drain line materials and underlying soil samples, with the concurrence of the RASO and NAVFAC NW.

The pipe will be completely removed and disposed of as LLRW as described in Section 2.2.5 of this TSP. Swipe samples (for removable surface contamination) and sediment samples (if sediment is present) will be collected and analyzed at the termination points of pipe removal. This would apply in the case where only a portion of a pipe run is intended for removal or when lateral lines are encountered, in which case swipe and sediment samples will be collected from the end of the pipe segment that is intended to remain. If the sample results exceed the release criteria, additional pipe removal and sampling will be performed. A Class 1 survey unit (Section 3.4) will be established in the area of the excavation, with a map of the survey unit concurred upon by the RASO. The survey unit map, which will include the locations of the soil samples that were collected, will be included in the FSS. A Class 2 survey unit will be established on the hard surfaces immediately adjacent to the excavation trench once the RASO and NAVFAC NW have concurred that the FSS for the trench was performed satisfactorily. The Class 2 survey unit will extend approximately 2 meters around the final excavated area and any areas utilized for waste loading operations.

Samples locations where results indicate activity above the release criteria will be characterized and remediated in 1-foot lifts. The FSS in a survey unit that has undergone remediation will be performed using a new unique set of systematic sampling locations.

No backfilling of excavations will occur inside buildings until the results of all FSS samples are less than the release criteria and the RASO concurs with FSS results prior to backfill.

2.2.5 Disposal of Items as LLRW

Items or materials identified as exceeding the release criteria specified in Table 2-1 will be disposed of as LLRW using a U.S. Army Joint Munitions Command (as Executive Agent for the Navy) Certified Waste Broker.

2.2.6 Remedial Action Support Survey

After remedial actions have been completed, each area where a remedial action occurred will be 100 percent scanned (as described in Section 3.5) for alpha, beta, and gamma radiation.
A sufficient number of static measurements (Section 3.5.2) and wipe samples (Section 3.10) will be taken in each area to confirm the effectiveness of remediation.

If the RASS indicates that contamination above the release criteria still exists, then these data will be used as characterization data to proceed with additional removal of material (Section 2.2). Additional characterization surveys (Section 2.3) may or may not be performed, as directed by the Tetra Tech EC, Inc. (TtEC) Radiation Safety Officer (RSO).

Once results indicate that the contamination level in each remediation area is less than the release criteria specified in Table 2-1, the area will be subject to an FSS, as described in Section 3.0.

2.3 Characterization Survey

The intent of characterization is to fully delineate the extent of contamination to minimize the total amount of radiological waste generated during remedial actions. Characterization surrounding identified areas of elevated activity will be achieved by performing additional scan and biased static measurements (Section 3.5) as directed by the TtEC Radiation Safety Officer Representative (RSOR). These data will define the extent of the remedial action, and will be promptly provided to the RSO. Concurrence of the RASO is required before remedial actions are taken.

3.0 FINAL STATUS SURVEY

The FSS will be sufficient to recommend unrestricted release of the site if no residual contamination is detected.

3.1 Release Criteria

This survey is being performed to determine whether residual radioactivity above the established release criteria, as listed in Table 2-1, is present inside Buildings 2 and 27. By using conservative assumptions for the dose limit, the source term, and the exposure pathway scenario, the results are conservative release criteria that are protective of the public at the 15 millirems per year (mrem/y) dose limit exclusive of background sources of radiation; however, areas exhibiting activity above any release criterion will be remediated in accordance with Section 2.0 of this TSP.

The results from this survey will be tested statistically using the unity rule presented in the MARSSIM (NUREG-1575; DoD et al. 2000) to ensure that the net residual activity in each survey unit is less than the mrem/y limit.

3.2 Reference Area

The reference (background) area will be the same as the one used during the remedial investigation of Building 11 (Shaw 2011). If deemed appropriate, other reference areas may be selected after mobilization to the site to collect material specific reference areas. The area must not be identified as being radiologically impacted. The RSO and the RASO may choose several

background locations once survey activities have started based on any additional materials that are encountered.

3.3 Investigation Levels

The investigation levels for all alpha and beta contamination surveys will be set at the release criteria listed in Table 2-1. The investigation level for gamma scan surveys will be three standard deviations (sigma) above the mean gamma readings measured in the reference area or other level approved by the RASO.

3.4 Survey Units

Building 2 has been divided into seven Class 1 survey units (including one for sink drain removal) and two Class 2 survey units. Building 27 has been divided into 18 Class 1 survey units (including one for sink drain removal) and 4 Class 2 survey units. An additional Class 2 Survey Unit extending 2 meters beyond the excavation areas around drain line removals will also be established in each building (Section 2.2.4). In each building, several areas have been subdivided such that floors and areas less than or equal to 2 meters above the respective floor are considered Class 1 survey units. Class 1 survey units consist of floor areas less than 100 square meters (m^2) or soil/excavation areas of less than 2,000 m^2. Buffer areas around each group of Class 1 survey units, extending approximately 2 meters outward, have been designated as Class 2 survey units; each Class 2 survey unit has a maximum total area of 1,000 m^2 for hard surfaces and 10,000 m^2 for excavation/soil areas. Using a different random start point in each survey unit, systematic data collection locations (*N*) have been laid out in a square grid pattern for the survey units. In some cases, the number of data collection locations may exceed *N* primarily because the value of *N* may not always be divisible by the exact number of columns and rows associated with the square grid pattern for a given survey unit. This is particularly true when *N* is a prime number or is not divisible by three and four.

Figures 3-1 and 3-2 provide the survey unit layouts in Buildings 2 and 27, respectively. However, survey units may be redesigned, reconfigured, or modified as needed after final field measurements are taken; the final layout of survey units will be provided with each building's final report.

In the examples below, reference area data from another Navy project were used because background data were not available at the time this TSP was prepared.

3.4.1 Establishing the Number of Measurements

N is calculated in the manner specified for the Wilcoxon Rank-Sum test (Equation 6-2 from the Radiological Removal Action Work Plan):

Equation 6-2 from the Radiological Removal Action Work Plan

$$N = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{3\left(P_r - 0.5\right)^2}(1.2)$$

Where:

$Z_{1-\alpha}$ = 1.645 Type I decision error level

$Z_{1-\beta}$ = 1.645 Type II decision error level

P_r = random measurement probability, which is based on relative shift discussed in Section 3.4.4

(1.2) = factor for oversampling to account for missing or unusable data

The second term in the equation increases the number of data points by 20 percent. The value of 20 percent was selected to account for a reasonable amount of uncertainty in the parameters used to calculate *N* and still allow flexibility to account for some lost or unusable data. While this 20 percent factor assists in meeting the data quality objectives (DQOs) provided in Table 5-1, it is not required during the data quality assessment to demonstrate compliance with the stated objectives of the statistical tests. The actual number of measurements required for each survey unit will be calculated for the final report.

P_r in Equation 6-2 is based on the relative shift. The relative shift is equal to Δ/σ, where Δ is equal to the derived concentration guideline level [DCGL]–lower boundary of the gray region [LBGR] and σ is an estimate of the standard deviation of the measured values in a survey unit.

3.4.2 LBGR Determination

The LBGR is the net median concentration of the contaminant in the survey unit. Since this value is unknown, MARSSIM (NUREG-1575; DoD et al. 2000) suggests using a value for the LBGR of one half the DCGL for planning purposes. However, once the median concentration activity in the survey unit is established (as expressed in a gross alpha and gross beta measurement), this value will be used as a ratio to the lowest DCGL for the decay method to determine the LBGR. Equation 7-7 from the Radiological Removal Action Work Plan provides the method used to determine the LBGR:

Equation 7-7 from the Radiological Removal Action Work Plan

$$LBGR = \frac{C_1}{DCGL_1} + \frac{C_2}{DCGL_2} + \frac{C_3}{DCGL_3} + \ldots + \frac{C_i}{DCGL_i} \leq 1$$

Where:

C_i = concentration of radionuclide "i"

$DCGL_i$ = DCGL of radionuclide "i"

For planning purposes, the LBGR will administratively be set to one half the DCGL, or a value of 0.5.

3.4.3 Standard Deviation

Likewise, there is no estimate of the standard deviation of the contaminant in the survey unit, especially if no contaminant is initially expected. Therefore, σ will be assigned the value of the standard deviation of the adjusted measurement values in the survey unit as shown in Equation 7-8 from the Radiological Removal Action Work Plan:

Equation 7-8 from the Radiological Removal Action Work Plan

$$\sigma = \sqrt{\left(\frac{\sigma_{C1}}{DCGL_1}\right)^2 + \left(\frac{\sigma_{C2}}{DCGL_2}\right)^2 + \ldots + \left(\frac{\sigma_{Ci}}{DCGL_i}\right)^2}$$

Where:

σ_{Ci} = standard deviation from radionuclide "i"

$DCGL_i$ = DCGL of radionuclide "i"

For planning purposes, σ will be calculated using survey measurements taken from a non-impacted building on another Navy facility. For example, based on other readings that may be expected:

$$\sigma = \sqrt{\left(\frac{9.73\,dpm/100\,cm^2}{100\,dpm/100\,cm^2}\right)^2 + \left(\frac{191.92\,dpm/100\,cm^2}{1{,}000\,dpm/100\,cm^2}\right)^2} = 0.215$$

For soil areas, a similar σ is estimated:

$$\sigma = \sqrt{\left(\frac{0.04\,pCi/g}{25.63\,pCi/g}\right)^2 + \left(\frac{0.03\,pCi/g}{9.45\,pCi/g}\right)^2 + \left(\frac{0.02\,pCi/g}{1.54\,pCi/g}\right)^2} = 0.13$$

3.4.4 Relative Shift

The relative shift is equal to Δ/σ, where Δ is equal to [$DCGL_W$–LBGR] and σ is an estimate of the standard deviation of the measured values in a survey unit (or for planning purposes from the background area on another Navy facility). The relative shift can be calculated as shown in Equation 6-1 from the Radiological Removal Action Work Plan:

Equation 6-1 from the Radiological Removal Action Work Plan

$$\frac{\Delta}{\sigma} = \frac{DCGL_W - LBGR}{\sigma} = \frac{1 - 0.5}{0.215} = 2.33$$

Using this Δ/σ value of 2.33, P_r was determined to be 0.944167.

3.4.5 Unity Rule

As stated in Section 4.3.3 and Appendix I.11 of MARSSIM (NUREG-1575; DoD et al. 2000), the unity rule will be used since multiple radionuclides (with different decay methods) are expected to be present. As stated in Appendix I.11.1, the DCGL is set at 1.0 (the total fraction of all radionuclides that might exceed the release criteria from Table 2-1).

Therefore, *N* is calculated using Equation 6-2 from the Radiological Removal Action Work Plan:

Where:

Type I decision error level: 1.645
Type II decision error level: 1.645
Random measurement probability: 1

$$21.9 = \left\{ \frac{(1.645 + 1.645)^2}{3(0.993329 - 0.5)^2} \right\} (1.2)$$

N for surveys is calculated as a minimum of 21.9 total data collection locations for hard surfaces. Rounding this number up to an even number would equate to 11 from each survey unit and 11 from the reference area, for a total of 22. However, to preclude the need for additional sampling due to a possible area of elevated activity, and to ensure that the density of measurements in each survey unit is adequate, this number will be further increased to a minimum of 20 readings from the survey unit and 20 from the reference area. As the number of samples for hard surfaces is more limiting than that for soil surfaces, the same number of samples is required for soil.

To maintain the potential for use as an FSS, data collected will be continuously analyzed to determine the relationship between each survey unit and the reference area.

3.5 Field Instrumentation Measurements

3.5.1 Scan Measurements

Scan measurements are performed to identify elevated areas of radioactivity within the survey unit. Alpha, beta, and gamma scans will be effective for identifying elevated concentrations of Cs-137, Ra-226, and Sr-90.

For hard surfaces, 100 percent of the accessible surface areas in the Class 1 survey units, 100 percent of areas within 2 meters of where remedial actions have occurred, and 50 percent of areas in the Class 2 survey units will be scanned using Ludlum Model 43-37 or 43-68 gas-flow proportional detectors coupled to Ludlum Model 2360 data loggers and Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) scintillation detectors coupled to Ludlum Model 2350-1 data loggers. For soil/excavation surfaces, 100 percent of the accessible surface areas in the Class 1 survey units and 50 percent of areas in the Class 2 survey units, including areas within 2 meters of where remedial actions have occurred, will be scanned using Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detectors coupled to Ludlum Model 2350-1 data loggers.

3.5.1.1 Alpha Scan Measurements

The results of surveys at other Navy facilities indicate that the alpha count rate on various surfaces in Buildings 2 and 27 could average less than 10 counts per minute (cpm) with a Model 43-68 detector. Alpha scan speeds for these surfaces will be determined using Equation 8-4 from the Radiological Removal Action Work Plan:

Equation 8-4 from the Radiological Removal Action Work Plan

$$P(n \geq 2) = 1 - \left[1 + \frac{(GE + B)t}{60}\right]\left[e^{\frac{-(GE+B)t}{60}}\right]$$

Where:

$P(n \geq 2)$	=	probability of getting two or more counts during the time interval t (%)	
t	=	time interval(s)	= 12
G	=	contamination activity (dpm)	= 100
E	=	detector efficiency (4π)	= 0.15
B	=	background count rate (cpm)	= 5
$P(n \geq 2)$	=	98.2% at a scan speed of 1 centimeter per second (cm/s)	

The scan surveys will be performed using a Ludlum Model 43-37 or Model 43-68 detector. The detector position will be adjusted so that the detector window is approximately 1/4 inch from the surface. The surveyor will move the detector at a scan speed of 1 cm/s while maintaining audio and visual observation of the instrument response. If the surveyor observes two or more counts during a scan interval (approximately 12 seconds), the surveyor will pause the detector movement and take a 12-second observation. If during the 12-second observation no additional counts are observed, the surveyor can continue the scan survey. Conversely, if additional counts are observed during the 12-second observation, the surveyor should mark the area for further investigation and subsequent biased measurements using a 126-cm^2 or smaller detector to locate and properly quantify any areas of elevated activity.

3.5.1.2 Beta Scan Measurements

For beta scans, the minimum detectable number of net source counts in the scan interval can be determined by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in *d′*) as shown in Equation 8-5 from the Radiological Removal Action Work Plan:

Equation 8-5 from the Radiological Removal Action Work Plan

$$MDCR = \mathrm{d}' \sqrt{\mathrm{b_i}} \left(\frac{60}{i} \right)$$

Where:

d' = index of sensitivity (α and β errors [performance criteria])
b_i = number of background counts in scan time interval (count)
i = scan or observation interval(s)

For beta scans:

d' = 3.28
b_i = 100 counts based on a background of 500 cpm
i = 12 seconds

Beta scan minimum detectable count rate ratio (MDCR) = 164 at a scan speed of 1 cm/s.

The scan minimum detectable concentration (MDC) is determined from the MDCR by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. As discussed below, the MDCR accounts for the background level, performance criteria (*d′*), and observation interval. The observation interval during scanning is the actual time that the detector can respond to the contamination source. This interval depends on the scan speed, detector size in the direction of the scan, and area of elevated activity. The scan MDC for structure surfaces is calculated using Equation 8-6 from the Radiological Removal Action Work Plan:

Equation 8-6 from the Radiological Removal Action Work Plan

$$Scan\ MDC = \frac{MDCR}{\sqrt{p}\ \varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2}}$$

Where:

MDCR is discussed above
p = surveyor efficiency factor
ε_i = instrument efficiency (count per particle)
ε_s = contaminated surface efficiency (particle per disintegration)
W_A = area of the detector window (cm^2)

For beta scans:

$MDCR$ = 164
p = 0.50
ε_i = 0.177
ε_s = 0.25
W_A = 821
Beta scan MDC = 638.4 dpm/100 cm^2 at a scan speed of 1 cm/s

3.5.1.3 Gamma Scan Measurements

One hundred percent of the Class 1 survey units and 50 percent of the Class 2 survey units will be scanned with Ludlum Model 44-10 NaI scintillation detectors coupled to a Ludlum Model 2350-1 data logger. The gamma scans will be performed in accordance with NAVSTA PS-Tt-003, Radiation and Contamination Surveys. Any areas with contamination exceeding the investigation level (Section 3.3) will be further investigated by removal of the surface material to expose potential radiological contamination located beneath the surface material. The intent of the gamma scan surveys is to expose any subsurface contamination for subsequent remediation and alpha/beta scan and static surveys.

Additionally, for all Class 1 survey units on the second floor surface, the accessible areas of the ceiling beneath the Class 1 survey unit will also be gamma scanned.

All gamma scan surveys will be data-logged for inclusion in the survey report. Scans will be performed at a rate of approximately 0.5 meter per second with the detector held approximately 10 centimeters (4 inches) above the ground and moved back and forth across the travel path while scanning, producing a serpentine scan pattern. Backgrounds used for gamma scan measurement will be commensurate with the materials encountered throughout each survey unit.

3.5.1.3.1 Minimum Detectable Count Rate for Gamma Surveys (2-inch by 2-inch NaI Probe)

MDCR is the minimum detectable number of net source counts in the scan interval, for an ideal observer, that can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d'), as shown in Equation 8-5 from the Radiological Removal Action Work Plan:

Equation 8-5 from the Radiological Removal Action Work Plan

$$MDCR = d' \sqrt{b_i} \left(\frac{60}{i} \right)$$

Where:

MDCR	=	minimum detectable count rate
d'	=	index of sensitivity (α and β errors) = 3.28
b_i	=	number of background counts in scan time interval = 96.77 counts
i	=	scan or observation interval = 1 second

For this calculation, an estimated background count rate of 5,806 cpm is used. It should be noted that a typical source will remain under the NaI probe for 1 second during the scan; therefore, the average number of background counts in the observation interval is 96.77 [b_i = 5,806 × (1/60)]. The required rate of true positives is 95 percent, and the rate of false positives is 5 percent. From Table 6.5 of MARSSIM (DoD et al. 2000), the value of *d'*, representing this performance goal, is 3.28. Using these inputs, the MDCR for this TSP is 1,936 cpm.

3.5.1.3.2 MDCR and Use of Surveyor Efficiency, Gamma (2-inch by 2-inch NaI Probe)

The minimum detectable count rate calculated assuming a surveyor efficiency ($MDCR_{SURVEYOR}$) can be calculated assuming surveyor efficiency (*P*) of 0.5 and the observed background count rate of 5,806 cpm using Equation 8-9 from the Radiological Removal Action Work Plan as follows:

Equation 8-9 from the Radiological Removal Action Work Plan

$$MDCR_{SURVEYOR} = \frac{MDCR}{\sqrt{P}} = \frac{1{,}936}{\sqrt{0.5}} = 2{,}738 cpm$$

3.5.2 Static Measurements

Static measurements will be collected at systematic and biased locations for alpha and beta (for hard surfaces only), gamma, and exposure rates in Class 1 and Class 2 survey units. For remedial action support or characterization surveys, the area surveyed will have a static measurement density approximating 20 measurements per 100 $m^2$of area in each area that was remediated or characterized.

3.5.2.1 Alpha and Beta Static Measurements

Two-minute alpha and beta static measurements will be performed at the specified systematic and biased locations in each of the Class 1 and Class 2 survey units (hard surfaces), and in support of other survey activities, to achieve the MDC limits necessary for the radionuclides of

concern. The count time may be increased or decreased as long as the MDC limits are met. Additional measurements may be collected if elevated radiation readings are identified while performing the scan surveys. Ludlum Model 43-68 gas-flow proportional detectors coupled to Ludlum Model 2360 data loggers will be used to perform alpha and beta static measurements.

The MDC for alpha measurements was calculated from background measurements at another Navy facility using Equation 8-7 from the Radiological Removal Action Work Plan:

Equation 8-7 from the Radiological Removal Action Work Plan

$$MDC = \frac{3 + 4.65\sqrt{R_B T_B}}{\varepsilon_s \varepsilon_i \frac{W_A}{100} T_B}$$

Where:

3+4.65	=	constant factor provided in MARSSIM
R_B	=	background count rate = 3.33 cpm
T_B	=	background count time = 2 minutes
ε_i	=	instrument efficiency = 0.296
ε_s	=	surface efficiency factor = 0.25
W_A	=	probe area size = 126 cm^2

The calculated MDC for alpha contamination is 80 dpm/100 cm^2 using a 2-minute static counting time.

The MDC for beta measurements was also calculated using Equation 8-7:

Where:

3+4.65	=	constant factor provided in MARSSIM
R_B	=	background count rate = 213.63 cpm
T_B	=	background count time = 2 minutes
ε_i	=	instrument efficiency = 0.177
ε_s	=	surface efficiency factor = 0.25
W_A	=	probe area size = 126 cm^2

The calculated MDC for beta contamination is 889 dpm/100 cm^2 using a 2-minute static counting time.

3.5.2.2 Gamma Static Measurements

Static gamma measurements will be collected at the specified systematic locations in each survey unit. Additional biased measurements may be collected if elevated gamma scan survey results identify measurements above the investigation level. Note that all static gamma measurements

exceeding investigation levels should have corresponding notes on the survey sheets annotating the investigative action taken (e.g., sample taken, surveyed with different instrument type.)

The gamma and exposure rate measurements will be performed in accordance with SOP NAVSTA PS-Tt-003, Radiation and Contamination Surveys. Note that all static gamma measurements will be data-logged for inclusion in the survey report.

For gamma surveys, MDCR is calculated in cpm. Equation 8-12 from the Radiological Removal Action Work Plan is used to calculate the MDCR:

Equation 8-12 from the Radiological Removal Action Work Plan

$$MDCR = \frac{3 + 4.65\sqrt{R_B T_B}}{T_B}$$

Where:

3 + 4.65	=	constant factor provided in MARSSIM
R_B	=	background count rate (cpm) = 5,806
T_B	=	background counting time (minute) = 1

Using the inputs observed in the reference area (listed above) in Equation 8-12, the calculated MDCR for the Ludlum Model 2350-1 is 357.32 cpm.

3.5.2.3 Exposure Rate Static Measurements

Exposure rate measurements will be collected from the specified systematic and biased locations in each of the survey units composed of hard surfaces. Additional measurements will be collected if elevated measurements are identified while performing the gamma scan surveys. A Ludlum Model 19 exposure rate meter will be used to perform the measurements.

3.6 Floor Surfaces

Most finished floor surfaces such as tile and carpet were removed during the remedial investigation. Remaining floor surfaces will be surveyed and removed to expose the original flooring material, as necessary. One hundred percent scan surveys for alpha and beta radiation will be conducted on the accessible surfaces of these materials. Systematic static alpha and beta measurements will be collected from the surfaces. Additional measurements and swipe samples will be collected at floor penetrations and locations where the investigation level is exceeded. Materials identified as having contamination present above the levels specified in Table 2-1 will be remediated and packaged for subsequent storage and disposal (Section 2.2.5).

If flooring is removed to the joist, the flooring area will be removed from the survey unit. RASSs or characterization surveys will be performed on the open floor joists to the extent that the structural integrity of the building will be maintained.

3.7 Drainage Systems

Drain systems will be surveyed independently of the Class 1 and Class 2 survey units. Swipe samples will be collected from inside accessible drain lines and from the accessible exterior surfaces of drain lines with inaccessible internals (such as sink drains or capped drains). Sediment samples, if available, will be collected for analysis. Alpha, beta, and gamma scan measurements will also be collected along the accessible exterior surfaces of drain lines.

3.8 Ventilation Systems

Ventilation systems within Class 1 survey units will be surveyed as follows. One hundred percent scan surveys for alpha and beta radiation will be conducted on the exterior and interior surfaces of ventilation systems. Biased static alpha and beta measurements will be collected from the exterior and interior surfaces of the ventilation systems.

Ventilation systems present in the Class 2 area will be surveyed as part of the Class 2 survey units. Scan surveys for alpha and beta radiation will be conducted on the accessible exterior and interior surfaces of ventilation systems. Biased static alpha and beta measurements will be collected from the accessible exterior and interior surfaces of the ventilation systems.

While performing the ventilation system surveys, particular emphasis will be placed on collecting survey data from likely accumulation points and areas that produce elevated scan measurement results.

3.9 Equipment and Materials

The radiological survey of equipment and material will be conducted in accordance with SOP NAVSTA PS-Tt-009, Release of Materials and Equipment from Radiologically Controlled Areas. Survey and swipe sampling data will be compared to the release criteria listed in Table 2-1. Materials identified as having contamination present above the levels specified in Table 2-1 will be packaged for subsequent decontamination, or storage and disposal as LLRW (Section 2.2.5).

3.10 Media Samples

Swipe samples will be collected from each of the specified systematic and biased locations in the survey units, from equipment and materials, and from within the ventilation and drainage systems. Where sufficient material is present, media samples (e.g., dust or sediment) will also be collected from ventilation systems (except dust), drainage systems, and other low-lying locations identified in the field where contaminants might accumulate. Additional samples may also be

collected based on scan survey results. Samples will be collected using SOP NAVSTA PS-Tt-006, Sampling Procedures for Radiological Surveys. If requested, additional sample volume will be collected following the same procedure and made available for analysis by the Washington State Department of Health.

Alpha/beta radiation analyses will be performed using a low background gas-flow proportional counter or Ludlum Model 2929 (or equivalent) swipe counter. Gamma radiation analyses will be performed by gamma spectroscopy.

Soil samples will be collected during the performance of work under this TSP. The samples will be analyzed for gamma spectroscopy at an off-site laboratory for Ra-226 and Cs-137. One hundred percent of soil samples collected for an FSS will be analyzed for Sr-90 at an off-site laboratory. Additionally, soil samples collected for characterization or remediation of Sr-90 will be analyzed for Sr-90 at an off-site laboratory. Samples collected only for characterization or remediation of Ra-226 and/or Cs-137 do not need to be analyzed for Sr-90.

3.11 Actions If Additional Activity Is Discovered

If areas of elevated activity are observed during the survey, additional characterization and remediation will be performed, as described in Section 2.0. Each new area will be subjected to an FSS as described previously in this TSP. Any additional areas will be mapped and submitted with the final report.

4.0 SITE REPORT

Results of the survey that demonstrate that the net residual dose of Buildings 2 and 27 is less than 15 mrem/y will be presented separately in building-specific FSS Reports. Any conclusion, other than a recommendation for unrestricted release, will be presented in a characterization report. Further surveys and remedial activities will not be conducted under this TSP without consent to the modification from the RSOR in consultation with the RASO.

Separate reports may be issued for each building.

4.1 Dose Modeling in Support of Unrestricted Release

The intent of the Buildings 2 and 27 surveys is to achieve unrestricted release for each building. To accomplish this goal, it was necessary to provide a means for calculating residual dose to the critical group; the residential scenario in RESRAD-BUILD was selected for this purpose.
The only modification to the default scenario presented in RESRAD-BUILD will be to select the appropriate values for Cs-137, Ra-226, (with lead-210 assumed to be in secular equilibrium) and Sr-90 contamination, and the appropriate room measurements.

5.0 QUALITY CONTROL

The DQOs for the survey are provided in Table 5-1.

Definable features of work (DFWs) establish the measures required to verify both the quality of work performed and compliance with project requirements. The DFW for this task is radiological surveys and associated sample results. A description of this DFW and the associated phases of quality control is presented in Table 5-2.

6.0 ENVIRONMENTAL PROTECTION

Environmental protection-driven requirements addressed in the Radiological Removal Action Work Plan apply. No additional requirements are necessary.

7.0 REFERENCES

Department of Defense (DoD), Department of Energy, Nuclear Regulatory Commission (NRC), and U.S. Environmental Protection Agency (EPA). 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) NUREG-1575. August.

Navy (Department of the Navy). 1943. Drawing Number 54080. First & Second Floor Plans, Additions to Bldg. No. 27, Naval Air Station, Seattle, Washington. November 22.

———————. 1975. Drawing Number 54141. Training Facility, Construction Battalion, Building 27, Department of the Navy, Naval Support Activity, Seattle, Washington, Drawing 3602. March.

———————. 1985. Drawing Number 54151. Floor Plan Bldg. No 27, Reserve Naval Mobile Construction Battalion Eighteen. August.

Shaw (Shaw Environmental & Infrastructure, Inc.). 2011. Final Radiological Remedial Investigation Report, Former Naval Station Puget Sound, Seattle, Washington. May.

———————. 2013. Final Action Memorandum. Former Naval Station Puget Sound, Seattle, Washington. May.

TtEC (Tetra Tech EC, Inc.). 2013. Final Accident Prevention Plan/Site Safety and Health Plan, Radiological Materials Time-Critical Removal Action. Former Naval Station Puget Sound, Seattle, Washington. July.

URS (URS Consultants, Inc.). 1996. Environmental Baseline Survey, Naval Station Puget Sound, Seattle, Washington. January.

This page intentionally left blank.

TABLES

This page intentionally left blank.

TABLE 2-1

BUILDINGS 2 AND 27 PRIMARY RADIATION PROPERTIES AND RELEASE CRITERIA FOR RADIONUCLIDES OF CONCERN

Radionuclide	Primary Radiation Properties		Release Criteria		
			Building Surfaces/Materials and Equipment Wastes		
	Half-life (years)	Type	Total Surface Activity[a]	Removable Activity[a]	Dose Based Release Criteria [b, c, d] (pCi/g)
Cesium-137	30.17	Beta Gamma	5,000	1,000	25.63
Radium-226	1,600	Alpha Gamma	100	20	1.07
Strontium-90	28.8	Beta	1,000	200	9.45

Notes:

[a] Units are disintegrations per minute per 100 square centimeters.

[b] Release criteria are taken from the Action Memorandum (Shaw 2013) (values do not include background).

[c] The resulting dose is based on 15 mrem/year using RESRAD Version 6.5.

[d] Release criteria for soil/sediment are the summation of the dose-based concentration guideline (15 mrem/year) and the mean background. A background investigation and establishment of site background levels will be conducted prior to implementation of the time-critical removal action.

Abbreviations and Acronyms:

pCi/g – picocuries per gram

This page intentionally left blank.

TABLE 5-1

SUMMARY OF DATA QUALITY OBJECTIVES

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
Statement of Problem	**Decisions**	**Inputs to the Decisions**	**Boundaries of the Study**	**Decision Rules**	**Limits on Decision Errors**	**Optimize the Sampling Design**
Buildings 2 and 27 are listed as areas impacted by radiological activities. The radionuclides of concern (ROCs) are Ra-226, Cs-137, and Sr-90. Whether the site-specific release criteria for these ROCs have been met or whether remediation is warranted must be determined.	The primary use of the data expected to result from completion of this TSP is to support the Final Status Surveys of Buildings 2 and 27. Therefore, the decision to be made can be stated as, "Do the results of the survey meet the release criteria?"	Radiological surveys required to support the Final Status Surveys of Buildings 2 and 27 include: • 100 percent alpha/beta/gamma scan surveys of Class 1 survey units • 50 percent alpha/beta scan surveys of Class 2 survey units • A minimum of 20 systematic exposure rate and alpha/beta measurements collected in each Class 1 and Class 2 survey unit	The boundaries of Buildings 2 and 27 are shown on Figures 3-1 and 3-2. The spatial boundaries are consistent with future work in the immediate area.	If the results of the survey meet the release criteria, the data will be used to support a Final Status Survey. Otherwise, the data with be used for remediation followed by subsequent surveys until the release criteria are met.	Limits on decision errors are set at 5 percent, unless double sampling is determined to be necessary; then the alpha error is reduced to 2.5 percent, as specified in the Radiological Removal Action Work Plan.	Operational details for the radiological survey process have been developed. The theoretical assumptions are based on guidelines contained in MARSSIM. Specific assumptions regarding types of radiation measurements, instrument detection capabilities, quantities and locations of data to be collected, and investigation levels are contained in this TSP and the Radiological Removal Action Work Plan.

Abbreviations and Acronyms:
Cs-137 – cesium-137
MARSSIM – Multi-Agency Radiation Survey and Site Investigation Manual
Ra-226 – radium-226
ROC – radionuclide of concern
Sr-90 – strontium-90
TSP – Task-specific Plan

This page intentionally left blank.

TABLE 5-2

DEFINABLE FEATURES OF WORK FOR RADIOLOGICAL SURVEYS

ACTIVITY	PREPARATORY (Prior to initiating survey activity)	DONE	INITIAL (At outset of survey activity)	DONE	FOLLOW-UP (Ongoing during survey activity)	DONE
Radiological surveys	• Verify that an approved TSP is in place. • Verify that the Remedial Project Manager is notified about mobilization. • Verify that an approved RWP is available and has been read and signed by assigned personnel. • Verify that Radiological Removal Action Work Plan, Site Safety and Health Plan, TSP, and AHAs have been reviewed. • Verify that assigned personnel are trained and qualified. • Verify that personnel have been given an emergency notification procedure. • Verify that workers assigned dosimetry have completed NRC Form 4. • Verify that the relevant SOPs and/or manufacturers' instructions are available and have been reviewed for equipment to be used for radiological surveys. • Verify that equipment is on-site and is in working order (initial daily check).		• Verify that radiological instruments are as specified in the Radiological Removal Action Work Plan and TSP. • Inspect training records. • Verify that a qualified RCT and SSHO are present at active work areas. • Verify that site activities are being photographed. • Verify that the reference area measurements have been obtained using the procedure described in the Radiological Removal Action Work Plan and in Section 3.2 of this TSP, which states that the same survey methodology and instruments used to collect the background data will be used to perform measurements within survey units. • Verify that daily checks were performed on all portable survey instruments per SOP NAVSTA PS-Tt-004. • Verify that radiological instrument calibrations and setup are current per SOP NAVSTA PS-Tt-004. • Verify that required dosimetry is being worn. • Verify that field logbooks, proper forms, and chain-of-custody documents are in use. • Verify that samples and measurements are being collected in accordance with the TSP, the Radiological Removal Action Work Plan, and relevant SOPs. • Verify that sample handling and analyses are in accordance with the Radiological Removal Action Work Plan and applicable SOPs.		• Verify that site is properly posted and secured, if necessary. • Conduct ongoing inspection of material and equipment. • Verify that a qualified RCT and SSHO are present at active work areas. • Verify that daily instrument checks and background measurements were obtained and documented. • Verify that survey and sample analysis results are documented. • Verify that personnel have read and signed the revised RWP, if revision is required. • Inspect sample chain-of-custody and survey log for completeness. • Verify that survey and analytical activities conform to the Radiological Remedial Action Work Plan, SAP, TSP, and SOPs. • Verify that survey instruments are recalibrated after repairs or modifications. • Verify that site activities are being photographed. • Verify that survey documentation is reviewed by the RTS.	

TABLE 5-2

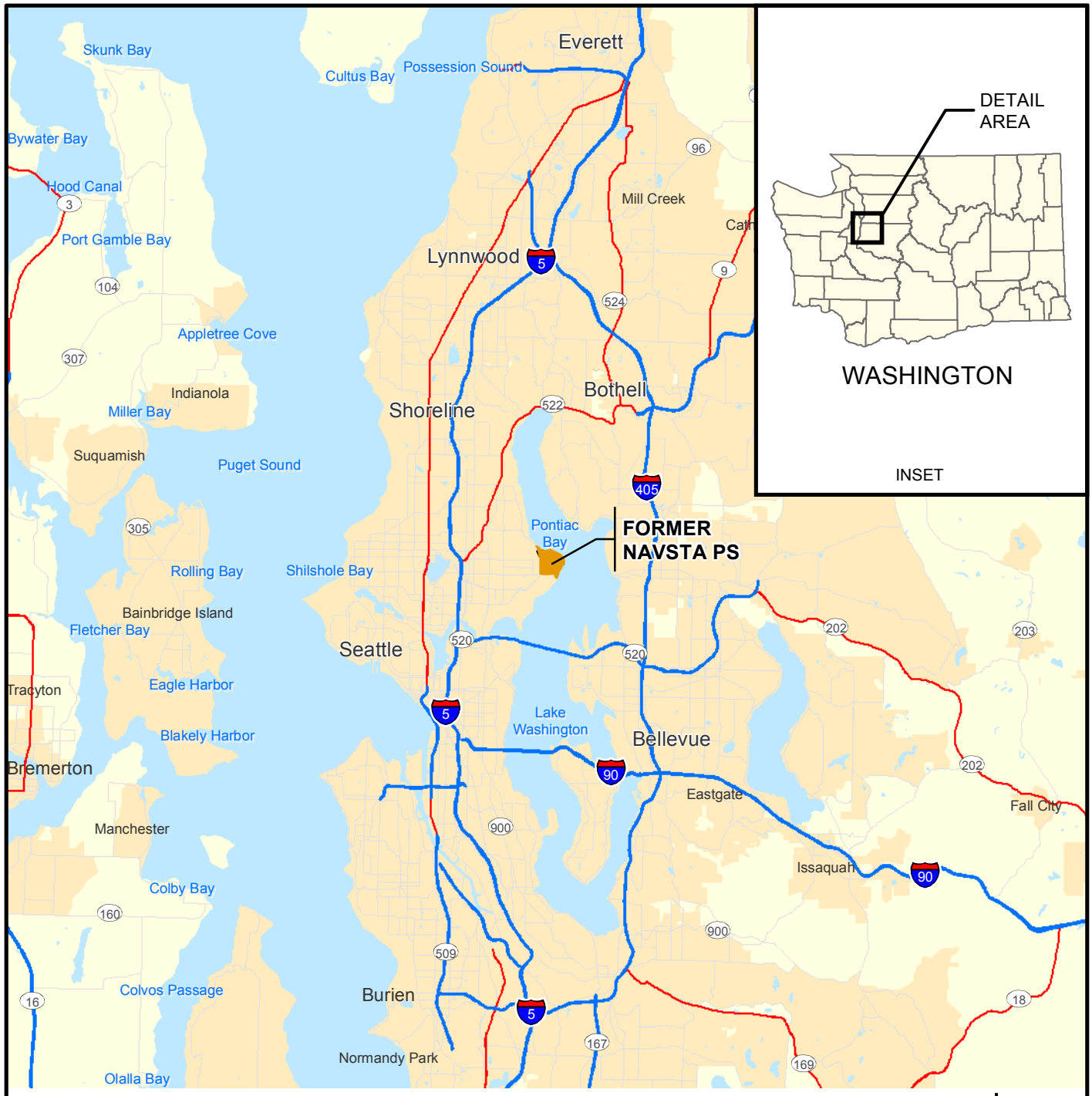
DEFINABLE FEATURES OF WORK FOR RADIOLOGICAL SURVEYS

Abbreviations and Acronyms:

AHA – Activity Hazard Analysis
NRC – Nuclear Regulatory Commission
RCT – Radiological Control Technician
RTS – Radiological Task Supervisor
RWP – Radiation Work Permit
SOP – Standard Operating Procedure
SSHO – Site Safety and Health Officer
TSP – Task-specific Plan

FIGURES

This page intentionally left blank.



LEGEND

- STATE HIGHWAY
- INTERSTATE HIGHWAY
- WATER

2.5 0 2.5 5 Miles

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 & 27
REMEDIAL ACTION SUPPORT & FINAL STATUS SURVEYS

FIGURE 1-1

REGIONAL LOCATION MAP

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7560.mxd

TETRA TECH EC, INC.

LEGEND

PROJECT SITE

1,000 0 1,000 Feet

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 & 27
REMEDIAL ACTION SUPPORT & FINAL STATUS SURVEYS

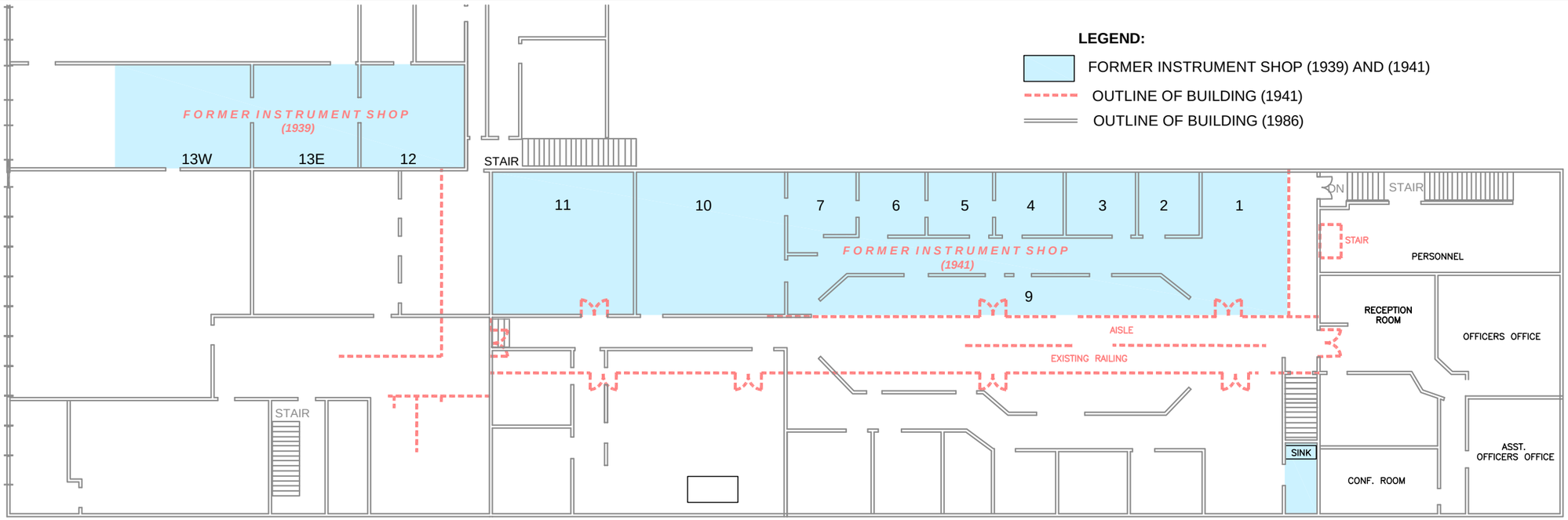
FIGURE 1-2

SITE LOCATION MAP

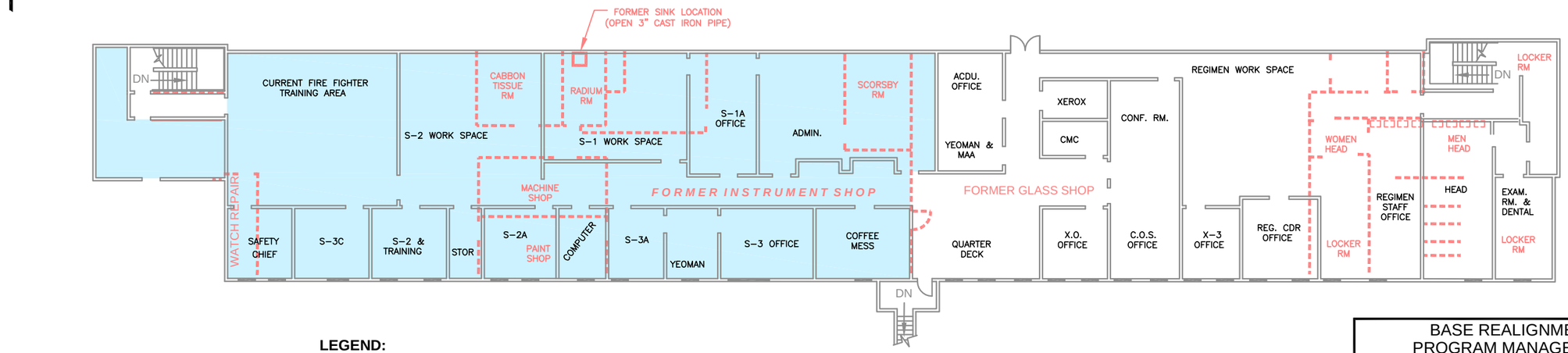
FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7561.mxd

TETRA TECH EC, INC.



SECOND FLOOR PLAN BUILDING 2



LEGEND:

- FORMER INSTRUMENT SHOP AREAS
- OUTLINE OF BUILDING (1943)
- OUTLINE OF BUILDING (1985)

SECOND FLOOR PLAN BUILDING 27

SCALE
0 10 20 FEET

SOURCE: US NAVAL STATION, SEATTLE WASHINGTON
BUILDING 27 PLAN - 1985 (DRAWING #54151)
1943 (DRAWING #54080)

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 & 27
REMEDIAL ACTION SUPPORT & FINAL STATUS SURVEYS

FIGURE 1-3

BUILDINGS 2 & 27 HISTORICAL INSTRUMENT SHOP LOCATIONS

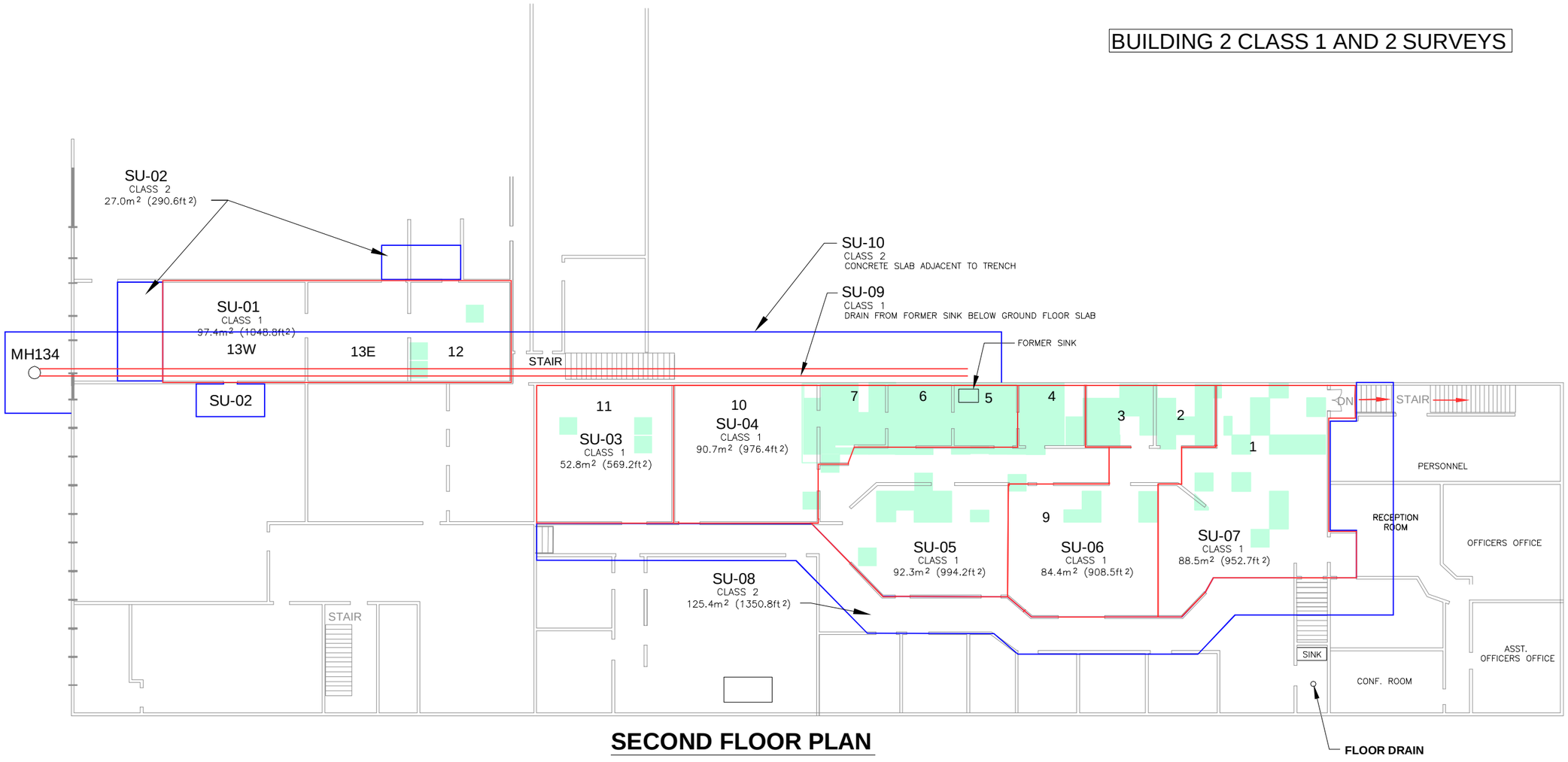
FORMER NAVAL STATION PUGET SOUND, SEATTLE WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

P:\CAD PROJECT FILES\SAND POINT NAVAL STATION PUGET SOUND\FIGURE 1-3.DWG
PLOT/UPDATE: APR 05 2012 07:01:51

BUILDING 2 CLASS 1 AND 2 SURVEYS



SECOND FLOOR PLAN

LEGEND:

- ABOVE PROJECT CLEANUP CRITERIA
- CLASS 1 SURVEY
- CLASS 2 SURVEY

SCALE
0 10 20 FEET

SOURCE: US NAVAL STATION, SEATTLE WASHINGTON
BUILDING 2 PLAN - 1986 (DRAWING #50263)
1941 (DRAWING #50106)
1939 (DRAWING #50030)

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 & 27
REMEDIAL ACTION SUPPORT & FINAL STATUS SURVEYS

FIGURE 3-1

BUILDING 2 CLASS 1 AND 2 SURVEYS

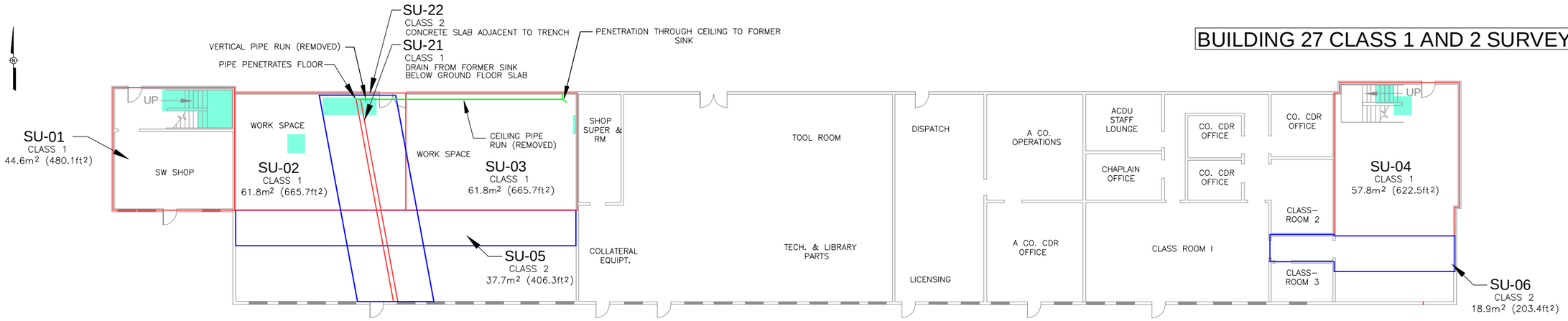
FORMER NAVAL STATION PUGET SOUND, SEATTLE WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

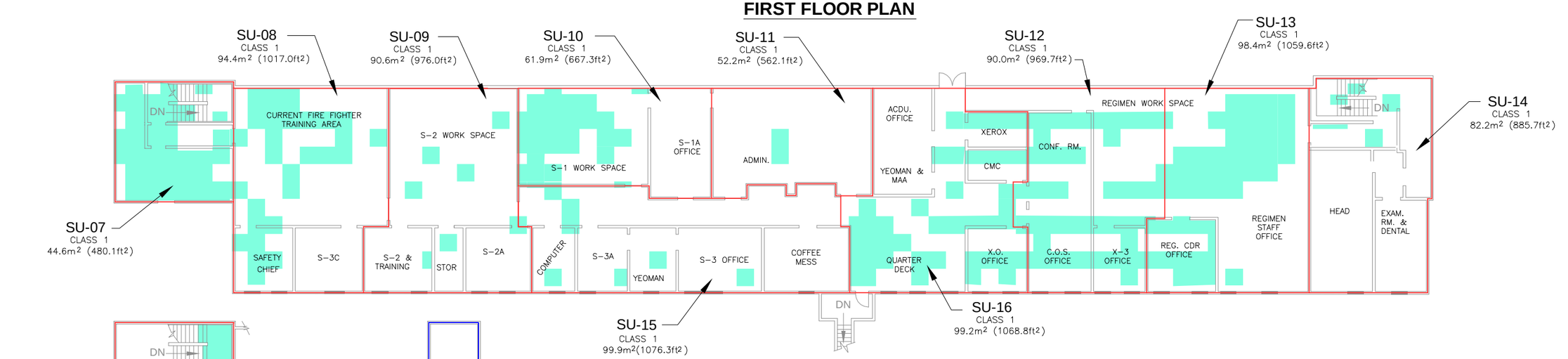
TETRA TECH EC, INC.

P:\CAD PROJECT FILES\SAND POINT NAVAL STATION PUGET SOUND CAD FILES\BUILDING 2 SECOND FLOOR.DWG
PLOT/UPDATE: JUN 25 2013 13:14:07

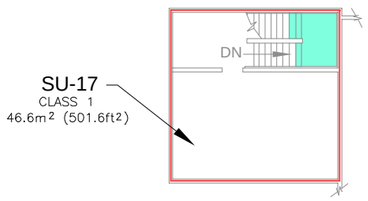
BUILDING 27 CLASS 1 AND 2 SURVEYS



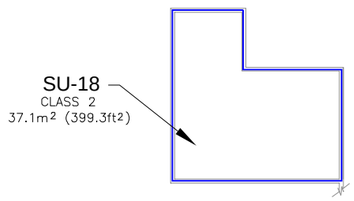
FIRST FLOOR PLAN



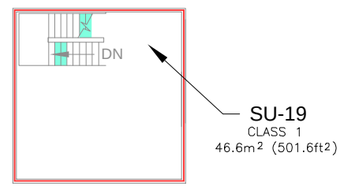
SECOND FLOOR PLAN



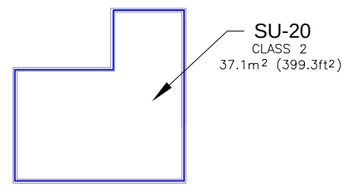
THIRD FLOOR PLAN SW TOWER



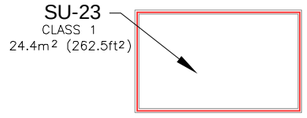
FOURTH FLOOR PLAN SW TOWER



THIRD FLOOR PLAN SE TOWER



FOURTH FLOOR PLAN SE TOWER



MECHANICAL ROOM PENTHOUSE

SCALE
0 10 20 FEET

SOURCE: US NAVAL STATION, SEATTLE WASHINGTON
BUILDING 27 PLAN - 1985 (DRAWING #54151)
1943 (DRAWING #54080)

LEGEND:

- ABOVE PROJECT CLEANUP CRITERIA
- CLASS 1 SURVEY
- CLASS 2 SURVEY

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TASK-SPECIFIC PLAN FOR THE BUILDINGS 2 & 27
REMEDIAL ACTION SUPPORT & FINAL STATUS SURVEYS

FIGURE 3-2

BUILDING 27 CLASS 1 AND 2 SURVEYS

FORMER NAVAL STATION PUGET SOUND, SEATTLE WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

P:\CAD PROJECT FILES\SAND POINT NAVAL STATION PUGET SOUND CAD FILES\BUILDING 27 FLOOR PLAN.DWG
PLOT/UPDATE: JUL 02 2013 06:54:20

ATTACHMENT 8

RADIATION PROTECTION PLAN

This page intentionally left blank.

U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98315-1101

CONTRACT NO. N62473-10-D-0809
CTO NO. 0011

ATTACHMENT 8

FINAL

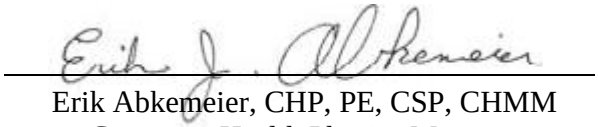
RADIATION PROTECTION PLAN

July 2013

RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION
AT FORMER NAVAL STATION PUGET SOUND
SEATTLE, WASHINGTON

Prepared by:

TETRA TECH EC, INC.
1230 Columbia Street, Suite 750
San Diego, California 92101-8536



Erik Abkemeier, CHP, PE, CSP, CHMM
Corporate Health Physics Manager

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

APPENDICES

This page intentionally left blank.

ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
APP	Accident Prevention Plan
CFR	*Code of Federal Regulations*
CHPM	Corporate Health Physics Manager
DAC	derived air concentration
DOT	U.S. Department of Transportation
EHS	environmental health and safety
MOU	Memorandum of Understanding
NRC	U.S. Nuclear Regulatory Commission
PjM	Project Manager
PPE	personal protective equipment
QC	quality control
Ra-226	radium-226
RASO	Radiological Affairs Support Office
RCA	Radiologically Controlled Area
RCT	Radiological Control Technician
RMA	Radioactive Materials Area
RML	Radioactive Material License
RPG	Radiation Protection Guidance
RPP	Radiological Protection Plan
RSO	Radiation Safety Officer
RSOR	Radiation Safety Officer Representative
RTS	Radiological Task Supervisor
RWP	Radiation Work Permit
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
TEDE	total effective dose equivalent
TIP	Task Initiation Procedure
TtEC	Tetra Tech EC, Inc.
VPESQ	Vice President for Environmental Safety and Quality Services
WAC	*Washington Administrative Code*

This page intentionally left blank.

1.0 PURPOSE/INTRODUCTION

This Radiation Protection Plan (RPP) details Tetra Tech EC, Inc's. (TtEC's) requirements for activities conducted under Radioactive Material License (RML) No. 29-31396-01, issued and subject to regulatory enforcement by the U.S. Nuclear Regulatory Commission (NRC), under reciprocity with the state of Washington. The following activities are subject to this RPP: project activities that involve the use and/or handling of licensed by-product, source, and/or special nuclear material (hereafter referred to as radioactive material); tasks with the potential for radioactive material to be present based on available data and historical records; and work in locations posted and controlled because of radioactive material. Project activities will incorporate the requirements within to maintain compliance in parallel with the current version of corporate procedure RP1-1, Radiological Protection Program.

Project activity performance steps are detailed in site-specific Work Plans, e.g., Standard Operating Procedures (SOPs), Work Instructions, and Task-Specific Plans. (Agencies that may have jurisdiction or an interest in project activities are also identified in such documents.) Project staff tasked to perform assignments involving the presence of radioactive material (i.e., those identified in the applicable portions of Section 2.0) will complete a review of this document and indicate an understanding of all requirements by completing a Radiation Protection Plan Acknowledgement Form (Appendix A).

For the purposes of this RPP, the Navy means U.S. Department of the Navy, Naval Facilities Engineering Command Northwest; U.S. Department of the Navy, Base Realignment and Closure, Program Management Office West; and Naval Sea Systems Command Detachment, Radiological Affairs Support Office (RASO).

1.1 POLICY

It is TtEC's policy that work with radioactive material be purposeful and performed in a manner that protects project staff, members of the general public, and the environment. Radiologically oriented work may not begin unless it can be performed in a safe and reliable manner that is compliant with the exposure reduction rules, regulations, and principles described in Section 1.3.

1.2 PROJECT-SPECIFIC RADIATION PROTECTION PLAN

Corporate procedure RP1-1, Radiological Protection Program, provides the foundation for the RPP and its use for any project or activity that involves the possession or use of radioactive material, including the subsequent potential for exposure to ionizing radiation. Content provided within this RPP reflects corporate policy and provides the guidance needed for project management to execute the scope of work in a safe manner. Site-specific guidance for radiological safety and control is further detailed in SOPs. SOPs are subject to approval by the Radiation Safety Officer (RSO) or designee and authorized for use as indicated on a Radiation

Protection Program SOP Crossover Document. This document may be revised separately from the RPP. A current copy for each viable project is available upon request. The RSO is also the company's Corporate Health Physics Manager (CHPM).

1.3 AS LOW AS REASONABLY ACHIEVABLE

Work involving radioactive material and any corresponding exposure to ionizing radiation must be purposeful and performed in a manner sufficient to ensure the protection of staff, members of the public, and the environment. TtEC applies industry recognized principles to radiological work so that exposure to ionizing radiation is maintained in accordance with corporate procedure NLP-01, As Low As Reasonably Achievable (ALARA) Program.

1.4 AUTHORIZATION TO STOP WORK

In accordance with corporate procedure RP1-1, Radiological Protection Program, and as detailed in Section 2.9, employees are authorized to stop work if an unsafe condition exists or safety protocol is being violated, and immediately report the condition to project management.

Work performed under a Radiation Work Permit (RWP) will stop, and the RASO, the Washington State Department of Health, and the Washington State Department of Ecology will be notified if any of the following atypical work site conditions are encountered:

- An individual total effective dose equivalent (TEDE) exceeding 500 millirems
- The collective TEDE for the job exceeding 1 rem
- Individual airborne exposures exceeding 10 derived air concentration (DAC) hours in a 7-day period
- General area exposure rates exceeding the limits of current radiological posting
- Contamination levels exceeding 100 times the limits, requiring classification of an area as a Contaminated Area

In cases where the Navy must be notified, the license RSO, with concurrence from the Navy's Radiological Environmental Protection Manager, RASO, must approve the RWP prior to restarting work.

1.5 SCOPE OF WORK

The scope of work involves the following activities:

- Task-specific training of personnel
- Site controls and establishment of work zones at sites with, or having the potential for, radioactive commodities or contaminants

- Handling and management of collected radioactive commodities, radiologically contaminated soil, construction and building materials, or other associated radiologically contaminated material
- Site investigation and remediation including characterization surveys and sampling; excavation; demolition; screening for and removal of commodities, and building and construction materials; and surveys and sampling to document final conditions

1.6 QUALITY CONTROL AND AUDITING

To maintain continued compliance and evaluate overall RPP effectiveness, quality control (QC) measures including self-assessment and management reviews will be used. Formal audits, including those conducted at field projects, will be coordinated and tracked to completion by the RSO as will any need for adjustments to audit frequencies.

1.6.1 Self-Assessment, Management Reviews, and Audits

A self-assessment and management review of RPP use, as detailed in corporate procedure NLP-08, Radiation Protection Program Audits, will be conducted. Project personnel including the Project Manager (PjM), project Radiation Safety Officer Representative (RSOR), and on-site personnel will support and cooperate with any audit conducted.

1.6.2 Responses and Corrective Actions

Radiological deficiencies must be responded to in a timely fashion. Deficiencies that represent an imminent threat to radiological control or safety (e.g., compromise of procedural protocol) will be immediately reported to the RSOR, RSO, and PjM or designee(s). Subsequent corrective actions will be tracked to completion by the RSO or designee. Radiological deficiencies, including corrective actions, will be promptly reported by the RSO to the Navy. Responses to findings will be submitted to the RSO or designee for review, approval, and final disposition.

1.6.3 Daily Instrumentation Check

As addressed in Section 3.16, survey instruments procured for field use will have proof of current calibrations in accordance with the manufacturers' procedures, employing applicable standards and sources traceable to the National Institute of Standards and Technology. Copies of instrument calibration certificates will be maintained on-site for reference. Instruments will be response-checked daily in accordance with applicable SOPs. (In addition to the manufacturers' instruction manuals, typical project instruments and their performance characteristics are identified in site-specific controlling documents such as a site-specific Radiological Work Plan.)

This page intentionally left blank.

2.0 RADIATION PROTECTION PERSONNEL

This section details the radiological safety responsibilities vested with key personnel within the project. (Nonradiological safety responsibilities will be detailed in a separate project-specific Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP). Reporting relationships between TtEC support personnel and the client will be referenced in a site-specific controlling document as well (e.g., Radiological Removal Action Work Plan).

2.1 VICE PRESIDENT FOR ENVIRONMENTAL SAFETY AND QUALITY SERVICES

The Vice President for Environmental Safety and Quality Services (VPESQ) has overall responsibility for TtEC's safety operations. The VPESQ is responsible for:

- Ensuring proper maintenance of the RPP consistent with applicable regulatory mandates, TtEC corporate policy, and recognized industry practice
- Establishing and maintaining all necessary management oversight specific to the RPP
- Implementing a management review process to ensure applicable use of RPP requirements

2.2 LICENSE RADIATION SAFETY OFFICER (CORPORATE HEALTH PHYSICS MANAGER)

The CHPM (also referred to as the RSO) is appointed by the VPESQ as the senior health physicist and the Health Physics Resource Manager for TtEC. The CHPM is responsible for:

- Reviewing and making recommended revisions to:
  - The RPP, RML procedures, radiation protection guidelines, and supporting documents
  - Project plans involving the use or handling of radioactive materials, or access to areas of radiological concern to ensure compliance with RPP requirements and supporting guidelines
- Acting as the Health Physics Resource Manager, also referred to as the corporate-level or license RSO
- Designating a Project Health Physicist, also referred to as the project-level RSOR, to provide day-to-day guidance on radiological protection issues
- Complying as the license RSO with RML No. 29-31396-01, including:
  - Primary point of contact for all communications to the NRC and Washington State Department of Health
  - Identification and training of RML authorized users
  - Assignment of project RSORs

  - Coordination of investigations involving radiological occurrences to include review and approval of a resulting Corrective Action Plan
  - Advance NRC notification in writing at least 14 days before initiating at a temporary job site under TtEC RML jurisdiction any activity, or change to scope involving new activities, in areas of radiological concern (excluding routine packaging or repackaging for purposes of transporting and not requiring a job- or site-specific work package, and characterization and/or final surveys where radioactive materials and/or radiation are not likely to be detected)
  - Refraining from taking ownership of licensed materials in excess of possession limits without prior notification and written NRC approval
  - Advance NRC notification in writing within 30 days of the temporary job site completion status involving decontamination and decommissioning activities, and disposition of any licensed material as related to RML jurisdiction
  - Placement of reciprocity request with applicable Agreement States when necessary
  - Maintenance of radiological exposure records
  - Development and/or approval of radiation safety training materials and/or courses
  - Performance of program audits as detailed in corporate procedure NLP-08, Radiation Protection Program Audits
  - Providing guidance on radiological protection issues
  - Identification of appropriate project staffing needs to implement RPP requirements
  - Assistance with the development of site Environmental Health and Safety (EHS) plans and approval of EHS plans for projects that involve the use or handling of radioactive materials or access to areas of radiological concern
  - Resource Specialist review for Task Initiation Procedures (TIPs) for proposed projects involving exposure to radiation or radioactive materials
- Delegating project responsibilities to other company health physicists (also referred to as RSORs), as necessary

2.3 PROJECT RADIATION SAFETY OFFICER REPRESENTATIVE (PROJECT HEALTH PHYSICIST)

The project RSOR, also referred to as the Project Health Physicist, is assigned by the RSO and vested with corporate-level authority to implement the RPP and the TtEC RML at a project site. Whenever radiological work is actively ongoing under the TtEC RML, the RSOR or designee identified as an authorized user will be present at the project site. The RSOR is vested with the following responsibilities at projects subject to jurisdiction involving the TtEC RML:

- Providing health physics guidance on an as-needed basis
- Conducting required radiological safety training

- Reviewing and approving project field procedures that involve the handling of radioactive materials or access to areas of radiological concern
- Conducting radiation incident investigations and project inspections
- Maintaining a project site file that details radiological protection training provided, dosimetry records generated, radiological surveys performed, and other documentation pertinent to the RPP, RML procedures, radiation protection guidelines, and supporting documents; copies of these will be provided to the CHPM at the conclusion of the project
- Arranging for and assisting in program radiation protection audits as detailed in the most current version of corporate procedure NLP-08, Radiation Protection Program Audits
- Assisting in the development and approval of the site EHS plan
- Helping in the identification of project radiological analysis needs and selection of analytical support contractors
- Coordinating required ALARA reviews
- Ensuring appropriate staff work practices are employed to maintain occupational radiation exposures ALARA
- Ensuring items needed to perform work in accordance with the RPP, RML, and supporting documents are available, such as appropriate instrumentation, protective devices, dosimetry, etc.
- Directing the preparation of, and performing the review and approval of, RWPs
- Stopping work if necessary to ensure radiological safety
- Communicating with the PjM and RSO as needed to ensure the RPP is implemented correctly
- Ensuring proper operation of radiation-measuring equipment, including the performance of daily function and QC tests, and removing out-of-compliance instruments from service
- Maintaining radiation-measuring equipment in accordance with manufacturers' recommendations
- Directing and supervising the performance of radiological surveys and sampling in accordance with the most current version of this RPP and supporting TtEC SOPs
- Reviewing survey reports and instrument performance data for accuracy, completeness, and compliance with project, procedural, and regulatory requirements
- Ensuring work is performed in accordance with current versions of project plans, procedures, and the RPP

The project RSOR reports to and receives technical direction from the RSO, advises the PjM on radiation protection and radiological operation matters, coordinates with the PjM on day-to-day project activities, and communicates and coordinates radiation protection and radiological operation activities with the RSO and the client. Company Health Physicists (also referred to as RSORs) may delegate project responsibilities to other staff members deemed qualified for the task assigned.

2.4 PROJECT MANAGER

The PjM is responsible for:

- Ensuring implementation of and compliance with the RPP requirements and current versions of the following support documents applicable to the project:
  - TtEC RML procedures (i.e., applicable NRC License Procedures)
  - TtEC Radiation Protection Guidance (RPG) documents
- Forwarding any TIP or modified TIP involving exposure to ionizing radiation or radioactive material to the RSO or designee for input and review (involvement includes the use of subcontractors who may use radioactive materials or radiation-generating devices in the course of corresponding work such as field radiography, soil density gauges, well logging, etc.)
- Determining with the assistance of the RSO or designee if the project is required to use the TtEC RML or other license
- The safe conduct of work in compliance with all permits, client contracts, and other controlling documents that apply
- Exposure to radiation ALARA by project staff
- Adequate resources and staffing to develop and implement this RPP in compliance with applicable regulations and requirements

The PjM reports to the TtEC Program Manager.

2.5 PROJECT SUPERINTENDENT

Responsibilities for the Project Superintendent include:

- Ensuring assigned personnel comply with radiological requirements
- Supplying relevant information to the RSOR regarding planned work activities and proposed applications necessary to maintain occupational radiation exposures ALARA
- Timely RSOR and PjM notification of radiological problems or issues encountered
- Verifying staff is sufficiently prepared for assigned tasks (e.g., appropriate tools and equipment needed to minimize the time spent in areas of radiological concern)

- Confirming that escorted visitors accessing areas of radiological concern are properly supervised and exhibiting safe work practices in accordance with RPP protocol

The Project Superintendent reports to the PjM.

2.6 RADIOLOGICAL TASK SUPERVISOR

The Radiological Task Supervisor (RTS) is the TtEC representative responsible for Radiological Control Technician (RCT) oversight and corresponding field operations conducted in areas of radiological concern. Designated as an authorized user at projects subject to jurisdiction under the TtEC RML, the RTS is vested with the following responsibilities:

- Supporting required ALARA reviews
- Coordinating plans for field activities with the Project Superintendent to ensure exposure to radiation is maintained ALARA and in accordance with corresponding RWPs
- Supervising the preparation of, and performing review of, RWPs
- Stopping work if necessary to ensure radiation safety
- Maintaining communication with the RSO, RSOR, PjM, and Project Superintendent as needed to ensure the RPP is fully implemented
- Confirming proper operation of radiation survey instruments, including the validation of daily function and QC checks, and removing noncompliant instruments from service
- Ensuring radiation survey instruments are maintained in a way that complies with manufacturer instructions and recommendations
- Directing and supervising the performance of radiological survey and sampling practices in accordance with the RPP, current versions of applicable SOPs, and corresponding RWPs
- Validating field survey reports and instrument performance data for accuracy, completeness, and compliance with the RPP, applicable SOPs, and corresponding RWPs
- Participating in periodic internal and external reviews of RPP content and implementation
- Supporting self-assessments and management reviews as needed and correcting identified deficiencies within the allotted time frame

The RTS reports to and receives technical direction from the RSOR.

2.7 RADIOLOGICAL CONTROL TECHNICIANS

The RCTs are responsible for:

- Ensuring occupational exposure to radiation is maintained ALARA
- RWP preparation, use, and adherence
- Stopping work if necessary to ensure radiological safety
- Performing radiation surveys and other radiological safety tasks in accordance with the RPP, applicable SOPs, and corresponding RWPs
- Confirming proper operation of assigned radiation survey instruments prior to field use to include verification of daily function and QC performance checks, and removing noncompliant instruments from service
- Using radiation survey instruments in accordance with the RPP, applicable SOPs, and corresponding RWPs and maintaining the instruments in a way that complies with manufacturers' instructions and recommendations

The RCTs report to and receive technical direction from the RTS.

2.8 RADIATION WORKERS (FIELD PERSONNEL)

Project staff (including the general labor force associated with TtEC and subcontractors) who have the potential to receive occupational exposure to radiation while on the job site, and who are expected to work under the requirements of this RPP as radiation workers, will:

- Receive sufficient training, prior to beginning work, in accordance with the most current version of corporate document RPG 2-5, Radiation Safety Training.
- Report to the RTS or RCT non-occupational radiation exposures that result from the use of medical or dental applications more aggressive than a standard X-ray.
- Comply with requirements of all procedures and guidelines applicable to the project.
- As required, exercise stop work authority and report radiological safety issues or concerns, including incidents and unplanned events, immediately to project management and Environmental Safety and Quality staff in writing, verbally, or with a Zero Incident Performance® slip; respond promptly to any stop-work and/or evacuate orders.
- Display use of industry recognized radiological work practices when inside areas of radiological concern, and conform promptly to instructions when provided by RCTs.
- Strictly adhere to radiological control procedures, guidelines, and postings including information provided in RWPs.
- Immediately report lost dosimetry devices to the RCT.
- Report planned medical radiation treatments in advance to supervision and the project RSOR and prior to entering areas of radiological concern or wearing dosimetry.

- Periodically confirm personal radiation exposure status and ensure that administrative dose guidelines are not exceeded.
- Notify the RCT of faulty or alarming radiological protection equipment.

When in areas of radiological concern, workers report to the RTS.

2.9 STOP WORK AUTHORITY

TtEC and subcontractor personnel will have the responsibility and authority to stop work when controls are inadequate or imminent danger exists.

In any situation in which stop work authority is used, the following requirements will apply:

- Exercise stop work authority in a justifiable and responsible manner.
- Once work is stopped, do NOT resume work until proper controls have been established.
- Resume work only with concurrence by the PjM or designee.

This page intentionally left blank.

3.0 TASK-SPECIFIC HAZARD ANALYSIS/CONTROLS

A task-specific hazard analysis is performed on a daily basis to allow for risk identification associated with site work, including physical, chemical, and radiological components. (Radiation exposures that result from naturally occurring background sources and medical applications conducted under the care of a physician are examples of dose that is independent of occupational monitoring requirements but considered when planning task assignments. In instances of verifiable therapeutic applications, employee-furnished notifications will be used as an informational reference and included as part of a corresponding radiation exposure file.) Risk-based hazards and controls are defined in a site-specific Activity Hazard Analysis. Anticipated physical and chemical risks are described in detail in the project-specific APP/SSHP. Radiological risk controls are categorized in the sections to follow, and protective measures apply as defined in task-specific RWPs and corresponding SOPs.

3.1 IDENTIFICATION OF RADIATION RISKS

Project tasks subject to RPP protocol indicate a known or suspected likelihood of activities occurring in radiologically impacted areas (e.g., locations with sources of radium-226 [Ra-226]).

3.2 CONTROLLING DOCUMENTS

Unless indicated otherwise in Section 1.0, work conducted under the RPP will be subject to requirements detailed in TtEC RML No. 29-31396-01 or applicable State of Washington Agreement State RML, as well as Title 246 *Washington Administrative Code* (WAC) regulations, and in accordance with any project-specific Memorandum of Understanding (MOU) criteria and applicable radiological control work documents (e.g., site-specific Base-wide Radiological Plan and SOPs). TtEC will incorporate site-specific versions of SOPs as needed to implement and satisfy license commitments. Title 10 of the *Code of Federal Regulations* (CFR) Section 20 applies to the RPP standards used. In parallel, industrial safety requirements and U.S. Environmental Protection Agency regulations detailed in 29 and 40 CFR also have applicability for a variety of regulatory subjects including Comprehensive Environmental Response, Compensation, and Liability Act; the Resource Conservation and Recovery Act; and the National Emission Standards for Hazardous Air Pollutants. Additionally, a Washington State Department of Health approved Radioactive Air Emissions Plan complying with the requirements of WAC 246-247-110 Appendix A, will be implemented to ensure protection of the general public from airborne emissions. This plan is included as Attachment 5 of the Radiological Removal Action Work Plan.

3.3 EVALUATION OF POTENTIAL EXPOSURE TO WORKERS

RPP dose limits for the control of occupational exposure to ionizing radiation are listed in 10 CFR 20.1201–1208. Dose limits for individual members of the pubic are detailed in 10 CFR 20.1301–1302. In accordance with company policy, all exposures will be minimized to the extent practical. Administrative guidelines, established below the federal limits, will be used as detailed in the current version of corporate procedure NLP-01, As Low As Reasonably Achievable Program. Occupational exposures for project personnel will be maintained below TtEC administrative values for annual TEDE as listed in NAVSTA PS-Tt-002, Project Dosimetry.

Occupational dose, if any, is expected to originate from external sources (e.g., Ra-226, cesium-137, or strontium-90). Dose resulting from internal exposures are not anticipated. External exposure controls are addressed in Section 3.8, and controls to prevent or limit internal exposures are detailed in Section 3.9. Dose rates for general area work sites are expected to reflect naturally occurring background values.

3.4 EVALUATION OF PUBLIC DOSE

Based on the scope of planned work, the limited activity of radionuclides expected, and low concentration of naturally occurring radioactive material anticipated, public dose associated with tasks performed under this RPP is not projected. To validate the maintenance of public dose goals, TtEC will implement necessary survey and sampling protocols in areas of intrusive work, and conspicuously post and restrict access to intrusive work locations that require monitoring (e.g., areas where soil excavations and/or handling, etc., may disturb sources of radioactive material). TtEC will also validate survey and sampling results and frequencies with the client (e.g., the RASO), RSO, RSOR, and RTS representatives to ensure established controls are effective.

3.5 TRAINING PROGRAM

Site personnel tasked to conduct project-oriented activities must satisfy corresponding APP/SSHP training requirements. Persons subject to assignments involving a known or suspected potential for occupational radiation dose will receive additional training commensurate with radiological awareness requirements as defined in 10 CFR 19.12, Instructions to Workers. Visitors and escorted persons must receive a site briefing and will be assigned to a qualified radiation worker aide when in an area of radiological concern.

3.5.1 Site Briefing

An RPP site briefing is designed for an escorted person and is presented when access is needed to radiologically impacted locations. Specific to the area(s) of concern where access is needed, the RPP brief will cover at a minimum:

- Applicable portions of 10 CFR 19, 10 CFR 20, the RPP, RWPs, site-specific reference documents, and supporting SOPs
- A description of radiation exposure risks and monitoring requirements
- Access and egress protocol specific to the radiologically impacted location(s) requiring entry
- Radiation exposure reduction techniques for an embryo/fetus
- Completion of applicable briefing/exposure monitoring documentation
- Notification of contacts as needed to complete training requirements

3.5.2 Radiation Worker Training

RPP training for the radiation worker is provided when unescorted access is needed to impacted site locations subject to radiological control. Inclusive of material that may be required by project-specific Work Plans and documents (e.g., APP/SSHP, Task-Specific Plans), training may be presented in the form of a group overview, video presentation, etc., with use of printed handouts approved by the RSOR. Training will address at a minimum:

- Applicable portions of 10 CFR 19, 10 CFR 20, the RPP, site-specific reference documents, and supporting SOPs specific to task performance
- A description of radiation exposure risks, monitoring requirements, and techniques
- Access and egress protocol specific to radiologically impacted locations
- Required contacts and expected actions in the event of an emergency (in accordance with the current version of corporate procedure NLP-06, Managing Radiological Emergencies)
- Expected actions and contacts if radioactive material is discovered in an area where it is not expected
- Understanding “hands and feet” and “whole body” monitoring requirements
- Risks with radioactive material and radiation-producing devices unique to the site
- ALARA work principles and techniques
- Understanding the requirements for and compliance with RWPs including protocol for dosimetry and personal protective equipment (PPE)
- Radiation exposure reduction techniques for the embryo/fetus
- Completion of applicable training and exposure monitoring documentation
- Notification of contacts as needed to complete training requirements

3.5.3 Radiological Control Technician Training Qualification

As coordinated between the RSO and RSOR, TtEC will evaluate and ensure acceptable qualification of RCTs. When selected for project assignment, RCT qualifications are evaluated between the RSO and RSOR in accordance with the requirements detailed in NRC License No. 29-31396-01. Project-specific training is provided to RCTs commensurate with anticipated duties and assignments.

3.6 DECLARED PREGNANT FEMALE WORKER

To maintain embryo/fetus radiation exposure ALARA, female employees who are pregnant or attempting to become pregnant are encouraged to declare this information to project management in writing to allow for criteria to be exercised as detailed in:

- 10 CFR 20.1208, Dose Equivalent to an Embryo/Fetus
- NRC Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, Revision 3, Washington, DC (NRC 1999)
- NRC Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure, Revision 1, Washington, DC (NRC 1996)

Because of the small anticipated annual dose for workers associated with project activities (i.e., less than 10 millirems/year), it is unlikely in instances of pregnancy that separate dose tracking for the embryo/fetus will be necessary. Managing occupational exposures for all staff within annual TtEC administrative TEDE guidelines is expected to satisfy maintenance of less than 500 millirems total dose for any pregnant female worker over the course of an entire gestation period.

3.7 AS LOW AS REASONABLY ACHIEVABLE PROGRAM

TtEC is committed to maintaining radiation exposure to workers and the public as far below company guidelines and regulatory limits as practical. RPP requirements are established for field operations in an effort to meet that commitment in accordance with the current version of corporate procedure NLP-01, As Low As Reasonably Achievable Program.

3.8 EXTERNAL EXPOSURE CONTROL

The following steps will be taken to control external radiation exposure to levels that are ALARA:

- Employ basic dose reduction strategies as detailed in corporate procedures and site-specific SOPs using the ALARA concepts of time, distance, and shielding.
- Use instruments at frequencies sufficient to accurately determine the level and extent of radiation fields.

- Present adequate staff training to ensure the ability to recognize situations involving objects that might be radioactive, to be wary of objects that are unfamiliar, and to rely on valid instrument readings to limit and safely manage external exposure.

3.9 INTERNAL EXPOSURE CONTROL

Internal exposure is expected to be below all the recognized DAC values as specified in 10 CFR 20. Should the potential for internal dose be confirmed during fieldwork (e.g., due to the nature of the planned activity such as remediation efforts), the activity will be temporarily suspended and the work area secured pending determination and use of corrective protocol as decided among the RSO, RSOR, and PjM.

3.10 MONITORING AND MEASURING EXTERNAL EXPOSURE

A vendor accredited by the National Voluntary Laboratory Accreditation Program will be used to provide project-related dosimetry services. Dosimetry applications and considerations will apply to field staff designated as radiation workers (i.e., personnel needing unescorted access to impacted site locations subject to radiological control). Prior to dosimetry issue, a radiation worker will have satisfactorily completed requirements as detailed in Section 3.5.2.

3.11 MONITORING AND MEASURING INTERNAL EXPOSURE

The monitoring of work practices conducted in areas of radiological concern will be coordinated among the RCTs, RTSs, and members of project management designated as radiation workers using frequencies necessary to confirm the application of correct techniques and PPE to minimize potential transfer of external contaminants inside the body.

Air sampling will be performed during intrusive activities conducted in areas of radiological concern. Air sample results will be reviewed and tracked among the RSO, RSOR, RTS, and designated RCTs to determine whether trends (e.g., concentrations greater than 10 percent of DAC) exist that require work stoppage and/or re-engineering of task-specific contamination controls.

3.12 SURVEYS AND MONITORING

A project-based summary of historical survey and monitoring information is typically available in site-specific documentation (e.g., a Radiological Work Plan). Protection of workers, the public, and the environment depends on accurate assessment and interpretation of past historical information as compared to present-day survey data collected in accordance with prescribed procedures and project support documents.

In situations subject to this RPP, guidance for determining survey frequency and technique is detailed in applicable portions of corporate procedures NLP-04, Radiological Entry Control

Program; NLP-05, Radioactive Contamination Control; RPG 2-9, Radiological Surveys and Operational Checks; and NAVSTA PS-Tt-003, Radiation and Contamination Surveys.

3.12.1 Surveys of Equipment and Materials

Equipment and material passing through areas controlled for radiological concern will be subject to survey criteria and techniques detailed in applicable portions of corporate procedure NLP-05, Radioactive Contamination Control, and NAVSTA PS-Tt-009, Release of Materials and Equipment from Radiologically Controlled Areas.

3.13 ACTION LEVELS

Action levels represent transition points at which concentrations of radioactivity require additional response and/or investigation (e.g., PPE upgrades or increased work technique controls). Action levels for radiological controls are detailed in corporate procedure NLP-01, As Low As Reasonably Achievable Program; NLP-04, Radiological Entry Control Program; and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control. Modification of action levels requires concurrence from the Navy.

3.14 RADIOLOGICALLY CONTROLLED AREAS AND POSTING

Site structures, outdoor locations, and/or perimeter boundaries posted with yellow and magenta markings are established to identify areas designated for radiological control, prevent (to the extent practical) access by unauthorized persons, and protect members of the public from exposure to radiation. A description of scenarios and postings employed for control purposes are detailed in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

3.14.1 Controlled Area

A Controlled Area may be established where access to impacted portions of a work site requires specialized qualification and approval. A Controlled Area (which may also be called a Restricted Area) is intended to serve as the outermost boundary around planned and established work zones.

Controlled Area access requires prior authorization and use of PPE as defined in a project-specific APP/SSHP. Visitors must have requisite training as specified in an SSHP. Personnel who enter a Controlled Area may not cross into more restrictive areas posted within unless prior authorization is obtained.

Where the perimeter to a Controlled Area is first encountered for radiological purposes, posting applications will have the wording “Caution Controlled Area” (or Restricted Area) and provide a contact phone number. (Supplemental information as specified by the RSOR or designee may

also be included as magenta [preferred], purple, or black markings on a yellow [preferred] or white background.) A minimum of one sign will be posted on each straight run of the Controlled Area (or Restricted Area) boundary. Note that areas not typically accessed by pedestrians (e.g., windows) need not be posted. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.2 Access Control Point

When used, an Access Control Point is part of a Controlled Area (or Restricted Area) boundary. Intended to serve as a transition corridor, an Access Control Point allows for the accountability of personnel, tools, and equipment that pass through. When established as a radiological control mechanism, an Access Control Point RCT will be present any time activities within are ongoing. During periods of inactivity, control point gates (part of the contiguous area boundary) are closed and locked.

3.14.3 Radiologically Controlled Area

A Radiologically Controlled Area (RCA) represents an area containing radioactive materials in excess of the levels provided in Table 1 of NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control. Access to this area is controlled to protect individuals from exposure to ionizing radiation. Intended to include (for posting purposes) the nearest boundary or perimeter associated with the affected area, RCA restrictions and corresponding access protocol can be located in NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the RCA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary. For waterfront areas, signs should be posted at areas accessible by watercraft.

3.14.3.1 Radioactive Materials Area

A Radioactive Materials Area (RMA) identifies any designated area where radioactive materials are stored or used. Intended to warn of the potential for occupational dose, a description of RMA scenarios and postings employed for control purposes can be located in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the RMA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.4 Contaminated Area

A Contaminated Area is any area accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors (AEC 1974), but do not exceed 100 times those values. Contamination is radioactive material that is deposited on a surface where it is unwanted. Subject to license control, a description of Contaminated Area scenarios and postings employed for control purposes can be located in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the RCA boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.5 High Contamination Area

A High Contamination Area is any area accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Regulatory Guide 1.86 (AEC 1974).

When used, a minimum of one sign will be posted on each straight run of the High Contamination Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.6 Radiation Area

A Radiation Area means any area accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 millisievert) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates. A description of Radiation Area scenarios and postings employed for control purposes can be located in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the Radiation Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.7 High Radiation Area

A High Radiation Area means any area accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (0.001 sievert) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

A description of High Radiation Area scenarios and postings employed for control purposes can be located in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the High Radiation Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.14.8 Airborne Radioactivity Area

An Airborne Radioactivity Area is a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations:

- In excess of the DACs specified in Appendix B to 10 CFR 20.1001–20.2401, or
- To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake or 12 DAC hours.

As an example, for Ra-226, the most likely airborne contaminant at Navy radiological remediation projects, the applicable DAC value is 3.0E-10 microcuries/milliliter. A description of Airborne Radioactivity Area scenarios and postings employed for control purposes can be located in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

When used, a minimum of one sign will be posted on each straight run of the Airborne Radioactivity Area boundary. Additional signs should be placed at approximately 30-meter intervals on long runs of any boundary.

3.15 CONTAMINATION CONTROL

Contamination control practices are established to preclude the spread of contaminants into uncontrolled areas. Recognized applications are detailed in corporate procedure NLP-05, Radioactive Contamination Control.

3.15.1 Physical Boundary

A physical boundary will be established using criteria referenced in Section 3.14.4 to fully enclose a location established as a Contaminated Area.

3.15.2 Entry

Entry into a Contaminated Area will be compliant with pre-established requirements as detailed on a job-specific RWP. In such instances, an RCT will be present to assist in radiological control and support. (See Section 3.17.1 for details related to RWP use.)

3.15.3 Exit

Exit from a Contaminated Area will be compliant with pre-established requirements as detailed on a job-specific RWP. In such instances, an RCT will be present to assist in radiological control and support. (See Section 3.17.1 for details related to RWP use.)

3.15.4 Limitations on Entry

Personnel with open wounds or sores are not generally granted access into a Contaminated Area. Entry may be authorized by the RSOR or designee, on a case-by-case basis, if appropriate protection of the wound or sore is verified, planned work activities are unlikely to compromise the protection, and there is no other medical reason to restrict entry.

Jewelry and personal items are not allowed in Contaminated Areas; only project furnished tools, materials, and equipment necessary to accomplish the planned task are acceptable. Container wrappings, packing, and similar materials must be segregated from essential items prior to entry.

3.15.5 Control of Items

Items such as equipment and tools to be removed from a Contaminated Area must meet unconditional release criteria as detailed in applicable portions of corporate procedure NLP-05, Radioactive Contamination Control, and NAVSTA PS-Tt-009, Release of Materials and Equipment from Radiologically Controlled Areas.

3.16 INSTRUMENTATION

As detailed in applicable portions of corporate procedure RPG 2-9, Radiological Surveys and Operational Checks, field survey instruments will be calibrated annually at a minimum in accordance with the manufacturers' specifications. Instruments will be removed from service on or before calibration due dates and returned to the supplier for recalibration.

3.17 CONTROL OF RADIOLOGICAL WORK

All radiological work activities will be planned in consultation with the RSOR, the PjM, and other project personnel tasked with oversight responsibilities. Work performed in areas of radiological concern require establishment of an RWP, which details radiologically based requirements and protective measures.

3.17.1 Radiation Work Permits

RWPs detail the protective measures and controls needed to perform tasks in areas of radiological concern. Information considered during RWP development is detailed in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-001, Issue and Use of Radiation Work Permits.

3.17.2 Task-specific Work Instructions

Task-specific work instructions are used to supplement RWP requirements and address in greater detail corresponding activities planned while personnel are inside areas of radiological concern. These instructions are required for tasks scheduled to occur in locations as determined by the PjM, RSO, RSOR, or the Project Superintendent. The RSO or designee will finalize, control, and issue radiologically based work instructions.

3.18 CREDENTIALING OF STAFF

Qualification and training requirements for RCTs are provided in NRC License No. 29-31396-01 and as detailed in applicable portions of corporate procedure RPG 2-5, Radiation Safety Training. The RSO verifies qualifications and conducts required license-specific training with any RSOR designated on the license as an authorized user.

To supplement and validate the correct use and implementation of this RPP and NRC License No. 29-31396-01, a Health Physicist certified by the American Board of Health Physicists provides support to active field projects.

3.19 PROCUREMENT, RECEIPT, AND INVENTORY OF SEALED RADIOACTIVE SOURCES

It is not anticipated that field projects will receive radioactive material shipments other than exempt-quantity radioactive check sources. As detailed in corporate procedures NLP-02, Radioactive Material Accountability, and NLP-03, Sealed Radioactive Source Control, check sources are controlled, stored, posted, and managed as radioactive material.

3.19.1 Leak Testing

Radioactive sealed sources with quantities exceeding the licensable threshold will be leak-tested as detailed in applicable portions of corporate procedures NLP-02, Radioactive Material Accountability, and NLP-03, Sealed Radioactive Source Control.

3.19.2 Transport of Sources

Check sources will be used on field projects only for the period of time necessary to execute planned work, will not be introduced onto a project location prior to project initiation, and will be returned to the provider immediately following the completion of planned field activities.

Check sources will be maintained as detailed in applicable portions of corporate procedures NLP-02, Radioactive Material Accountability, and NLP-03, Sealed Radioactive Source Control.

3.19.3 Reporting Lost, Damaged, or Stolen Sources

As detailed in applicable portions of corporate procedures NLP-02, Radioactive Material Accountability, and NLP-03, Sealed Radioactive Source Control, if a check source is lost, damaged, or stolen, the event will be reported immediately to the RSOR or designee. The RSOR will immediately notify the RSO, the PjM, and the Navy and initiate appropriate recovery actions. In consultation with the Navy, a report will be filed by the RSO or designee with the appropriate law enforcement agency if it is determined that radioactive material was stolen. The RSO will make any necessary notifications to the NRC.

3.20 SHIPPING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

Off-site shipment of radioactive materials other than exempt-quantity radioactive check sources by TtEC is not anticipated. Information pertinent to an authorized shipper for a field project is provided in Section 6.0.

3.21 CONTROL OF RADIOACTIVE WASTE

Radioactive waste will be minimized by compliance with contamination control practices (Section 3.15) combined with segregation and survey practices. A waste contractor contracted to the Navy through the Army Joint Munitions Command will provide brokerage services including waste characterization sampling, waste containers, and transportation of radioactive materials/waste generated from a field project. Soil and used PPE will typically be processed for final disposition in disposal bins. When filled, bins will be transferred to the custody and control of the authorized shipper.

As detailed in corporate procedure NLP-02, Radioactive Material Accountability, and NAVSTA PS-Tt-008, Control of Radioactive Material, commodities will be stored in a locked radioactive materials storage area, controlled by the RSOR or designee, and periodically be packaged and transferred to the authorized shipper for disposal. Radioactive material will be packaged, stored, shipped, and disposed of as required by U.S. Department of Transportation (DOT) regulations.

3.22 RADIATION PROTECTION RECORDS

As detailed in the applicable portions of corporate procedure NLP-07, Radiological Protection Records, the RSO or designee is responsible for ensuring that airborne monitoring, contamination surveys, and exposure/dose rate surveys are reviewed for accuracy and completeness as an on-going process. Individual exposure records including dosimetry and bioassay reports for personnel are reviewed for results as generated.

3.23 REPORTS AND NOTIFICATIONS

Workers who have previous occupational work history with radiological environments will supply the RSO or designee with prior estimated or reported dose histories on an NRC Form 4 or equivalent as defined in 10 CFR 20.2104.

Records of radiation exposures to workers who have been issued external dosimetry monitoring devices will be maintained. Dosimetry monitoring results for workers will be reported to the RSO annually at a minimum. Annual occupational exposure greater than or equal to 100 millirems for the previous calendar year, or otherwise when requested, requires a summary of individual exposure to be reported to the employee monitored.

3.24 LICENSES

Entities subject to the use of this RPP will conduct radiological-based tasks with use of TtEC NRC License No. 29-31396-01. TtEC will ensure that the Radiological Control Program and work practices are implemented and performed in accordance with the NRC and the RPP. (Any government-designated waste contractor may implement their NRC-issued license to conduct waste characterization sampling of waste material in support of low-level radioactive waste shipment and disposal. An MOU between TtEC and a waste contractor will be developed, identifying interfaces and commitments for the transfer of radioactive materials. Active MOUs will be maintained by the RSO or designee.)

3.25 REVIEW AND APPROVALS OF RADIATION PROTECTION PLANS

The RSO or designee will prepare the RPP, which will then be reviewed for approval with subject matter experts (e.g., the PjM and RSOR). In addition, the Navy will have an opportunity to review the draft content, provide input, and indicate acceptance of the plan. Changes to the RPP will be reviewed and accepted following the same process.

3.26 PLANNED SPECIAL EXPOSURES

No anticipated event within work scopes subject to this RPP will require use of a planned special exposure. In the event it is necessary to initiate such a need, an activity-specific work instruction including a formal ALARA review and an RWP will be prepared and submitted for acceptance following the same process as the RPP submittal described in Section 3.25.

This page intentionally left blank.

4.0 PERSONAL PROTECTIVE EQUIPMENT

Minimum PPE requirements based on chemical contaminants are established by the Health and Safety Manager (in a project- or task-specific APP/SSHP). This primary level of PPE, Modified Level D, is historically sufficient for radiological work activities and is supplemented by activity-specific RWPs based on the radiological conditions and field tasks required to perform planned activities. Information considered for PPE during RWP development is detailed in applicable portions of corporate procedure NLP-04, Radiological Entry Control Program, and NAVSTA PS-Tt-007, Radiologically Controlled Areas – Posting and Access Control.

4.1 SELECTION OF PERSONAL PROTECTIVE EQUIPMENT

Personnel must wear PPE commensurate with contamination hazards associated with both the work area and the planned activity. Activities that require heavy physical effort or that have an increased potential for damage to PPE may require additional layers or different PPE materials, even in areas of low contamination. Site- or task-specific PPE requirements beyond the minimum traditionally used will be detailed in a corresponding RWP and NAVSTA PS-Tt-012, Radiological Protective Clothing Selection, Monitoring and Decontamination.

4.2 DONNING AND DOFFING PPE

To prevent contamination of personnel or the spread of contamination, PPE must be donned and doffed in a specific manner. Directions for donning and doffing standard PPE ensembles are provided in the applicable sections of corporate procedure NLP-05, Radioactive Contamination Control, and NAVSTA PS-Tt-012, Radiological Protective Clothing Selection, Monitoring and Decontamination. Additional instructions for non-standard site- or task-specific PPE requirements will be provided in the applicable RWP.

This page intentionally left blank.

5.0 DECONTAMINATION PROCEDURES

Contamination control when handling radioactively contaminated materials will be conducted in accordance with corporate procedure NLP-05, Radioactive Contamination Control. Decontamination of materials and equipment will be performed at a dedicated location (e.g., decontamination pad, room) in accordance with site-specific procedure SOP NAVSTA PS-Tt-010, Decontamination of Equipment and Tools.

This page intentionally left blank.

6.0 SHIPPING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

Field projects subject to the use of this RPP will conduct radiological-based activities using TtEC's NRC License No. 29-31396-01. The government-designated waste contractor associated with a field project may implement its applicable NRC or State license to conduct waste characterization sampling of waste material in support of low-level radioactive waste shipment and disposal. An MOU between TtEC and a waste contractor will be used, identifying interfaces and commitments for the transfer of radioactive materials. In such instances, a current MOU will be maintained by the project RSOR for projects subject to the requirements of the RPP.

Environmental samples shipped for off-site analysis and exempt-quantity radioactive check sources are packaged and shipped in accordance with DOT regulations via commercial carriers.

This page intentionally left blank.

7.0 REFERENCES

AEC (Atomic Energy Commission). 1974. Regulatory Guide 1.86. Termination of Operating Licenses for Nuclear Reactors. June.

EPA (U.S. Environmental Protection Agency). 2000. Radionuclides Notice of Data Availability Technical Support Document, Office of Ground Water and Drinking Water. March.

NRC (U.S. Nuclear Regulatory Commission). 1996. Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure, Revision 1, Washington, DC. February.

————————. 1999. Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, Revision 3, Washington, DC. June.

This page intentionally left blank.

APPENDIX A

RADIATION PROTECTION PLAN ACKNOWLEDGMENT FORM

This page intentionally left blank.

Radiation Protection Plan Acknowledgment Form

I have reviewed, understand, and agree to follow the Radiation Protection Plan for this project. Additionally, I understand that there are additional nonradiological health and safety requirements, which are presented in the Site Safety and Health Plan. I agree to abide by the requirements of the Radiation Protection Plan for the work that I will perform.

Printed Name	Signature	Representing	Date

This page intentionally left blank.