U.S. Department of the Navy
Naval Facilities Engineering Command Northwest
1101 Tautog Circle, Suite 203
Silverdale, Washington 98370

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

FINAL
AFTER ACTION REPORT

October 2016

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

AFTER ACTION REPORT

October 2016

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

Steven Adams, CHP TtEC Radiation Safety Officer	October 19, 2016 Date
Bill Dougherty TtEC Project Manager	October 19, 2016 Date

EXECUTIVE SUMMARY

Tetra Tech EC, Inc. (TtEC) prepared this After Action Report (AAR) under contract with The U.S. Department of the Navy (DON) to describe and summarize the radiological materials time-critical removal action (TCRA) performed at former Naval Station Puget Sound (NAVSTA PS) located in Seattle, Washington. This TCRA was performed to protect the public health and welfare and the environment by addressing radiological contamination identified at NAVSTA PS within Building 2, the Building 27 South Shed, the storm drain systems and soil located in the vicinity of these buildings, and potential contamination associated with Buildings 11, 12, and 40 (project site). This AAR documents the radiological materials TCRA tasks completed under Contract No. N62473-10-D-0809 and Contract Task Order (CTO) No. 0011 for the Base Realignment and Closure Program Management Office under Naval Facilities Engineering Command Northwest. The TCRA work activities were performed by TtEC in accordance with the Final Radiological Removal Action Work Plan (Work Plan) (Attachment 5) and other supporting plans and documents described in this AAR. Figure ES-1 shows the project area.

Site Description

Located approximately 6 miles northeast of downtown Seattle, Washington, former NAVSTA PS is situated along the western shore of Lake Washington. The property 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 two primary storm drain systems that serve the project site include 1) a 24-inch-diameter system that originates south of Building 2 and continues along the west side of Building 2, then passes beneath NE NOAA Drive and Building 27, and 2) a 36-inch-diameter system located in the paved areas west of Building 27. Both systems drain to the north and converge on Manhole (MH) 160, and from there discharge into Lake Washington. Catch basins (CBs) on branch lines located along the west, south, and east sides of Building 27 drain to these storm drain lines. Another storm drain system located on the east side of Building 2 that continued to an outfall on NOAA property received flow from various sources within Building 2, including a sink in a former instrument shop and runoff from the roof.

The first floor work areas and second floor offices situated on the north side of the Building 2 north hangar are occupied by the Seattle Conservation Corps. The remainder of Building 2 is vacant. The Building 27 former aircraft hangar space and North Shed are occupied by the Magnuson Athletic Club and Arena Sports.

Background

Originally named Naval Air Station Seattle at Sand Point, portions of the former NAVSTA PS facility were constructed in 1925 on land donated by King County. Many of the major buildings were built in the late 1930s prior to World War II. Building 27 was constructed in 1937 and Building 2 was constructed in 1938. Further construction and remodeling was performed in later years, including expansion of the Instrument Shop in Building 2 in 1941 (1941 Instrument Shop) and the addition of the South Shed to Building 27 in 1944.

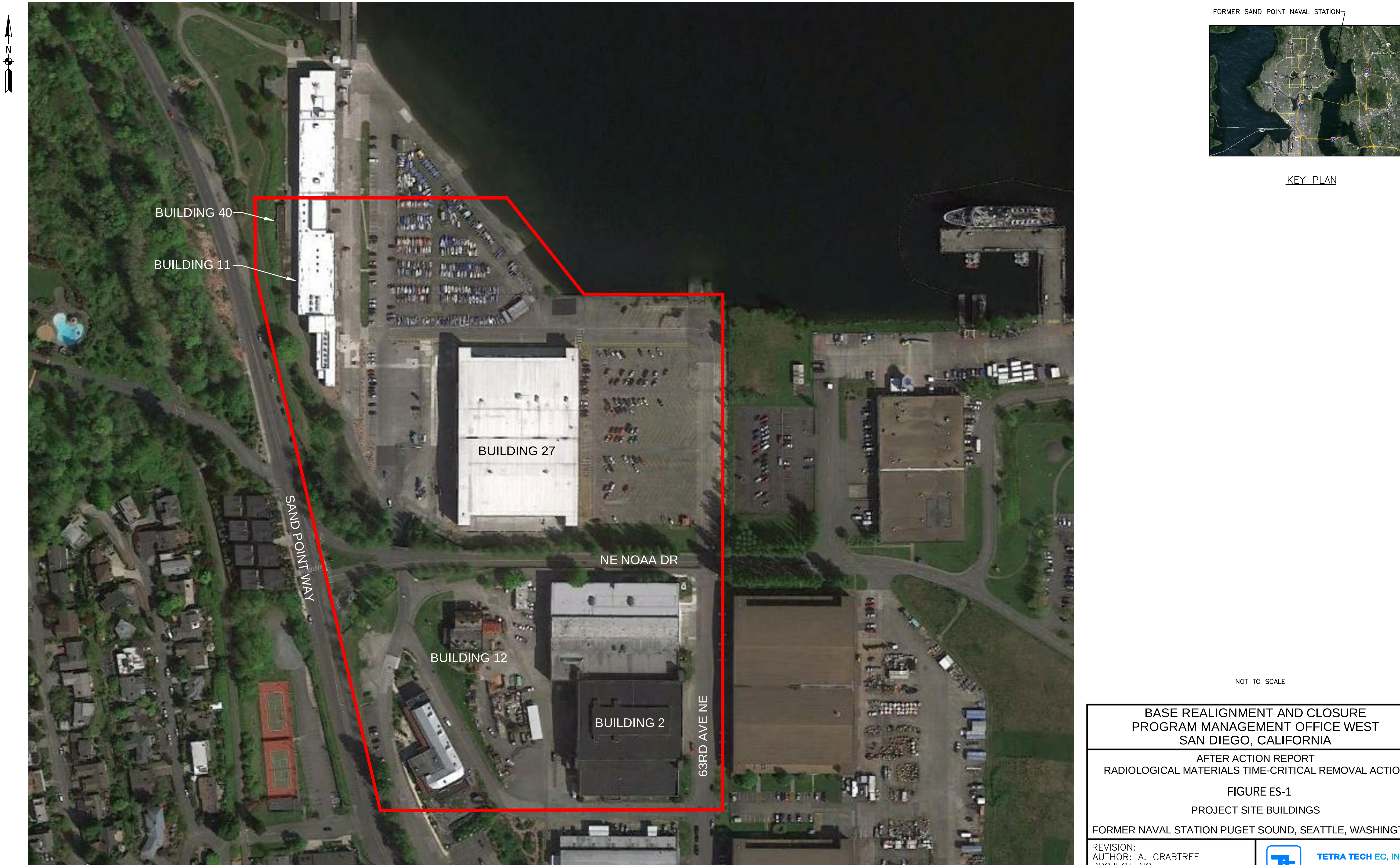
In June 1991, the Base Realignment and Closure Commission announced the closure of NAVSTA PS. A disestablishment ceremony was held by the DON on 28 September 28 1995 to commemorate the closing of NAVSTA PS.

Following closure, the DON conducted investigation and cleanup of portions of former NAVSTA PS. No radiological contamination was identified during these activities. Based on the results of these investigations, the DON generated the Finding of Suitability to Transfer and initiated transfer of the former NAVSTA PS property to several government agencies, including the City of Seattle, in accordance with the closure plan.

The City of Seattle reviewed historical drawings during planning of proposed renovations for Building 27, and identified a room labeled “Radium Room.” Following this discovery, Seattle Parks and Recreation reviewed drawings for Building 2 and identified an area labeled “Instrument Shop.” Further research revealed that, from the late 1930s through the 1960s, the DON commonly performed maintenance on radioluminescent aircraft dials and gauges that typically containing radium-226 (Ra-226). Historical DON records confirmed that former NAVSTA PS routinely received shipments of Ra-226 that was used for the maintenance of the radioluminescent devices.

Based on these findings, Seattle Parks and Recreation retained a contractor to perform dose rate radiation surveys in Building 2, Building 27, and three nearby pump houses identified as Pump Houses A, B, and 116. The survey results revealed two locations in the Building 27 South Shed with radiation levels above background levels (Argus 2009a). The two areas were associated with a former sink drain line located on the second floor of Building 27 (former Radium Room) and the location where the pipe extended to the first floor. No elevated concentrations of radiation above background were identified in Building 2 or the three pump houses (Argus 2009b).

Following these surveys, the DON secured the areas and completed a radiological remedial investigation (RI).The results of the RI were documented in a report entitled Radiological Remedial Investigation Report (Shaw 2011). The RI identified radiological contamination associated with Building 2, the Building 27 South Shed, and the storm drain systems and soil located in the vicinity of these buildings. Based on the results of the RI Report, and due to continued deterioration of the NAVSTA PS project site buildings and the discovery of trespassers in Building 2, the DON elected to perform a radiological materials TCRA at the project site. The decision to perform a TCRA was documented in the Final Action



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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE ES-1

PROJECT SITE BUILDINGS

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

This page intentionally left blank.

Memorandum, Time-Critical Removal Action (Action Memorandum) (DON 2013), which included input from regulatory agencies and the public.

TCRA Removal Action Objectives, Release Criteria, and Regulatory Guidance

The TCRA removal action objectives (RAOs) and release criteria were established in the Action Memorandum. The radionuclides of concern (ROCs) included cesium-137 (Cs-137), Ra-226, and strontium-90 (Sr-90). The intent of the TCRA was to achieve unrestricted release for the NAVSTA PS project site and to ensure that individuals were not exposed to unacceptable levels of radiation or radioactive materials. The criterion for unrestricted release was established in the Action Memorandum (DON 2013) as a net residual dose of less than 15 millirem per year (mrem/y).

The TCRA for former NAVSTA PS was conducted in accordance with the DON's Environmental Restoration Program using the Comprehensive Environmental Response, Compensation, and Liability Act amended by the Superfund Amendments and Reauthorization Act of 1986 process. Regulatory oversight was provided by the Washington State Department of Ecology, as the lead regulatory agency, and the Washington State Department of Health (WDOH).

Mobilization

In July 2013, TtEC mobilized to perform TCRA activities under TtEC's State of Washington Radioactive Materials License WN-L0244-1. Equipment that was used was first surveyed upon arrival at the project site and verified to be free of radioactive contamination. During mobilization, temporary fencing was installed or reconfigured to encompass the planned work areas, dust controls and air monitoring were implemented, and traffic was controlled and rerouted, as appropriate, prior to initiating intrusive activities.

Building 2

Building 2 was identified as radiologically impacted in the RI Report (Shaw 2011). For the TCRA, the second floor area was divided into eight survey units (SUs). An SU is a physical area consisting of structures or land areas of specified size and shape for which a separate decision would be made as to whether or not that area exceeded the release criteria. The survey activities in each SU included alpha and beta scans, static measurements, and swipe samples. During the TCRA activities, contamination identified on walls and floors and in the ventilation system above the second floor level in the RI Report (Shaw 2011) and as a result of TCRA survey and sampling efforts was remediated and the contaminated materials were placed in low-level radioactive waste (LLRW) bins for off-site disposal by the U.S. Army Joint Munitions Command (USAJMC) contractor. The areas requiring remediation included ventilation ducts and registers, wood flooring and floor joists, and walls. *Surveys performed following the remediation efforts did not identify any contamination above the release criteria.*

According to the RI Report (Shaw 2011), Ra-226 contamination was identified inside the remaining portion of the sink drain line associated with the former 1941 Instrument Shop in Building 2. This drain was connected to a belowground collector line that also received flow from other locations in the building, including the roof, and drained to the east and ultimately discharged into MH-115 on the east side of the building. Analysis of a sediment sample collected during the TCRA from inside the drain line at a downgradient location just outside of Building 2 also identified Ra-226 contamination exceeding the release criteria. The results of analysis of samples of the soil that surrounded the drain line at the same location were below the release criteria. Due to concern that removing the drain line could adversely affect the structural integrity of Building 2, that portion of drain line buried under the ground floor slab of the building was investigated to determine whether it could be cleaned in place, removed without affecting the structural integrity of the building, or abandoned in place. After consideration, it was determined that hydrojetting to remove sediment, video inspection, and gamma scan surveys of the interior of the collector line would be the most appropriate investigation methodology for the collector line. Hydrojetting operations for the drain line were continued until the cleaning water ran clear, and a video inspection confirmed that all visible sediment had been removed. The video inspection, which also recorded the physical condition of the pipe, identified no notable defects that would indicate the potential for release of contamination into the surrounding soil. The gamma scan survey of the interior of the collector line produced no gamma scan results exceeding the investigation criteria. *Based on the video inspection and gamma scan results, no further activities involving the drain line were performed.*

In October 2013, final status survey (FSS) activities were initiated by TtEC for Building 2. *All of the Building 2 FSS results were below the TCRA release criteria.* Dose modeling was unnecessary for the eight Building 2 SUs since the residual net mean surface area concentrations for both alpha and beta were less than zero. Consequently, *no increased annual dose above background levels was anticipated for Building 2, and the 15 mrem/y dose limit for unrestricted release was achieved.*

The WDOH subsequently performed verification surveys in Building 2 and found that all survey data were below regulatory limits. *In a letter dated 27 January 2015, the WDOH Office of Radiation Protection formally released Building 2 for unrestricted use.*

Building 27

Building 27 was also identified as radiologically impacted in the RI Report (Shaw 2011). For the TCRA, the Building 27 South Shed was divided into 34 SUs. SU-20 was the only soil SU and resulted from the removal of a sink drain line buried below the ground floor slab.

During the TCRA, radiologically impacted wood flooring, ceiling materials, walls, electrical conduit, pipe, and ventilation ducts in Building 27 were removed and placed in LLRW bins for disposal by the USAJMC contractor. Surveys performed following the remediation efforts revealed no contamination above the TCRA release criteria. The WDOH subsequently performed verification surveys that revealed further contamination in localized areas of the South Shed and adjoining stair towers. These areas were remediated and resurveyed to ensure that the contamination had been removed. Based on the WDOH findings, TtEC performed additional surveys of the South Shed north common wall, as well as the east and west walls common to the southeast and southwest stair towers to ensure that any potential radiological contamination was identified. All areas of identified contamination on portions of the structures that would remain following deconstruction of the Building 27 South Shed were remediated and resurveyed. During the remediation and surveying of the South Shed, a radiological device was discovered while removing wallboard from the common wall that separates the Building 27 South Shed from the southeast stair tower. The device was removed and transferred to the USAJMC contractor for disposal as LLRW.

Follow-up WDOH verification surveys performed in the South Shed and adjoining stair towers revealed no further areas of contamination. *In its 27 January 2015 letter, the WDOH released the South Shed common north wall, the east and west walls, the southeast and southwest stair towers, the roof, and the south wall 1.5 feet above the second floor level for unrestricted use.* The WDOH concurred that the remainder of the south wall should be disposed of as LLRW.

Deconstruction of the Building 27 South Shed occurred in January and February 2015. At the time deconstruction began, some of the surfaces that were slated for deconstruction had not been exhaustively surveyed to confirm that residual contamination did not remain. Therefore, debris from deconstruction of these portions of the South Shed was disposed of by the USAJMC contractor as LLRW. Following deconstruction of the South Shed, the ground floor concrete slab and interior concrete wall surfaces were surveyed. None of the survey results revealed the presence of radiological contamination, except at one localized area on the concrete floor; this area was remediated. *None of the post-remediation survey results revealed further contamination.*

Dose modeling was performed for the Building 27 SUs. For several building SUs, the mean net surface area concentrations for alpha and beta were less than zero. Consequently, modeling for dose for those SUs was unnecessary. For the remaining SUs, the maximum modeled dose for building hard surfaces was 0.086 mrem/y and the maximum modeled dose for soil SU-20 was from backfill material and was 1.758 mrem/y, which are well below the unrestricted release criterion of 15 mrem/y as specified in the Action Memorandum, and the 12 mrem/y updated EPA guidance value (EPA 2014) for what is considered a protective dose.

Areas Associated with Buildings 2, 12, and 27

The results of the radiological RI activities identified the presence of elevated radionuclide concentrations in soil in areas surrounding Buildings 2, 12, and 27 and storm drain systems adjacent to Building 27. Based on this information, TtEC performed characterization activities based on the conclusions provided in the RI Report (Shaw 2011) and the recommendations included in the Action Memorandum (DON 2013). The characterization activities included performing gamma walkover surveys (GWSs) to refine and supplement data generated during the radiological RI, and collecting soil samples for laboratory analysis. Based on the initial GWS results, several additional areas were identified as needing further investigation. A total of 41 soil borings were drilled and samples were collected from those borings for analysis. Soil borings were hand augured to a maximum depth of 8 feet during the characterization activities. None of the field screening readings collected during the soil boring sampling activities showed elevated gamma measurements. With the exception of two soil boring samples, none of the laboratory analytical results identified contamination. Both of the soil boring locations that had been identified as contaminated were remediated. The remediated soil was placed in LLRW bins for off-site disposal by the USAJMC contractor. In addition to the samples from the soil borings, based on the results of the GWSs, two surface samples were collected for analysis from the area along the NE NOAA Road south retaining wall. None of the analytical results revealed contamination.

During the TCRA, remedial actions were performed by TtEC, including removal of the contaminated storm drain piping and contaminated soil associated with 12 areas of elevated surface activity called "hotspots" (HSs). Remediation of the HSs was accomplished by excavating the soil and placing it directly into LLRW bins. Surveys of the excavations were performed and soil samples were collected and analyzed. Based on the results, the 12 HS locations either were incorporated into SUs and were designated for further remediation, or underwent FSS activities. Further remediation was performed for three HSs and two SUs. In addition, storm drain systems were remediated by removal, after which the excavation was surveyed and sampled. A radiological device was uncovered approximately 4 inches below the surface during remediation of one of the HSs located in the asphalt paved area west of Building 27. The device was transferred to the USAJMC contractor for disposal as LLRW. At the conclusion of the remediation efforts, a total of 13 soil SUs had been designated for the areas associated with Buildings 2, 12, and 27. FSS activities were performed, including the collection of soil samples. Since none of the FSS results revealed the presence of radiological contamination above the release criterion, the SUs were backfilled.

Dose modeling was performed for the 13 SUs. *None of the modeling results for the SUs exceeded the 15 mrem/y unrestricted release criterion.* The maximum dose for the 13 SUs was calculated at 7.039 mrem/y.

Storm Drain Line Cleaning and Associated Activities

In addition to the storm drain systems noted above, actions were taken by the DON during the TCRA activities to address radiological contamination associated with other storm drain systems located within the NAVSTA PS project site. In these instances, storm drain line cleaning and associated activities were performed during the TCRA to remove sediment, inspect the pipelines, perform gamma scans of the interior of the storm drain lines, MHs, and CBs, and sample soil in the vicinity of the storm drain lines. Each of the storm drain lines was cleaned using hydrojetting equipment to flush accumulated sediment from the lines. Sediment samples were collected from four MHs and submitted to the laboratories for analysis. The analytical results did not identify the presence of contamination. Following the hydrojetting operations, the interior of each storm drain line was inspected and gamma scan surveys were conducted. The results of the gamma scan surveys and the inspection results provided the basis for identifying eight soil sample collection locations adjacent to the storm drain lines. In total, 11 soil samples were collected and analyzed for the ROCs. *All results were below the TCRA release criteria.*

Sediment and water generated by the hydrojetting process were managed at the centralized waste storage and processing area. Ten composite sediment samples were collected and analyzed. None of the analytical results revealed the presence of contamination in the sediment samples. Accumulated water was sampled and analyzed for chemicals and the ROCs. The wastewater was subsequently discharged to the sanitary sewer in accordance with a letter of authorization from the King County Wastewater Treatment Division, Industrial Waste Program.

Survey of Buildings 2, 11, and 40 Welding Areas

From a review of historic NAVSTA PS documents, the DON identified areas in Buildings 2, 11, and 40 where past welding operations likely had taken place. Due to the potential historical use of thoriated tungsten welding rods in Buildings 2, 11, and 40, the DON determined that further investigation of these areas was warranted during the TCRA. TtEC performed survey activities in the Buildings 2, 11, and 40 welding areas. None of the survey results identified the presence of thorium-232, Ra-226, Cs-137, or Sr-90 contamination.

Site Restoration

Site restoration activities were performed following the TCRA activities. These activities included installing two new storm drain systems, backfilling and grading soil and storm drain remediation areas, adding topsoil to and reseeding previously vegetated areas, and repaving areas where pavement had been damaged and/or removed. The restoration of remediated areas in Building 2 was limited to installing new wood floor decking in some areas to close off openings in the floor. Following demolition of the South Shed, the Building 27 hangar structure and adjoining stair towers were restored in accordance with a plan approved by the Seattle Landmarks Preservation Board to meet Historic Preservation Act requirements. TCRA activities for the NAVSTA PS site were completed in May 2015.

Conclusion

During the TCRA, no alpha or beta measurements were found above the investigation levels; none of the alpha, beta, or gamma measurement results revealed activity above the release criteria for the ROCs; and no processed personnel dosimetry badges revealed gamma doses above background levels. The information and data presented in this AAR confirm the DON's conclusion that the TCRA resulted in a reduction of the potential dose to levels below the RAOs, and no further action is required.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

PAGE

TABLE OF CONTENTS
(Continued)

TABLES

FIGURES

TABLE OF CONTENTS
(Continued)

PHOTOGRAPHS

TABLE OF CONTENTS
(Continued)

APPENDICES
(on CD)

ATTACHMENTS

This page intentionally left blank.

ABBREVIATIONS AND ACRONYMS

$+3\sigma$	plus three sigma (standard deviations)
AAR	After Action Report
ACM	asbestos-containing material
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
Argus	Argus Pacific, Inc.
ASTM	ASTM International
BRAC	Base Realignment and Closure
bgs	below ground surface
Bi-214	bismuth-214
CB	catch basin
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeter
COC	chain of custody
cpm	counts per minute
Cs-137	cesium-137
CTO	Contract Task Order
DCGL	derived concentration guideline level
$DCGL_W$	DCGL for average concentration over a wide area
DoD	Department of Defense
DOE	Department of Energy
DON	Department of the Navy
dpm	disintegrations per minute
DQO	data quality objective
EBS	Environmental Baseline Survey
EE/CA	Engineering Evaluation/Cost Analysis
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
FCR	Field Change Request

ABBREVIATIONS AND ACRONYMS
(Continued)

FSS	Final Status Survey
GWS	gamma walkover survey
H_a	alternative hypothesis
HEPA	high-efficiency particulate air
H_o	null hypothesis
HS	hotspot
keV	kiloelectron volt
LBGR	lower boundary of the gray region
LLRW	low-level radioactive waste
LPB	Landmark Preservation Board
	or lead-based paint
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MDL	method detection limit
MeV	megaelectron volt
MH	manhole
mrem/y	millirem per year
NaI	sodium iodide
NAVFAC NW	Naval Facilities Engineering Command Northwest
NAVSTA PS	former Naval Station Puget Sound
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
Pb-210	lead-210
PCB	polychlorinated biphenyls
pCi/g	picocuries per gram

ABBREVIATIONS AND ACRONYMS
(Continued)

PVC	polyvinyl chloride
QC	quality control
Ra-226	radium-226
RAO	removal action objective
RASO	Radiological Affairs Support Office
RCA	radiologically controlled area
RCT	Radiological Control Technician
RESRAD	residual radioactivity (computer code)
RESRAD-BUILD	residual radioactivity in buildings (computer code)
RI	remedial investigation
RML	Radioactive Materials License
ROC	radionuclide of concern
RSO	Radiation Safety Officer
RSOR	Radiation Safety Officer Representative
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
Shaw	Shaw Environmental & Infrastructure, Inc.
SHPO	State Historic Preservation Office
SOP	standard operating procedure
Sr-90	strontium-90
SU	survey unit
Th-232	thorium-232
TCRA	time-critical removal action
TEDE	total effective dose equivalent
TSP	Task-specific Plan
TtEC	Tetra Tech EC, Inc.
USAJMC	U.S. Army Joint Munitions Command
VOC	volatile organic compound
VSP	Visual Sample Plan
WAC	*Washington Administrative Code*
WRS	Wilcoxon Rank-Sum (test)

ABBREVIATIONS AND ACRONYMS
(Continued)

WDOH	Washington State Department of Health
WSDOT	Washington State Department of Transportation

1.0 INTRODUCTION

Tetra Tech EC, Inc. (TtEC) prepared this After Action Report (AAR) under contract with The U.S. Department of the Navy (DON) to describe and summarize the radiological materials time-critical removal action (TCRA) performed at former Naval Station Puget Sound (NAVSTA PS) located in Seattle, Washington. The NAVSTA PS TCRA was performed to protect the public health and welfare and the environment by addressing radiological contamination identified at NAVSTA PS. While the focus of the TCRA was on the central portion of Building 2, the Building 27 South Shed, and open soil and paved areas and storm drains located in the vicinity of these buildings, the scope of the TCRA was expanded to include an investigation of welding shops in Buildings 2, 11, and 40 due to the possibility that thoriated welding rods had been used there. The results of the removal action and site restoration activities performed within the NAVSTA PS project site are summarized in this AAR.

This AAR documents the TCRA tasks identified in the scope of work completed under Contract No. N62473-10-D-0809 and Contract Task Order No. 0011 for the Base Realignment and Closure (BRAC) Program Management Office under Naval Facilities Engineering Command Northwest (NAVFAC NW), including:

- Removal of radiologically contaminated components in Building 27, 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 hangar structure
- Removal of radiologically contaminated components in Building 2, including associated radiological surveys, restoration, and waste management
- Removal of the non-operational Building 2 ventilation system when contamination was found above the release criteria, and leaving those sections that did not exceed the release criteria 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 associated with Buildings 2 and 27, including additional assessments, associated radiological surveys, restoration, and waste management
- Disposal of wastes in a permitted landfill and disposal of low-level radioactive waste (LLRW) in a licensed waste disposal facility

The TCRA work activities were performed by TtEC in accordance with the Final Radiological Removal Action Work Plan (Work Plan) (Attachment 5) and other supporting plans and documents described in Section 2.5 of this AAR.

1.1 FORMER NAVAL STATION PUGET SOUND LOCATION AND DESCRIPTION

Located approximately 6 miles northeast of downtown Seattle, Washington, former NAVSTA PS is situated along the western shore of Lake Washington (Figures 1-1 and 1-2). The property 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 and encompasses the central portion of Building 2, the Building 27 South Shed (a 2-story annex attached to the south side of the Building 27 hangar structure) and adjacent south stair towers, some of the land area surrounding Buildings 2, 12, and 27, and the welding shops in Buildings 2, 11, and 40.

Building 2 is located west of the NOAA facilities and south of NE NOAA Drive. Building 12 is located west of Building 2. Building 27 is located northwest of the NOAA facilities and north of NE NOAA Drive. Buildings 11 and 40 are located northwest of Building 27. The locations of these buildings within the project site are shown on Figure 1-3. Exposed soil areas exist between the entrances to Building 2, and also south and west of Building 27. When the NOAA access road was built between Buildings 2 and 27 in the 1970s, the elevation was raised, and retaining walls and an overpass were constructed. Soil areas on both sides of the NOAA road still exist, but were altered in places. The original concrete tarmac still exists west, north, and east of Building 27, but a large historically unpaved area west of Building 27 has been paved more recently with asphalt. Sections of soil between Buildings 2, 12, and 27 also have been paved more recently with asphalt.

The two primary storm drain systems that serve the project site are: 1) a 24-inch-diameter system that originates south of Building 2 and continues along the west side of Building 2, then passes beneath NE NOAA Drive and Building 27, and 2) a 36-inch-diameter system located in the paved areas west of Building 27. Both systems drain to the north and converge on Manhole (MH) 160, and from there discharge into Lake Washington. Catch basins (CBs) on branch lines located on the east, west, and south sides of Building 27 drain to these storm drain lines.

1.1.1 Current Land Use

The first floor work areas and second floor offices situated on the north side of the Building 2 north hangar are occupied by the Seattle Conservation Corp. The remainder of Building 2 is vacant. The Building 27 former aircraft hangar space is occupied by the Magnuson Athletic Club and Arena Sports facilities.

1.2 PHOTOGRAPHS

The TCRA fieldwork activities were documented using a photographic record. Photographs of typical operations performed during the TCRA fieldwork are provided in this AAR in front of the appendices.

1.3 PURPOSE AND ORGANIZATION OF REPORT

The purpose of this AAR is to describe and summarize the TCRA conducted by TtEC at former NAVSTA PS to protect the public health and welfare, and the environment from actual or potential releases of radiologic contaminants and document the results.

This AAR is organized as follows:

- **Section 1.0 Introduction –** Section 1.0 provides project information, including descriptions of NAVSTA PS and the TCRA project site, the current and future land use of the property, fieldwork photographic documentation, and the purpose and organization of this AAR document.
- **Section 2.0 Background –** Section 2.0 places the project site within context of NAVSTA by presenting an abbreviated history, regulatory framework, and license, and the objectives of the TCRA; identifying the release criteria and remediation goals; and summarizing the various documents that support the radiological work performed.
- **Section 3.0 Project Area Overview –** Section 3.0 provides an overview of the initial activities, air monitoring, established background reference areas, survey design and classification, reference coordinate system, statistical tests, dose modeling, waste disposal, and demobilization activities. Each of these sections is applicable to the work performed throughout the TCRA.
- **Section 4.0 Project Site Buildings Overview –** Section 4.0 summarizes the survey instrumentation, detection sensitivity, survey procedures and data interpretation, investigation levels, final status surveys (FSSs), regulated materials assessments, and abatement activities associated with the TCRA. This section also summarizes the TCRA activities performed for Buildings 2 and 27, as well as the former welding areas associated with Buildings 2, 11, and 40.
- **Section 5.0 Project Site Soil and Storm Drain Overview –** Section 5.0 summarizes the soil and sediment activities related to the TCRA, including the release criteria, FSSs, laboratory analyses, excavation and remediation of Building 27 soil survey unit (SU)-20, soil areas associated with Buildings 2, 12, and 27, storm drain line cleaning and associated activities, analysis of additional storm drain system sediment, and the electrical system upgrade survey activities.

- **Section 6.0 Site Restoration –** Section 6.0 summarizes the activities performed to restore or improve the project site, including the storm drain system installation, and the Building 27 south wall and stair towers, and monitoring well repairs. In addition, this section discusses the activities associated with the final inspection of the project site at the completion of the TCRA activities.
- **Section 7.0 Conclusions and Recommendation –** Section 7.0 presents the conclusions to the TCRA and the final recommendation for unrestricted release of the property.
- **Section 8.0 References –** Section 8.0 lists the documents and references cited in this AAR.
- **Appendices A through W –** The individual appendices present information and technical data gathered during the performance of the TCRA, and other documents that support the conclusion presented in this AAR.
- **Attachment 1 –** Building 2 Final Status Survey Results
- **Attachment 2 –** Building 27 Final Status Survey Results
- **Attachment 3 –** Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27
- **Attachment 4 –** Report of Storm Drain Line Cleaning and Associated Activities
- **Attachment 5 –** Final Radiological Removal Action Work Plan

2.0 BACKGROUND

The following sections provide an abbreviated history and pertinent background information leading to the development of the Work Plan (Attachment 5), the Task-Specific Plan (TSP) for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (TtEC 2013a), and the Final TSP for Buildings 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys (TtEC 2013b). Included are brief descriptions of the supporting documents and reports that guided the TCRA work activities.

2.1 HISTORY

Originally named Naval Air Station Seattle at Sand Point, portions of the former NAVSTA PS facility were constructed in 1925 on land donated by King County. Many of the major buildings were built in the late 1930s prior to World War II. Building 27 was constructed in 1937 and Building 2 was constructed in 1938. Further construction and remodeling were performed in later years, including expansion of the Instrument Shop in Building 2 in 1941 (1941 Instrument Shop) and the addition of the South Shed to Building 27 in 1944.

Naval Air Station Seattle supported aircraft transport and ship outfitting personnel for the Alaskan and Western Pacific theaters of operation during World War II, and was later 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 when Naval Air Station Seattle was decommissioned.

Three years after the DON ceased its aircraft activities, the facility was divided into three parts. 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 DON retained the remainder. From 1970 to April 1982, logistic services, such as supplies, billeting, and administration, were provided to the 13th Naval District, Department of Defense (DoD), and other federal agencies. In April 1982, Naval Support Activity Seattle was re-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 announced the closure of NAVSTA PS. A disestablishment ceremony was held by the DON on September 28, 1995 to commemorate the closing of NAVSTA PS.

The DON conducted an Environmental Baseline Survey (EBS) (URS 1996) and performed cleanup activities on portions of former NAVSTA PS following closure. During these investigations, areas of potential environmental concern were identified where storage or release of hazardous substances had occurred; however, no radiological contamination was identified (URS 1996). A summary of the EBS (URS 1996) is provided in Section 2.5.1. Based on the results of these investigations, the DON generated a Finding of Suitability to Transfer for the property. The transfer deed between the DON and the City of Seattle included an environmental covenant that allowed the City to seek action to address contamination that was not identified in the EBS (URS 1996). The DON initiated transfer of the former NAVSTA PS property to several government agencies in accordance with the BRAC closure plan.

2.1.1 Radiological History

While planning proposed renovations to Building 27, the City of Seattle reviewed historical drawings and identified a room labeled "Radium Room." Following this discovery, Seattle Parks and Recreation reviewed drawings for Building 2, and identified an area labeled "Instrument Shop." Additional research revealed that from the late 1930s through the 1960s, the DON commonly performed maintenance on radioluminescent aircraft dials and gauges typically containing radium-226 (Ra-226). Historical DON records confirmed that former NAVSTA PS routinely received shipments of Ra-226, which was used for the maintenance of the radioluminescent devices. These maintenance operations were commonly conducted in aircraft hangars, suggesting that radioactive materials may have been used or stored both in Buildings 2 and 27.

With the potential for radioactive materials use, dose rate radiation surveys were performed within Building 2, Building 27, and three nearby pump houses identified as Pump Houses A, B, and 116 in April (Argus 2009a) and May 2009 (Argus 2009b) by Argus Pacific, Inc. (Argus) under contract with Seattle Parks and Recreation. The Argus surveys identified two locations in the Building 27 South Shed where radiation levels were above background levels. 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. The Argus survey for Building 2 and the three pump houses (2009b) did not reveal the presence of radiation above background levels.

Following the 2009 Argus surveys, the DON completed a radiological remedial investigation (RI) at former NAVSTA PS and the results were documented in the Radiological Remedial Investigation Report (Shaw 2011). A summary of this RI report is provided in Section 2.5.2. Based on the results of the RI report, an Engineering Evaluation/Cost Analysis (EE/CA) was initiated to develop and evaluate removal action alternatives for the project site. Due to continued deterioration of the NAVSTA PS project site buildings and the discovery of trespassers in Building 2, the DON elected to forego further development of the EE/CA and perform a radiological materials TCRA. The Final Action Memorandum, Time-Critical Removal Action (Action Memorandum) (DON 2013) was prepared to present the written decision and document the appropriate removal action based on regulatory and public comments. A summary of the Action Memorandum is provided in Section 2.5.3.

2.2 REGULATORY FRAMEWORK

The TCRA for former NAVSTA PS was conducted in accordance with the DON's Environmental Restoration Program using the process identified in Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). Regulatory oversight was provided by the Washington State Department of Ecology, as the lead regulatory agency, and the Washington State Department of Health (WDOH).

The TCRA activities followed the substantive requirements of CERCLA and the Nation Oil and Hazardous Substances Pollution Contingency Plan (NCP). In accordance with Title 40, *Code of Federal Regulations* Section 300.415(3)(b)(1), for any release where the lead agency (DON) makes the determination that there could be a risk to public health or welfare or the environment, regardless of whether the site is included on the National Priorities List, the lead agency may take any appropriate removal action to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or threat of release.

2.3 STATE OF WASHINGTON RADIOACTIVE MATERIALS LICENSE

TtEC performed the TCRA activities under State of Washington Radioactive Materials License (RML) WN-L0244-1, dated 1 August 2013. A copy of the RML is included in Appendix A. Radioactive material could only be stored and/or used in and around Buildings 2, 12, and 27 at former NAVSTA PS. All radioactive wastes were transferred to another WDOH licensee for disposal under contract to the U.S. Army Joint Munitions Command (USAJMC).

2.4 REMOVAL ACTION OBJECTIVES

The removal action objectives (RAOs) for the former NAVSTA PS project site were established in the Action Memorandum (DON 2013). The RAOs included:

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

- Dispose of non-LLRW in a permitted landfill and LLRW in a licensed LLRW waste disposal facility.

2.4.1 Radionuclides of Concern

The ROCs for the TCRA were identified in the Action Memorandum (DON 2013) as Cs-137, Ra-226, and Sr-90. Table 2-1 lists these ROCs along with their associated half-lives and principal types of radiation (alpha, beta, and gamma).

2.4.2 Unrestricted Radiological Release Criteria

The DON determined that actual or threatened releases of radiological contaminants from the NAVSTA PS project site could present a risk to public health, welfare, or the environment, and that this threat could be abated and eliminated by performing a TCRA. Consequently, the DON took steps to ensure that residual radioactivity within the NAVSTA PS project site did not result in individuals being exposed to unacceptable levels of radiation or radioactive materials. This decision was documented in the Action Memorandum (DON 2013), which is summarized in Section 2.5.3.

The intent of the removal action and surveys was to achieve unrestricted release for the NAVSTA PS project site. The criterion for unrestricted release was established in the Action Memorandum (DON 2013) as a net residual dose of less than 15 millirem per year (mrem/y) for soil survey units and the limits specified for Cs-137, Ra-226, and Sr-90 in AEC Regulatory Guide 1.86 (AEC 1974) for building survey units. Residual levels of radioactive material that corresponded to allowable radiation dose standards were derived by analysis of various pathways and scenarios, such as direct exposure, inhalation, and ingestion. Derived concentration guideline levels (DCGLs), were developed as cleanup levels based on the estimated dose to the public from residual contamination. These radionuclide-specific values were based on the limits specified for Cs-137, Ra-226, and Sr-90 on building surfaces in Atomic Energy Commission (AEC) Regulatory Guide 1.86 (AEC 1974), and dose modeling at 15 mrem/y using the following residual radioactivity (RESRAD) (computer code) scenarios: 1) Industrial Worker scenario for soil/sediment, with the radon pathway turned on and an occupancy factor of 0.115 indoor and 0.115 outdoor, or 2) Recreationist scenario for soil, with an outdoor occupancy factor of 0.059, whichever value was more restrictive. This resulted in DCGLs for Ra-226, Cs-137, and Sr-90 of 1.07 picocuries per gram (pCi/g), 25.63 pCi/g, and 9.45 pCi/g, respectively.

The radionuclide-specific release criterion (referred to as DCGLs) used for the FSS activities was equivalent to the ROC release criteria established in the Action Memorandum (DON 2013). The DCGLs were presented in terms of radioactivity concentrations and referred to the average levels of radiation or radioactivity above background levels across the project site based on dose. The DCGLs applicable to the FSSs were expressed in disintegrations per minute (dpm)/100 square centimeters (cm^2) or pCi/g, as appropriate. The radionuclide-specific release criteria for building surfaces and soils are listed in Table 2-2.

Typically, each radionuclide DCGL corresponded to the release criterion (e.g., regulatory limit in terms of dose or activity). However, in the presence of multiple radionuclides, the total of the DCGLs for all radionuclides could exceed the release criterion. In this case, the individual DCGLs would need to be adjusted to account for the presence of multiple radionuclides contributing to the total dose. Consequently, the individual DCGLs were adjusted using the unity rule and development of a gross activity DCGL for surface activity to adjust the individual radionuclide DCGLs. The unity rule was satisfied when radionuclide mixtures yielded a combined fractional concentration limit that was less than or equal to 1, as specified in Section 7.2.1 of the Work Plan (Attachment 5). Detailed discussions of the release criteria for the NAVSTA PS project site were provided in the individual FSS reports presented in Attachment 1 (Building 2 Final Status Survey Results), Attachment 2 (Building 27 Final Status Survey Results), and Attachment 3 (Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27).

2.5 SUPPORTING DOCUMENTS SUMMARY

The following sections summarize the relevant supporting plans and other documents necessary to facilitate and complete the TCRA activities. Deviations to these plans were implemented with the concurrence of the DON and the Radiological Affairs Support Office (RASO) and are described in Section 2.5.8. Each of these supporting documents is incorporated by reference into this AAR, and is available for review through the Administrative Record.

2.5.1 Environmental Baseline Survey Report

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

2.5.2 Radiological Remedial Investigation Report

Under contract with the DON, Shaw Environmental & Infrastructure, Inc. (Shaw) completed a radiological RI at former NAVSTA PS during April 2010 through December 2010. The results of this investigation were documented in the RI Report (Shaw 2011). Release criteria developed by Shaw for the investigation were listed in Tables 6 and 7 of the RI Report. The radiological RI project release criteria for equipment and structures (surfaces) were obtained from AEC

Regulatory Guide 1.86 (1974). The dose-based calculations were performed using the most current version of RESRAD software (for outdoor areas). The dose-based calculations implemented 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 did not use default values were specified in the RI Report. During the TCRA, reference area background soil samples were collected and analyzed. These sample results provided the basis for an updated release criteria for the TCRA, which is discussed in further detail in Section 3.3.2.

Contamination exceeding the radiological RI release criteria was found in and around the former 1939 and 1941 Instrument shops in Building 2, and within the Building 27 South Shed and two adjoining Building 27 stair towers. Radiological contamination was also found in piping associated with Buildings 2 and 27 and in CBs and soil adjacent to these structures and nearby Building 12. More specifically, radiological contamination exceeding the RI release criteria was identified in association with the following:

<u>Building 2</u>

- Floors and walls of the former 1939 and 1941 Instrument Shops and the area immediately adjacent to (south and east) of the former 1941 Instrument Shop at the second floor level
- The former 1941 Instrument Shop closed-loop ventilation system in the attic area
- Sludge from a drain pipe associated with the former sink located in Room 5 of the former 1941 Instrument Shop
- Sediment from a collection pit located immediately outside the Building 2 west exterior wall

<u>Building 27</u>

- Floors and walls of the South Shed and adjoining southwest and southeast stair towers, predominantly at the second floor level, with isolated areas of contamination on concrete floor of the first floor Welding Shop near a drain pipe associated with the former Radium Room sink penetrating the concrete floor and another area consistent with dripping from a ceiling penetration
- Heating and air conditioning system equipment located within the South Shed rooftop penthouse structure
- Floor exhaust vents and associated ducting located along the north and south perimeter walls of the former Instrument Shop, including surfaces within the joist space through which ducting was routed
- A single run of the exhaust duct that was suspended from the ceiling in the first floor Tech and Library Parts area

Storm Drain Systems

- Sediment in CB-1, which was located south of the Building 27 South Shed and received discharge from sinks located in the central area of the South Shed
- Sediment in CB-3, which was located off the southwest corner of Building 27 and received discharge from the former Radium Room sink
- Sediment in CB-5, which was located on the west side of Building 27 and collected surface flow from the surrounding ground surfaces

Soil

- Historically unpaved (nontarmac) areas south and west of Building 27
- Limited areas along the north side of Building 12 and the south and east sides of Building 2
- A single discrete item (radioactive button) removed from the soil along the east side of Building 2

2.5.3 Action Memorandum

The Action Memorandum (DON 2013) was prepared to present the written decision documenting the appropriate removal action based on regulatory and public comments. Based on the results of the RI Report (Shaw 2011), release criteria were developed for the TCRA. The release criteria for equipment and structures (surfaces) were taken from AEC Regulatory Guide 1.86 (AEC 1974). The Action Memorandum included an endangerment determination, proposed actions and estimated costs, and applicable or relevant and appropriate requirements (ARARs) for the proposed TCRA.

The dose-based calculations were performed using the most current version of RESRAD software package for outdoor areas (Yu et al. 2014) with a dose limit of 15 mrem/yr in accordance with the EPA guidance at the time.

However, in June 2014, the EPA released updated guidance ("Radiation Risk Assessment at CERCLA Sites: Q&A"), changing the recommendation on what is considered a protective dose from 15 to 12 mrem/y (EPA 2014).

2.5.4 Radiological Removal Action Work Plan

The radiological work activities for the former NAVSTA PS project area were performed using guidance established in the Work Plan (Attachment 5). This Work Plan provided guidance for:

- Radiological training
- Various work control procedures

- Radiological survey types, classifications, and selection
- Survey planning and implementation
- Results assessment and decision making
- Release criteria and investigation levels
- Field and laboratory instruments and instrumentation equations
- Decontamination, dismantling, remediation, and disposition
- Radioactive materials management
- Documentation and records management
- Removal action fieldwork implementation, including removal of radiologically contaminated soil and drain lines and removal of radiologically contaminated building components
- Site restoration and demobilization

The procedures and methodologies outlined in the Work Plan were applicable to the work performed for the radiologically impacted buildings, sites, structures, and areas at former NAVSTA PS, as well as other NAVSTA PS-wide support functions.

In addition, the Work Plan included the following attachments:

- Sampling and Analysis Plan (SAP)
- Project Contractor Quality Control Plan
- Environmental Protection Plan/Waste Management Plan
- Standard Operating Procedures (SOPs)
- Air Emissions Plan
- TSP for Buildings 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys
- TSP for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys
- Radiation Protection Plan

2.5.5 Air Emissions Plan

TtEC prepared the Final Air Emissions Plan for the TCRA activities, dated July 2013. The Final Air Emissions Plan was consistent with the RML for radiological remediation within the project site. A copy of the RML is provided in Appendix A.

The Air Emissions Plan included methodologies for minimizing soil airborne particulates and fugitive dust emissions during the performance of fieldwork and specified that an air sampler would be located at the boundary of the radiologically controlled area (RCA) located adjacent to the north, south, east, and west of Building 27. These air samplers remained in these locations for the entirety of the NAVSTA PS TCRA. Air filters were collected weekly for quarterly composite analysis. The total effective dose equivalent (TEDE) to the maximum exposed individual was calculated in the Final Air Emissions Plan at 6.99E-8 mrem/y using the Clean Air Act Assessment Package - 1988 (CAP-88) modeling software (EPA 2014). During soil remediation activities, four air sampling units were stationed around the RCA boundary, and operated continuously while remediation operations were performed. Air samplers were operated for a minimum of 20 hours per week. A copy of the Air Emissions Plan is provided in Appendix B.

2.5.6 Work Instructions

TtEC prepared a number of work instructions for completing work activities that were not specifically covered in the Work Plan (Attachment 5), TSP for the Buildings 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys (TtEC 2013b), or TSP for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (TtEC 2013a). These work instructions are summarized in the following sections and copies of the individual documents are provided in Appendix C.

2.5.6.1 Storm Drain Line Cleaning

The Work Instruction for Storm Drain Line Cleaning and Associated Activities dated October 2014 was prepared by TtEC for the NAVSTA PS TCRA project site. This work instruction established the requirements for cleaning, gamma scanning, and inspecting to determine the condition of radiologically impacted storm drain lines identified on Figure 1-1 of the Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4). The focus of these efforts was a 24-inch-diameter system passing beneath Building 27 and a 36-inch-diameter system located in the paved areas west of Building 27. Both systems drain to the north and converge on Manhole (MH) 160, and from there discharge into Lake Washington. The work instruction addressed activities related to sediment removal and was to be used in conjunction with the Work Plan (TtEC 2013a) and associated appendices, and the Accident Prevention Plan/Site Safety and Health Plan (TtEC 2013c). The work instruction also included the methodology and procedures for soil coring and sampling in accordance with the SAP. In addition, radiological controls for hoses and the vacuum truck were included in the work instruction. A copy of the work instruction is provided in Appendix C.

2.5.6.2 Welding Shop Investigations

From a review of historic NAVSTA PS documents, the DON identified areas in Buildings 2, 11, and 40 where past welding operations likely had taken place. Due to the potential historical use of thoriated tungsten welding rods, the DON determined that further investigation of these areas was warranted. In response, individual work instructions for Buildings 2, 11, and 40 scoping surveys for thorium-232 (Th-232) were developed. The work instructions provided the rational for the survey activities, specified the instruments to be used and the number of measurement locations, and identified soil/sediment sample collection locations, as appropriate, Each of the work instructions for the Buildings 2, 11, and 40 scoping surveys is included in Appendix C.

2.5.6.3 Building 27 Re-Survey

The Work Plan (Attachment 5) and TSP for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (TtEC 2013a) originally specified the use of gas-flow proportional detectors at a verified quantifiable survey scan rate with a combination of systematic and biased static measurements to be collected based on the scan readings. Because Ra-226 contamination was discovered during the NAVSTA PS TCRA along cracks between the Building 27 floor and wall space due to water infiltration, the work instruction was developed with the intent of surveying using the typical quantifiable survey scan method with the addition of performing a hand scan survey using a Ludlum 43-93 detector and emphasizing audible increases in counts during the scanning activities. This work instruction also extended the size of Class 1 SUs and added SUs for survey activities. A copy of this work instruction is provided in Appendix C.

2.5.7 Lead Compliance Plan

TtEC developed the Lead Compliance Plan, dated 10 September 2013, for work activities that could emit lead during the TCRA. The purpose of the Lead Compliance Plan was to describe procedures to ensure that workers were not exposed to elevated levels of lead in air, measured over an average 8-hour period. This program was designed to ensure that the project site was in compliance with the U.S. Army Corps of Engineers Health and Safety Requirements Manual EM 385-1-1, Section 06.B.05.b and WAC 296-62-07521 (USACE 2008). The Lead Compliance Plan included procedures for air monitoring, personal air samples, protective clothing, administrative controls, medical surveillance procedures, and training. A copy of the Lead Compliance Plan is provided in Appendix D.

2.5.8 Field Change Requests

A total of 12 field change requests (FCRs) were generated during the TCRA fieldwork to address necessary changes to the approved plans. These changes were generally determined to be necessary to address changed field conditions or improve operational efficiency.

The FCRs generated for the TCRA were:

- FCR 1 – Changed the background reference area for buildings from Building 11 to Building 47.
- FCR 2 – Revised the frequency at which gamma survey investigation levels were established.
- FCR 3 – Revised the scan speed used for alpha surveys.
- FCR 4 – Incorporated provision for reporting soil screening results using the 186 kiloelectron volt (keV) peak as a precursor to running the 21-day ingrowth method. Also updated laboratory reporting to include a full list of gamma isotopes for this screening method.
- FCR 5 – Updated TCRA release criteria to reflect new background values.
- FCR 6 – Incorporated U.S. Department of Energy (DOE) Health and Safety Laboratory Manual 300 4.5.2.3 as an alternative to DOE Method 901.1 to analyze for Ra-226 and Cs-137 in soil.
- FCR 7 – Reconfigured the Building 2 Class 1 SUs.
- FCR 8 – Incorporated provisions in the SAP for sampling and surveying underground pipe, MHs, and CBs to determine whether they could be left in place to avoid potential safety risks associated with removal.
- FCR 9 - Incorporated provisions in the Work Plan (Attachment 5) for sampling and surveying underground pipe, MHs, and CBs to determine whether they could be left in place to avoid potential safety risks associated with removal.
- FCR 10 – Incorporated the removal and replacement of storm drain pipes and CBs as directed under Contract Task Order (CTO) Modification 7.
- FCR 11 – Incorporated a Re-survey Work Instruction in response to the results of the WDOH verification survey in Building 27.
- FCR 12 – Revised the survey requirements for the surfaces exposed following removal of ventilation duct from the Building 27 attic space.

Copies of the FCRs for the TCRA are included in Appendix E.

2.5.9 Dive Operations Plan

During the TCRA storm drain line cleaning and associated activities, summarized in Section 6.2, the Dive Operations Plan was implemented to isolate and clean the underwater storm drain outfall. Global Diving and Salvage, Inc. prepared the Dive Operations, Magnuson Park Storm Water Outfall, Seattle, Washington, Pipe Cleaning Operations, 2014 Plan (Dive Operations Plan) in accordance with EM-385-1-1 (USACE 2008). The Dive Operations Plan identified the designated on-site dive team members and their tasks. The tasks included:

- Locating the underwater storm drain outfall to Lake Washington
- Removing silt and debris from the open end of the outfall
- Installing a temporary pneumatic plug
- Removing the temporary plug when cleaning operations were complete

The Dive Operations Plan included an activity hazard analysis and emergency management plan. A copy of the Dive Operations Plan is included in Appendix F.

2.5.10 Asbestos Abatement Work Plan

The Asbestos Abatement Work Plan, Revision 1 was prepared by the William Dickson Company for demolition and hazardous materials abatement associated with Buildings 2 and 27 at the NAVSTA PS project site. The purpose of the plan was to minimize and/or eliminate the impact of the asbestos removal activities to workers, the environment, and areas adjacent to the removal activities. The scope of work included the removal of friable and non-friable asbestos-containing materials (ACM). ACM at the NAVSTA PS project site included built-up roofing, caulking and sealants; cement asbestos board interior panels, exterior siding, and vapor barriers; floor tile and mastic; thermal insulation on pipe and fittings; and electrical panels. The Asbestos Abatement Work Plan included site control measures, ACM removal techniques, decontamination procedures, air monitoring, training requirements, and waste shipment and disposal procedures. A copy of the Asbestos Abatement Work Plan is provided in Appendix G.

2.5.11 Historical Preservation

Two historical districts are associated with NAVSTA PS: Sand Point Historic District and Naval Air Station Seattle National Register of Historic Places District. Building 27 is listed as a contributing structure in both districts. In preparing for the TCRA activities, the DON contacted the Washington State Historic Preservation Officer (SHPO) and requested SHPO concurrence with its finding that the TCRA would have an adverse effect on historic properties, further requesting initiation of consultation in the preparation of a Memorandum of Agreement to address the adverse effects. Relative to the planned actions at Building 27, SHPO responded that, in its opinion, demolition of the South Shed would have no adverse effect on Building 27. However, this determination was only valid if the south end wall was treated appropriately to meet the standards of the Secretary of the Interior.

Following SHPO's determination, TtEC staff prepared a Landmarks Preservation Board (LPB) Certificate of Approval application proposing the demolition of the South Shed and detailing plans for restoring the Building 27 south wall and stair towers to meet Historic Preservation Act requirements. On 31 October 2014, TtEC and the DON presented the proposed plan at a meeting with the LPB architectural committee. Based on the committee review, the proposal was forwarded for board review. On 19 November 2014, TtEC and the DON presented the proposal to the board, at which time the application was approved. The Certificate of Approval application and LPB approval letter are included in Appendix H.

2.5.12 Building 27 South Shed Demolition Plan

SHPO concurred that demolition of the Building 27 South Shed would have no adverse effect on historical preservation of the structure, as described in Section 2.5.11. Since the South Shed would be demolished at the conclusion of the TCRA activities, a demolition plan was prepared. The demolition plan included the methodology and procedures for the deconstruction work activities, including pre-demolition work, underground utilities, site controls, utility demolition, site restoration, equipment to be used, and waste disposal. A copy of the Building 27 South Shed Demolition Plan is provided in Appendix I.

This page intentionally left blank.

3.0 PROJECT SITE OVERVIEW

This section provides an overview of the overall activities performed at the NAVSTA PS project site during the TCRA. The purpose of this section is to eliminate redundancy in the remaining sections of this AAR and to provide an overview of the radiological activities completed for the project site. The tables and figures introduced in this section will be referenced throughout the remaining sections of this AAR.

The radiological work performed during the TCRA was conducted under TtEC's RML. The RML is described in Section 2.3, and is provided in Appendix A. In accordance with NCP requirements, the ARARs for the work were presented in the Action Memorandum (DON 2013). The selected ROCs and their associated half-lives are presented in Table 2-1 and the radiological release criteria established in the Action Memorandum are listed in Table 2-2. Although Th-232 was not identified as an ROC for the NAVSTA PS project site, Th-232 investigations were performed during the TCRA as described in Section 4.9.

3.1 INITIAL ACTIVITIES

In July 2013, TtEC mobilized to perform activities associated with the TCRA. Equipment that was used was surveyed upon arrival at the project site and verified to be free of radioactive contamination prior to use. AEC Regulatory Guide 1.86 limits (AEC 1974) specified for Cs-137, Ra-226, and Sr-90 were used for clearance of the equipment. Work activities began with a walkthrough of the project site conducted by TtEC health and safety personnel accompanied by health physics professionals. The walkthrough was performed to ensure that personnel working at the project site would not encounter unsafe conditions, to determine the amount of trash/debris to be removed for disposal, and to inspect any equipment and materials to be surveyed prior to release.

Field activities for the first phase of the TCRA were initiated prior to initiating the surveys. During these activities, temporary fencing was installed or reconfigured, dust controls and air monitoring were implemented, and traffic was controlled and rerouted, as appropriate, prior to initiating intrusive activities.

3.2 AIR MONITORING

In accordance with RML WN-L0244-1 Condition 21.D (Appendix A), TtEC conducted continuous perimeter air monitoring and collected a sufficient number of air samples to prepare an annual report calculating the actual dose to the maximally exposed individual using the annual possession quantity (yearly throughput) for each ROC.

To ensure compliance with this license condition, TtEC prepared an Air Emissions Plan (Appendix B) describing the continuous air sampling to be performed during remediation activities at the NAVSTA PS project site. The data generated were used to verify that airborne concentrations of radiological constituents did not result in a dose exceeding 10 mrem/y to the maximally exposed individual, and ensure protection of the general public from potential airborne emissions.

As required in the Air Emissions Plan, TtEC conducted air monitoring along the perimeter of the Building 27 RCA from 2 August 2013 to 30 April 2015 by continuously operating four air sampling units during work hours. One air sampling unit each was located at the north (Air Monitor 2202), south (Air Monitor 2203), east (Air Monitor 2204), and west (Air Monitor 2201) RCA boundaries. The air sample analytical results and associated reports are provided in Appendix J. In compliance with TtEC's RML, the air sample analytical results did not exceed 10 percent of the derived air concentrations for members of the public and demonstrated that the annual dose did not exceed 10 mrem/y to the maximally exposed individual.

Concurrent with the above monitoring performed by TtEC, the WDOH also implemented a perimeter air monitoring program, which substantiated the results of the TtEC program.

TtEC also conducted low-volume radiological air sampling in the immediate vicinity of remediation activities during the TCRA to determine whether respiratory protection was required for the work area and ensure worker protection. Air sampling was performed by collecting and analyzing upwind, downwind, and grab samples in accordance with the Work Plan (Attachment 5). The radiological air monitoring analytical results are included in Appendix J. None of the radiological air sample analytical results were greater than 10 percent of the derived air concentration.

TtEC air monitoring was terminated with concurrence from the WDOH, NAVFAC NW, and the RASO at the conclusion of the TCRA fieldwork on 30 April 2015.

3.3 BACKGROUND REFERENCE AREAS

Certain radionuclides may occur at significant levels in the media of interest at the project site (e.g., soil, concrete, metal, building materials, etc.) as part of background. As a result of nuclear weapons fallout, Cs-137 and other radionuclides are also present in background at the project site (Wallo et al. 1994). Establishing background concentrations that describe a distribution of measurement data was necessary to identify and evaluate contributions that could be attributable to historical NAVSTA PS operations. Determining background levels for comparison with the conditions determined in specific SUs at the project site entailed conducting surveys in one or more reference areas to define the radiological conditions of the site.

Ideally, a site background reference area should have similar physical, chemical, geological, radiological, and biological characteristics as the SU being evaluated. Background reference areas are normally selected from areas that are not radiologically impacted, but are not limited to natural areas undisturbed by human activities. In some situations, a reference area may be associated with the SU being evaluated, but could not have been potentially contaminated by site activities.

Reference areas provided a location for background measurements that were used for comparison with collected SU data. Ideally, the radioactivity present in a reference area would be the same as the radioactivity present in the SU had it never been contaminated. All locations selected as reference areas were approved by the Radiation Safety Officer (RSO) or Radiation Safety Officer's Representative (RSOR) with the RASO's concurrence. The same survey methods and equipment used for conducting surveys in impacted areas were used for the reference area survey. Figure 3-1 show the locations of the reference areas used for the TCRA.

3.3.1 Building Reference Areas

After reviewing the applicable plans and variety of surfaces in the NAVSTA PS project site, multiple locations were identified as possible background reference areas. Building 47 was selected for use as the background or reference area for Buildings 2 and 27 survey activities, along with the non-impacted rooms on the south side of the Building 2 south hangar. The non-impacted northwest stair tower associated with Building 27 was also selected for the Building 27 survey activities. The reference area locations are show on Figure 3-1.

For interior surfaces in Buildings 2 and 27, the average background value for each instrument was determined by performing 20 measurements at random locations in Building 47 and the non-impacted rooms on the south side of Building 2 south hangar. For Building 27, 20 measurements were also collected at random locations from the non-impacted stair towers on the north side of the structure. The detector probe was held 4 inches (10 centimeters) from the surface area for gamma measurements and 0.25 inch (0.6 centimeter) from the surface for calculated alpha and beta surface concentrations. The average of the measurements provided the background count rate for each energy emission. Background exposure rates were also collected for reference data. Background reference measurements for each instrument and SU were presented in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) reports.

3.3.2 Soil Reference Area

An investigation was performed to establish the NAVSTA PS project site background reference area concentrations for soil and sediment prior to beginning fieldwork. The reference area for the survey activities was selected in consultation with the RSO, RSOR, and the RASO after mobilization to the field. The reference area was selected from the grassy space to the southeast of Building 27 that had not been previously identified as radiologically impacted. A shallow 36 square meter (m^2), 20-foot-long trench was excavated, and a total of 20 soil samples were collected systematically for use as reference area measurements. Each of the 20 soil samples was analyzed at DoD Environmental Laboratory Accreditation Program (ELAP)-accredited off-site laboratories by gamma spectroscopy (Curtis & Tompkins Laboratory) and radiochemical separation, and beta counting for total strontium (Test America, Richland Laboratory). These reference area samples provided the basis for the background net activity concentration. The laboratory background average concentrations were 0.3370 pCi/g for Ra-226, 0.0025 pCi/g for Cs-137, and 0.0099 pCi/g for Sr-90. These average background concentration values were added to the DCGLs for Ra-226, Cs-137, and Sr-90 (1.07 pCi/g, 25.63 pCi/g, and 9.45 pCi/g, respectively) to establish the updated release criteria for the TCRA for Ra-226, Cs-137, and Sr-90 as 1.41 pCi/g, 25.63 pCi/g, and 9.46 pCi/g, respectively, which are documented in FCR-5.

The soil reference area location is shown on Figure 3-1. Table 3-1 summarizes the reference area soil sample laboratory analytical results. The gamma spectroscopy and total strontium analytical reports are provided in Appendix K.

3.4 SURVEY DESIGN AND TYPE

Several types of radiological surveys were conducted at former NAVSTA PS during the TCRA activities. Surveys were used to identify radionuclides and levels of contamination present, assist remedial actions, and support the release of materials, equipment, open areas, utilities, and buildings. Guidance in designing and conducting the surveys included the MARSSIM (DoD et al. 2000), the "Nonparametric Statistical Methodology for the Design and Analysis of the Final Status Decommissioning Survey Guide" (Survey Guide) (NUREG-1505; NRC 1998), and the "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions Guide" (Field Conditions Guide) (NRC 1997). The objective of the FSS for the TCRA was to demonstrate that identified residual radioactivity levels met the release criteria. The following sections describe the various types of surveys performed at NAVSTA PS during the radiological materials TCRA fieldwork.

3.4.1 Scoping Survey

Scoping surveys were performed to provide site-specific information based on a limited number of measurements. Scoping surveys were conducted with guidance from MARSSIM (DoD et al. 2000) and consisted of judgment measurements based on applicable information included in the RI report (Shaw 2011), historical documents, and professional experience. Sufficient information was collected to identify situations that may have required immediate radiological attention or to support development of further project site activities.

The primary objectives of scoping surveys were 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 could be optimized for use in a characterization survey or FSS

3.4.2 Characterization Survey

Characterization surveys were performed to determine the nature and extent of radiological contamination at the NAVSTA PS project site. This included 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 was surveyed was a site-specific decision addressed throughout the Work Plan (Attachment 5), the TSP for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (TtEC 2013a), and the TSP for the Buildings 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys (TtEC 2013b).

Characterization surveys were planned based on the RI Report (Shaw 2011), MARSSIM guidance, and/or scoping survey results. The primary objectives of characterization surveys were 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 could be optimized for use in the FSS
- Provide input to the FSS design

3.4.3 Remedial Action Support Survey

Remedial action support surveys were performed during the TCRA to assess the effectiveness of the remedial action while remediation activities were underway, and to guide the cleanup effort in real time. The primary objectives of the remedial action support surveys were to:

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

3.4.4 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 NAVSTA PS project site activities (such as scoping, characterization, and remedial action support surveys) provided valuable information for planning the FSS in accordance with MARSSIM (DoD et al. 2000).

The primary goals of FSSs were to:

- Verify classification
- Demonstrate that the potential dose from residual radioactivity was below the release criteria
- Demonstrate that the potential dose from small areas of elevated activity was below the release criterion

3.4.5 Personnel Surveys

Surveys were performed on personnel leaving an RCA to ensure that individuals were free of radiological contamination as identified in the Work Plan (Attachment 5) and associated SOPs.

3.4.6 Material and Equipment Surveys

Before being put into service or leaving an RCA, equipment and/or materials were surveyed in an area of low background concentrations to ensure that the equipment and materials release criteria for the ROCs were not exceeded.

3.4.7 Survey Type Selection

The type of survey selected for an area or SU was either specified in the recommendations contained in the RI report (Shaw 2011) or was based on discussions with and technical direction from the RASO. The exceptions were remedial action support surveys, personnel surveys, and equipment and material surveys, which were used as necessary to assess the effectiveness of decontamination activities and to release personnel, equipment, and material.

The survey progression was typically reassessed when an SU failed to meet the release criteria. If a Class 2 SU failed to meet the criterion for release, it underwent decontamination or remedial action, where necessary, and was reclassified as a Class 1 SU for the follow-up survey actions. If a Class 1 SU failed to meet the release criteria, remediation and remedial action support surveys were performed. A second Class 1 survey followed decontamination or remedial activities. If the Class 1 survey met the release criterion, the survey served as an FSS.

3.5 SURVEY AREA CLASSIFICATION

The RI report (Shaw 2011) identified numerous areas within the former NAVSTA PS project site that were classified as radiologically impacted. Based on the available information from previous surveys, each contaminated area was assigned as either Class 1 or Class 2. No Class 3 areas were designed during the NAVSTA PS TCRA. The following sections describe the Class 1 and Class 2 survey classifications.

3.5.1 Class 1 Areas

Class 1 areas have (or had prior to remediation) a potential for radioactive contamination. This potential is based on the project site operating history or known contamination based on the results of previous surveys. 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 previous surveys

3.5.2 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 release criteria. Examples of Class 2 areas include:

- Locations where radioactive materials were present in an unsealed form
- Potentially contaminated transport routes
- Upper walls and ceilings of buildings or rooms subjected to airborne radioactivity
- Areas in which low concentrations of radioactive materials were handled
- Areas designated as such in previous surveys
- Buffer areas on the perimeter of Class 1 areas

3.5.3 Classification and Survey Unit Size

An SU is a physical area consisting of structures or land areas of specified size and shape for which a separate decision is needed as to whether or not that area exceeded the release criteria. The SU is the primary entity for demonstrating compliance with the release criteria. SUs were limited in size for the TCRA based on classification, exposure pathway modeling assumptions, and site-specific conditions. The limitation on SU size for Class 1 and Class 2 areas ensured that each area was assigned an adequate number of data points. Tables 3-2 and 3-3 summarize the classification and size for each SU designated during the TCRA.

3.6 REFERENCE COORDINATE SYSTEM

A reference coordinate system was laid out for each SU to identify survey/sample locations using the most current version of Visual Sample Plan (VSP) software (Gilbert et al. 2001) based on a random start point and triangular grid pattern. The length between triangular grid data points was determined by the total number of samples or measurements to be taken using Equation 5-2 in the Work Plan (Attachment 5).

3.7 STATISTICAL TESTS

MARSSIM (NUREG-1575; DOD et al. 2000) recommends use, in part, of the Wilcoxon Rank-Sum (WRS) test to conservatively evaluate field results. According to MARSSIM (DoD et al. 2000), there is no need to conduct statistical tests if the difference between the largest SU measurement and smallest reference area measurement is less that the wide-area DCGL ($DCGL_W$). Regardless, a WRS test for each Building 2 SU, the Building 27 SU, and the soil excavation SU was conducted to ensure that the release criteria was met. The WRS test was used to compare the medians between reference and SU samples (contamination concentration measured in reference background materials versus the same parameter measured in site investigative materials) when either or both sampling distributions deviated significantly from normal.

3.7.1 Decision Errors

Two types of decision errors were used when performing the statistical tests outlined in MARSSIM (DoD et al. 2000). The first type of decision error, called a Type I error, occurred when the null hypothesis was rejected when it was actually true. This type of error is sometimes called a "false positive." The probability of a Type I error is denoted by α. The Type I error is often referred to as the significance level or size of the test.

The second type of decision error, called a Type II error, occurred when the null hypothesis was not rejected when it was actually false. This type of error is sometimes called a "false negative." The probability of a Type II error is denoted by β. The power of a statistical test was defined as the probability of rejecting the null hypothesis when it was actually false. It is numerically equal to 1- β, where β is the Type II error rate.

Each survey performed during the TCRA was designed to limit Type I and Type II errors to a maximum probability of 5 percent. It was important to minimize the chances of concluding that an SU met the release criteria (reject the null hypothesis) when it actually exceeded the limits (Type I error), and concluding that an SU exceeded the release criteria (accept the null hypothesis) when it actually met the limits (Type II error).

3.7.2 Wilcoxon Rank-Sum Test

The WRS test is designed to test a hypothesis about the location of a population distribution. It is most often used to test the hypothesis about a population median and often involves the use of matched pairs. This test is also a nonparametric test that may be used when it is only necessary, or possible, to know if observed differences between two conditions are significant. The WRS test is structured to denote a change in magnitude, as opposed to any attempt at a quantitative measurement. Per Section 2.5.1.2 of MARSSIM (DoD et al. 2000), the WRS test is the recommended statistical test for comparison of SU radionuclide concentrations with background radionuclide concentrations.

According to MARSSIM Section 8.2.3, if the difference between the largest SU measurement and the smallest reference area measurement is less than the DCGL, the WRS test will always show that the SU meets the release criteria.

The null hypothesis (H_o) was specifically stated for the WRS test that the residual contamination remaining in the SU exceeds the background level by more than the DCGL. Conversely, the alternate hypothesis (H_a) was stated that the residual contamination remaining in the SU was less than the background level plus the DCGL. Explicitly stated:

H_o = *Residual activity of the SU is greater than or equal to the background plus the DCGL*

H_a = *Residual activity of the SU is less than the background plus the DCGL*

A WRS test was performed for each of the NAVSTA PS project site SUs and the null hypothesis was rejected in all cases. This demonstrates that each of the SUs met the release criteria since the estimated dose due to residual activity was less than the release criteria.

3.7.2.1 Determining the Number of Measurements

The number of sampling points for each SU were calculated to ensure that sufficient data were available for statistical comparison had the FSS results not been less than the radionuclide-specific release criterion. Since radionuclide-specific measurements were not performed for building surfaces, N was calculated in the manner specified for the WRS as demonstrated by Equation 6-2 from the Work Plan (Attachment 5).

The second term in Equation 6-2 increased 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 helped in meeting the data quality objectives (DQOs), it was not required during the data quality assessment to demonstrate compliance with the stated objectives of the statistical tests.

3.7.2.2 Lower Boundary of the Gray Region Determination

The lower boundary of the gray region (LBGR) is the concentration of the contaminant that will result in the $1 < (DCGL – LBGR)/\sigma < 3$. Since this value is unknown during survey planning, MARSSIM (NUREG-1575; DoD et al. 2000) suggests using an LBGR value of one-half the $DCGL_W$ for planning purposes. Gross alpha activity will assume the concentration was due to Ra-226, while gross beta activity will assume the concentration was due to both Cs-137 and Sr-90. In the event of alpha or beta activity less than zero, the activity used in calculations was set at zero. There was a range of ROC concentrations for an SU for which the consequences of making a decision error were relatively minor. This range of concentration values was defined in the MARSSIM as the gray region (DoD et al. 2000). The upper bound of the gray region was the $DCGL_W$ and the LBGR was a site-specific variable. Equation 7-7 from the Work Plan (Attachment 5) provides the method used to calculate the LBGR.

3.7.2.3 Standard Deviation and Relative Shift

During survey planning, there is no estimate of the standard deviation of the contaminant in the SU, especially if no contaminant is initially expected. Therefore, during survey planning, σ is assigned the value of the standard deviation of the adjusted measurement values in the SU as shown in Equation 7-8 from the Work Plan (Attachment 5). The data from each SU are provided in the corresponding WRS test data presented in the individual FSS reports (Attachments 1 through 3).

The relative shift was equal to Δ/σ, where Δ was equal to $[DCGL_W–LBGR]$ and sigma was the standard deviation of the concentration in a SU. The relative shift was calculated as shown in Equation 6-1 from the Work Plan (Attachment 5).

3.7.2.4 Unity Rule

As stated in Section 4.3.3 and Appendix I.11 of MARSSIM (NUREG-1575; DoD et al. 2000), the unity rule was used since multiple radionuclides (with different decay methods) were expected to be present at the NAVSTA PS project site. As stated in Appendix I.11.1, the sum of the factions of the mean concentration of each radionuclide divided by its $DCGL_W$ must not exceed 1.0. Therefore, *N* was calculated using Equation 6-2 from the Work Plan (Attachment 5).

3.8 DOSE MODELING

The intent of each of the documents prepared for the NAVSTA PS TCRA was to achieve unrestricted release for the project site. The criterion for unrestricted release was a net residual dose of less than 15 mrem/y. To accomplish this goal, it was necessary to provide a means for calculating residual dose to the critical group.

3.8.1 Dose Modeling for Buildings

Default residual radioactivity in buildings (RESRAD-BUILD) Version 3.5 parameters were used to model the net residual radioactivity in Buildings 2 and 27, with two exceptions (Yu et al. 2010). In assigning a removable fraction for building surfaces, a number of factors must be taken into account. In a decommissioned and decontaminated building, any residual contamination might be expected to be predominantly fixed because decontamination efforts should have used reasonable steps in cleaning the building. The default RESRAD-BUILD parameter is a removable fraction of 10 percent of the average surface concentrations for all radionuclides. However, the AEC Regulatory Guide 1.86 (AEC 1974) and the Work Plan (Attachment 5) specified a maximum acceptable removable concentration of 20 percent of the average surface concentrations for all radionuclides. Therefore, the removable fraction was set at 20 percent.

In the presence of multiple radionuclides, the unity rule was used to account for the multiple radionuclides contributing to the total dose. In addition, the actual surface area of each SU was used, and lead-210 (Pb-210) was modeled at secular equilibrium with Ra-226 activity to ensure that all possible exposures were considered.

For hard surfaces, the mean net surface area concentrations for alpha and beta were less than zero in several Building 27 SUs and all of the eight Building 2 SUs. Modeling for dose for these SUs was not necessary, as the net residual dose above background levels was essentially zero. To calculate the residual dose for those SUs with mean net surface concentrations for alpha and beta that were greater than zero, the residential scenario in RESRAD-BUILD Version 3.5 was used. The dose modeling results for Buildings 2 and 27 hard surfaces are summarized in Table 3-2. The dose modeling results for Building 2 and Building 27 are discussed in Sections 4.7.5 and 4.8.5, respectively. The final dose modeling parameters and summaries were provided in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents. The maximum dose for the hard surface SUs was 0.086 mrem/y in Building 27 SU-14.

3.8.2 Dose Modeling for Soil and Sediment

For the assessment of soil and sediment, RESRAD identifies four exposure scenarios: Resident Farmer, Suburban Resident, Industrial Worker, and Recreationist. The City of Seattle currently operates the NAVSTA PS project site as part of Warren G. Magnuson Park, which is available to the public for sports, recreation, and leisure. Per the deeds of conveyance, the property has multiple land use restrictions and shall be used and maintained for public park and recreation purposes in perpetuity. Future residential use is not authorized under the existing land deed restrictions. The DON selected Industrial Worker and Recreationist as the appropriate exposure scenarios for current and future land use for the NAVSTA PS project site.

While the DON does not usually leave the radon pathway on when assessing outdoor areas, to consider all possible scenarios, assessments were made with the radon pathway on and off. Dose modeling results performed with the radon pathway on were determined to be more conservative, and modeling with the radon pathway on was therefore selected for the NAVSTA PS project site. In addition, Pb-210 (a daughter product of Ra-226) in secular equilibrium with Ra-226, was included as the most conservative case.

The RESRAD code default parameter is defined as a 10,000-m^2 contaminated soil area that is 2 meters thick and has no material cover (clean soil). During the development of the DCGLs in the Action Memorandum (DON 2013), this was changed to 1,000-m^2 and a 1-meter depth to match the contamination scenarios found at the NAVSTA PS project site during the previous RI. However, several of the excavations performed during the TCRA were excavated to depths greater than 1 meter. Consequently, the RESRAD code default parameter of 2 meters of excavation depth was used during the FSS and backfill dose modeling.

The model for the average member of the critical group was based on default RESRAD Version 7.0 parameters. RESRAD modeling was conducted using recommended exposure pathways for Industrial Worker and Recreationist scenarios from the RESRAD User's Manual Table 2.2 and key parameters from Table 2.3, with the following exceptions:

1. The actual surface area of the SU was used (in m^2).
2. The distance of the length parallel to the aquifer was changed to the square root of the actual surface area for the SU.
3. Modeling was performed using the mean concentrations of Cs-137, Ra-226 (with the Pb-210 daughter), and Sr-90 using the reported activity. The activity used to model for Cs-137, Ra-226, and Sr-90 values was based on the isotopic net concentration (SU mean isotopic concentration minus background mean isotopic concentration). If the total strontium result for an individual sample did not exceed the NAVSTA PS project site action limit, then the sample was not analyzed for Sr-90, and the total strontium activity was conservatively used in place of Sr-90 activity.
4. The indoor and outdoor fractions were adjusted for the Industrial Worker scenario from 75 percent indoors and 25 percent outdoors during a typical work year of approximately 2,000 hours to distribute the worker's time to 50 percent indoors and 50 percent outdoors (occupancy factor of 0.115). As the recreational site incorporates outdoor (e.g., grounds maintenance) with indoor (e.g., material storage) activities, the equivalence of occupancy factors was more appropriate than modeling that incorporated the majority of the worker's time spent indoors. Thus, the RESRAD Industrial Worker scenario for soil/sediment was modeled with the radon pathway turned on and an occupancy factor of 0.115 indoor and 0.115 outdoor.

5. The Recreationist scenario default of 50 hours in a given year was revised to 520 hours to be more representative of the recreational facility's use, reflecting an average of 10 hours per week performing recreational activities. Thus, the Recreationist scenario was modeled with an outdoor occupancy factor of 0.059.

If the net concentrations for the ROCs for a specific soil SU were less than zero, the net concentration of zero was used in the dose modeling. Demonstration of a net residual dose of less than 15 mrem/y was considered sufficient for unrestricted release of each soil SU. The final dose modeling summaries were provided in the Building 27 Final Status Survey Results (Attachment 2) and the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3). The results of the modeling efforts for the NAVSTA PS TCRA soil SUs (SU-01 through SU-12, SU-20) associated with Building 27 and HS-07 are provided in Table 3-3. The maximum dose for all soil SUs was calculated at 7.039 mrem/y in SU-03.

3.9 AS LOW AS REASONABLY ACHIEVABLE

As low as reasonably achievable (ALARA) is a philosophy of striving for excellence in the practice of health physics and is an important aspect of radiation-safety regulations. The National Council on Radiation Protection and Measurements has stated, "ALARA is simply the continuation of good radiation-protection programs and practices which traditionally have been effective in keeping the average and individual exposures for monitored workers well below the limits" (NCRP 1993). The application of ALARA clearly includes the consideration of economic and social factors, and thus will inherently be different for different sources or facilities.

The ALARA concept is founded in the professional judgment of radiation safety managers and personnel and is not, therefore, able to be used as a measure as to whether or not a particular radiation safety program is adequate in comparison with other programs. In addition, the ALARA concept does not provide a numerical limit below which the ALARA concept is achieved.

3.9.1 Environmental ALARA Process

This section describes the steps taken to implement the environmental ALARA policy, including the identification of potential radiological impacts, review of radiological impacts, and performance of qualitative and quantitative ALARA analyses.

3.9.1.1 Identification of Potential Radiological Impacts

Each new radiological operation was subjected to ALARA reviews before work began to ensure that radiation exposures to workers, the public, and the environment met ALARA principles. ALARA reviews were conducted for all operations, practices, and procedures that had potential for individual or collective doses to workers. Reviews culminated in changes or additions to work planning documents, SOPs, and radiological work permits. These documents were used to identify activities that had potential for radiological environmental impacts and could require environmental ALARA analysis. If a radiological impact was identified that could impact the environment significantly, the RSO communicated the impact to the work staff and the RASO.

3.9.1.2 Review of Radiological Impacts

Radiological impacts to the environment, workers, and the public from field operations were assessed for compliance with ALARA principles. Results from radiological survey activities, and air, soil, sediment, and water samples were used to assess the radiological impacts of TCRA activities.

Determination of environmental radiological impacts from radiological activities was made using nine methods: 1) sampling at air monitoring stations located around the excavation site perimeter to track radiological impacts; 2) field monitoring and sampling to identify areas requiring additional remediation; 3) remediation of contaminated areas at or above the release criteria; 4) control of radiologically impacted areas and work sites; 5) frisking of personnel and examining equipment leaving a radiologically controlled area; 6) use of release criteria that equate to dose; 7) review of historical radiological operations to allow complete investigation of all areas of radiological concern; 8) characterization of radiologically impacted sites to ensure complete removal of radioactive material above the release criteria; and 9) dosimetry worn by personnel to measure time-averaged doses from beta and gamma radiation.

3.9.1.3 Performance of Qualitative ALARA Analyses

Laboratory analyses were performed for ROCs as well as for a number of naturally occurring radionuclides to ensure that any possible radioactive contamination was identified. After each survey activity was completed, the qualitative radiological impacts from operations were evaluated by performing a dose assessment. The results of the analyses and assessments were provided to the RASO and regulatory agencies for review.

3.9.1.4 Performance of Quantitative ALARA Analyses

Based on qualitative ALARA analyses, projects that could cause a potential dose to the public were subjected to quantitative ALARA analyses. Quantitative ALARA analyses included societal, technological, economic, and public policy considerations. In addition, these ALARA analyses considered NRC guidance for performing the following environmental ALARA assessments:

- Identification of possible radiation protection systems, such as alternative operating methods or controls, that are reasonably achievable. The options should range from the most rudimentary (base case) to the most technologically sophisticated systems.

- Quantification of exposures and doses to workers and the public in the vicinity of the work through air monitoring and dosimetry.
- Quantification of the economic factors, including the costs of purchasing, installing, operating, and maintaining the radiological equipment, and the potential health effects associated with the exposure of people and any other direct or indirect cost resulting from exposures to radiation during investigation and/or remediation activities.
- Identification and estimation of other health and non-health detriments and benefits, such as equipment loss and accidents.
- Evaluation of process alternatives using a quantitative cost-benefit analysis, when possible. When evaluations included assumptions, judgments, and limitations that could be quantified, and potential doses were well below the dose limit, qualitative analyses were used with full documentation.
- Implementation of the ALARA principles and monitoring of the results.

The following specific factors were used in performing a quantitative ALARA analysis:

- Dose to workers, the public, and the environment before and during work processes
- Residual dose to the local population
- Applicable alternative processes (treatments, operating methods, or controls) for site investigation or remediation activities
- Costs for each alternative evaluated
- Societal and environmental (positive and negative) impacts associated with alternatives

Based on recent estimates of dose to the public from TCRA operations, only qualitative ALARA analyses were required. Much of the data and analysis used for environmental ALARA evaluations was developed as part of the routine work processes.

To ensure that ALARA levels were met, removal actions conducted in accordance with the Action Memorandum (DON 2013) were designed to: 1) substantially reduce ionizing radiation below cleanup goals, and 2) eliminate identified pathways of exposure to ionizing radiation. Qualitative ALARA analyses performed during the TCRA resulted in no FSS alpha or beta measurements above the investigation levels; none of the FSS alpha, beta, or gamma measurement results identified residual activity above the release criteria for the ROCs; and no personnel dosimetry badges processed identified gamma dose above background levels.

3.10 RADIOLOGIC DEVICES

According to the RI Report (Shaw 2011), three localized areas of elevated activity were identified during the radiological investigation gamma walkover survey (GWS) activities. During the TCRA, these three areas were designated as HS-10, HS-11, and HS-12, and were located in the paved area west of Building 27. TtEC initiated excavation of these three hotspots in May 2014. During the excavation activities, a radiological device identified as a knob (DS-0001) was found in soil approximately 4 inches below the asphalt surface at HS-10 (Figure 5-2). A survey of DS-0001 identified a net alpha measurement of 27,731 dpm/100 cm^2, a net beta/gamma measurement of 362,288 dpm/100 cm^2, and a net removable alpha measurement of 26 dpm/100 cm^2. Using a Berkley Nucleonics SAM 940 portable radiation isotope instrument, Ra-226 was identified as the primary nuclide for the device. DS-0001 was transferred to the USAJMC contractor for off-site disposal as LLRW. The survey results and SAM 940 report for DS-0001 are provided in Appendix L.

On 31 July 2014, a radium gauge (DS-0002) was discovered while removing wallboard from the common wall that separates the Building 27 South Shed from the southeast stair tower. The wall space in which DS-0002 was located was filled with insulation and trash. Originally surveyed as part of Class 2 SU-19, the attenuation from the wall layers and trash likely provided enough shielding so the device was not discovered until subsequent removal of the drywall and wallboards. A survey of DS-0002 identified a maximum net alpha measurement of 60 dpm/100 cm^2, net beta/gamma measurements ranging from 8,436 dpm/100 cm^2 to 59,462 dpm/100 cm^2, and a net removable alpha measurement of 3 dpm/100 cm^2. Using a Berkley Nucleonics SAM 940 portable radiation isotope instrument, Ra-226 was identified as the primary nuclide for the device. DS-0002 was transferred to the USAJMC contractor for off-site disposal as LLRW. The survey results and SAM 940 report for DS-0002 are provided in Appendix L.

3.11 WASTE DISPOSAL

Waste management and disposal activities were performed throughout the TCRA. LLRW was placed in bins and transferred to the USAJMC contractor for off-site disposal at U.S. Ecology located in Grand View, Idaho. Table 3-4 lists the waste generated during the TCRA, the estimated volume of each waste stream, and the disposition of the waste materials. An LLRW waste summary is provided in Appendix M. In addition, disposal documentation for non-LLRW wastes is provided, as applicable, in Appendix M.

The King County Wastewater Treatment Division, Industrial Waste Program issued the DON Letters of Authorization #11515-01 and 11515-03 to allow TtEC to perform construction dewatering. This authorized the discharge of up to 21,000 gallons per day (the capacity of a single holding tank) to the sanitary sewer at a rate not to exceed 50 gallons per minute. The water from each of the holding tanks was sampled and analyzed for chemicals and radionuclides.

The analytical results were evaluated against the King County authorization criteria for discharge to the sanitary sewer. Based on these analytical results, King County authorized discharge of 209,071 gallons of wastewater. The wastewater laboratory analytical reports and King County discharge authorizations are included in Appendix M.

3.12 DEMOBILIZATION

Demobilization from NAVSTA PS occurred in May 2015. All equipment and tools used during the survey activities were scanned using a Ludlum 2360 data logger with a Ludlum 43-93 alpha/beta scintillation detector. In addition, swipe samples were collected and analyzed using a Ludlum 2929 for gross removable alpha and beta. All results were verified to be less than the Regulatory Guide 1.86 (AEC 1974) limits specified for Cs-137, Ra-226, and Sr-90. The equipment (which included instrumentation, tools, etc.) was then released back to the applicable vendor for unrestricted use.

This page intentionally left blank.

4.0 PROJECT SITE BUILDINGS OVERVIEW

Building 2 and the Building 27 South Shed were identified as radiologically impacted in the RI Report (Shaw 2011). The locations of these structures within the context of the NAVSTA PS project site are shown in Figure 1-3. The following sections provide an overview of the FSS activities performed for each of the radiologically impacted buildings and former welding areas.

4.1 SURVEY INSTRUMENTATION

The instruments selected for the Buildings 2 and 27 survey activities were able to detect the ROCs or radiation types of interest, and were, in relation to the survey or analytical technique, capable of measuring levels equal to or less than the DCGL. Detailed descriptions of all survey instruments used during the NAVSTA PS TCRA fieldwork were provided in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents.

Before the start of and throughout the NAVSTA project site TCRA, survey and laboratory instruments were maintained within calibration-based parameters using National Institute of Standards and Technology (NIST)-traceable standards. Survey instruments were source checked daily, prior to each surveillance activity. During operational checks, all of the instruments were within the ±20 percent criteria established when setting up the baseline information. Calibration certificates specific to the field instrumentation used for data collection purposes and source certificates for radioactive sources used to perform instrument response checks and analysis were provided in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents.

4.1.1 Alpha and Beta Surface Activity Measurements

Surveys for alpha and beta particulate radiation were performed using a Ludlum Model 2360 data logger equipped with a Ludlum Model 43-68, 126-cm^2 gas-flow proportional detector, Ludlum Model 43-37-1, 821-cm^2 gas-flow proportional detector, or Ludlum Model 43-93, 100-cm^2 scintillation detector, as appropriate. These instruments measure alpha and beta radiation levels and can record data in scaler (time-integrated count) or ratemeter (instantaneous count rate) mode. With the detector assembly positioned approximately 0.25 inch from the designated surveillance surface, the data logger operated in scaler mode, which recorded static measurements for alpha and beta particulate radiation based on a stationary 2-minute count cycle. Alpha and beta scans were performed by the surveyor moving the detector at a consistent speed while maintaining audio and visual observation of the instrument response.

Instrument efficiency, 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 was determined during calibration by the instrument vendor. The detector was positioned over a calibration source that featured a NIST-traceable surface emission rate. The 2π particle fluence rate was corrected for decay. The surface emission rate of the source was then corrected for the area subtended by the probe. Additional considerations, supportive of reliable instrument efficiencies, included calibration sources, source geometry, source-to-detector distances, window density thickness, and detector-related factors. Each of these additional considerations was defined in the Work Plan (Attachment 5).

4.1.2 Gamma Surface Activity Instruments

Static and scan surveys for gamma (photon) radiation were performed using a Ludlum Model 2350-1 data logger and a Ludlum Model 44-10 scintillation detector assembly that featured a 2-inch by 2-inch sodium iodide (NaI) crystal. Capable of detecting gamma photon energies ranging from 60 keV to 3 megaelectron volts (MeV), the instrument was programmed to respond to the full spectrum of gamma photon energies. Static gamma photon measurements required positioning the detector assembly 4 inches (10 centimeters) above the designated surveillance surface and recording a stationary 60-second integrated count. Scan measurements were obtained by traversing a path at a consistent speed (scan rate) and slowly sweeping the detector assembly in a serpentine pattern, while maintaining the detector approximately 4 inches (10 centimeters) above the area being surveyed.

4.1.3 Swipe Samples Instrument

Swipe samples were collected for the analysis of removable radiological contaminants in accordance with SOP NAVSTA PS-Tt-006, Sampling Procedures for Radiological Surveys. Swipe samples, also referred to as smear samples, were obtained at each of the discrete surveillance points in the Buildings 2 and 27 SUs. All samples were processed using a Ludlum Model 2929 (or equivalent) swipe counter.

4.2 DETECTION SENSITIVITY — MINIMUM DETECTABLE CONCENTRATIONS

The International Organization for Standardization 7503-1 (ISO 1988), NUREG/CR-1507 (NRC 1997), and the ASTM International (ASTM) Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments in Support of Decommissioning (ASTM 1998) were used as technical guidance to ensure accuracy in the measurement of radiologic surface activity. Equation 8-1a from the Work Plan (Attachment 5) was used to calculate the surface activity in dpm/100 cm^2:

4.2.1 Static Minimum Detectable Concentration

The static minimum detectable concentration (MDC) represents the smallest level of radioactivity on a surface that is statistically detectable by the measurement process. Equation 8-7 from the Work Plan (TtEC 2013a) was used to calculate instrument MDC in units of dpm/100 cm^2 for alpha and beta radiation, and Equation 8-12 was used to calculate the MDC for gamma radiation.

4.2.2 Scan Minimum Detectable Count Rate

The minimum detectable count rate (MDCR) (i.e., number of net source counts) in the scan interval was 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. Equation 8-5 from the Work Plan (Attachment 5) was used for this calculation.

The number of source counts required for a specified level of performance was determined by multiplying the square root of the number of background counts by the detectability value associated with the desired performance. Equation 8-5a from the Work Plan (Attachment 5) was used for this calculation. The MDCR, assuming surveyor efficiency, was calculated using Equation 8-9 from the Work Plan (Attachment 5).

4.2.3 Scan Minimum Detectable Concentration for Alpha and Beta

The scan MDC was derived from the MDCR by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. The MDCR accounts for the background level, performance criteria, and observation interval. During scanning, the observation interval was the actual time that the detector could respond to the contamination source. This interval depended on the scan speed, detector size in the direction of the scan, and area of elevated activity.

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. Assumptions were made that the surface being surveyed was similar in nature to the material on which the detector was calibrated. In this respect, the approach is purely theoretical. Surveying surfaces that are dirty, nonplanar, or weathered can significantly affect the detection efficiency, and therefore bias the expected MDC for the scan.

The Ludlum Model 43-37-1 proportional counter had a background count rate on the order of 5 to 10 cpm. A single count would not cause a surveyor to investigate further. A counting period long enough to establish that a single count indicated an elevated contamination level would be prohibitively inefficient. For these types of instruments, the surveyor usually needed to observe at least two counts while passing over the source area before stopping for further investigation.

The detector was moved into position by the operator and the count time (12 seconds in Building 2, and 4 seconds in Building 27) was started. At the end of the count, the detector was moved one probe width (15.9 cm) into the next position and then the next count began. If two or more counts were recorded during the interval, the computer software stopped the recording process and instructed the operator to pause in this location for a second reading. The operator ensured that the meter had not moved and then indicated to the computer that the meter was ready to perform the pause reading. If two or more counts were observed during the pause, the computer instructed the operator to mark the area for further investigation. The operator then physically marked the location so that it could be easily identified. If less than two counts were identified during the pause then the computer instructed the operator to continue the survey. During these scan surveys, the operator also had the ability to add pertinent comments into the program as the survey progressed, but did not have the ability to delete or alter any data. The computer recorded all counts, pauses, and associated comments. This process was followed until the scan survey was complete.

For alpha radiation, the probability of getting two or more counts was calculated using Equation 8-4 from the Work Plan (Attachment 5). For beta/gamma radiation, the scan MDC for surfaces was calculated using Equation 8-6 from the Work Plan (Attachment 5).

4.3 SURVEY PROCEDURES AND DATA INTERPRETATION

The survey procedures conducted during the TCRA were implemented in accordance with approved SOPs and were consistent with the Work Plan (Attachment 5) and TSP for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (TtEC 2013a). Figures identifying the approximate surveillance points where measurements were logged and samples were collected are provided in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents. Table 3-2 summarizes the survey data for each of the building SUs.

4.3.1 Alpha/Beta Scan Surveys

Scanning is the process by which portable radiation detection instruments are used to detect radionuclides on a specific surface (i.e., ground, wall, floor, equipment). Scan surveys were integral to the TCRA for determining contamination levels. Class 1 SUs received 100 percent scan coverage, while the Class 2 SUs received 50 percent scan coverage. The surveys were used as an evaluation technique performed by moving a detection device over a surface at a specified speed and distance above the surface with the intent of locating radionuclide contamination. Investigation levels for scan surveys were determined during survey planning to identify areas of elevated activity. Scan surveys were performed as a series of “rolling static measurements” to locate radiation anomalies indicating residual gross activity that may have required further investigation or action.

The framework for determining the scan MDC was based on two stages of scanning. Decisions were not made on the basis of a single indication; rather, upon noting an increased number of counts, the surveyor paused briefly and then decided whether to move on or take further measurements. Thus, scanning consisted of two components: initial interval monitoring and secondary interval monitoring. The second component occurred only after a positive response was made at the first stage. This response was marked by the surveyor conducting a subsequent interval static measurement in the same location.

The final stage of data evaluation consisted of identifying patterns or areas where additional biased measurements were appropriate based on the scan data. This stage consisted of collecting static fixed and removable contamination measurements at the biased locations where two or more alpha counts were identified in successive measurements in the same area during scan intervals. Scan readings from each Building 2 and 27 SU are presented in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents.

4.3.2 Gamma Scan Surveys

During the FSS activities for Buildings 2 and 27, 100 percent of the surface area in each Class 1 SU and 50 percent of the surface area in each Class 2 SU was scanned with Ludlum Model 44-10 NaI scintillation detectors coupled to a Ludlum Model 2350-1 data logger. The intent of the gamma scan surveys was to identify any potential contamination for subsequent remediation, alpha/beta scans, and static surveys. Backgrounds used for gamma scan measurement were commensurate with the materials encountered throughout each SU. No areas with contamination exceeding the investigation level were discovered during the TCRA gamma scans performed for Building 2. For Building 27, confirmation 1-minute gamma static measurements were collected at all locations where gamma scan readings exceeded the investigation level. Confirmation alpha/beta biased statics/swipes were collected from all locations where gamma static readings exceeded the investigation level. None of these confirmation alpha/beta measurements exceeded the TCRA release criteria. The gamma scan survey results are provided in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents.

4.3.3 Static Surveys

Complete sets of alpha and beta static measurements were obtained in the reference areas and corresponding SUs. Basic statistical quantities were calculated for the data in an effort to identify patterns, relationships, and anomalies. Static alpha, beta, and gamma surveys were used to determine contamination levels on various surface areas. These surveys were performed by holding a detection device over a surface for a specified time at a set distance, as described in Section 4.1.1. A systematic measurement pattern was used for both the reference area and the SUs. Collected data were reviewed by the RSOR to determine whether investigative levels had been exceeded.

Alpha and beta static survey data were converted to units of dpm/100 cm^2. These measurements were compared directly to background measurements after using Equation 8-1a from the Work

Plan (Attachment 5) to convert the background data from counts to surface activity in units of dpm/100 cm^2. The static survey measurements for each of the designated SUs are provided in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents.

4.3.4 Direct Exposure Rate Measurement Surveys

Direct exposure rate measurement surveys were performed to measure ambient gamma radiation levels. Exposure rate measurements were obtained by holding the detection device approximately 1 meter from the surface being surveyed. Measurements were obtained in reference areas and compared with measurements logged in SUs to evaluate external exposure rates from gamma radiation. Exposure rate measurement results for each Building 2 and 27 SU are presented in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents.

4.3.5 Media Sampling

Swipe samples were collected from each of the specified systematic locations in the each of the designated Building 2 and Building 27 SUs to assess the presence of radioactive contamination that could readily be removed from a surface. Swipe samples were collected from all discrete systematic and biased survey points at the project site buildings to evaluate the presence of alpha and beta surface activity. Collected data were reviewed by the area supervisor and then examined by the RSOR to determine whether investigative levels had been exceeded. No elevated swipe measurements were identified during the Buildings 2 or 27 FSS activities. The maximum swipe measurement activity was less than 20 percent of the release criteria for each Class 1 and Class 2 SU. If elevated readings had been were identified, additional biased samples would have been collected for measurement purposes. Swipe sampling analytical results for the TCRA ware discussed in the Building 2 Final Status Survey Results (Attachment 1) and the Building 27 Final Status Survey Results (Attachment 2) documents.

4.3.6 Data Interpretation

Interpreting survey results is most straightforward when measurement data are entirely higher or lower than the specified release criteria. In such cases, the decision that a SU meets or exceeds the release criteria requires little in terms of data analysis. Nevertheless, the survey design always made use of the statistical tests in helping to ensure that the number of sampling points and the measurement sensitivity were adequate for the decision made.

During the collection of data, a verification and validation process was incorporated to evaluate whether the DQOs of the survey were met and whether the data were sufficient to determine compliance.

Data collected from each SU were independently subjected to the following reviews:

1. Collected data were compared with the prescribed activities documented according to the applicable SOPs for NAVSTA PS, found in the Work Plan (Attachment 5).
2. Collected data were compared to the DQOs documented in the TSP for the Buildings 2 and 27 Remedial Action Support and FSS reports (TtEC 2013a).
3. A health physics supervisor, not directly involved in the data collection process, conducted an independent technical review of the information at the end of each surveillance step.

This process ensured the validity of collected data, the measurement techniques used, and consistency in surveillance data collection. Radiological survey data were obtained in units of cpm. Since cpm has no intrinsic meaning to the release criteria, data were converted to units of dpm/100 cm^2 to compare the results with the release criteria.

The first-level check for validating data integrity during collection and reporting of survey results during the TCRA was verification of numerical work. After collection of survey data each day, the results were reviewed by the Radiological Control Technician (RCT) to verify their completeness. The purpose of the first-level check was to ascertain whether the data presented were free of numerical or transcription errors and that established procedures and methodology were followed.

DQOs are qualitative and quantitative statements developed to define the purpose of the data collection effort, clarify what the data should represent to satisfy this purpose, and specify the performance requirements for the quality of information to be obtained from the data. These outputs were used to develop a data collection design that met the performance criteria and other design requirements and constraints. The EPA seven-step process was implemented to develop the DQOs during the TCRA. This seven-step process was discussed in the Work Plan (Attachment 5), the TSP for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (TtEC 2013a), and the Buildings 2 and 27 FSS reports provided as Attachment 1 and Attachment 2, respectively.

4.4 INVESTIGATION LEVELS

Investigation levels are specific levels of radioactivity used to indicate whether additional investigation may be necessary and also serve as a quality control (QC) check. When determining an investigation level using a statistically based parameter (e.g., standard deviation), the following was considered:

- Survey objectives
- Underlying radionuclide distributions (e.g., normal, log normal, nonparametric)

- Data population descriptors (e.g., standard deviation, mean, median)
- Prior survey and historical information

When investigation levels were exceeded, the measurements were confirmed to ensure that the initial measurement/sample was actually greater than the specific investigation level. This involved collecting further measurements to confirm the initial result and quantify the area of elevated residual radioactivity, if appropriate.

4.4.1 Investigation Levels for Alpha and Beta Radiation Surveys

The investigation level for building surface alpha scan surveys consisted of identifying alpha counts (two or more alpha counts for Ludlum Model 43-37-1 detectors, and a single alpha count for Ludlum Model 43-93 or 43-68 detectors) during the specified monitoring interval (12 seconds in Building 2 and 4 seconds in Building 27), followed by alpha counts (two or more alpha counts for Ludlum Model 43-37-1 detectors, and a single alpha count for Ludlum Model 43-93 or 43-68 detectors) over a successive monitoring interval (12 seconds in Building 2 and 4 seconds in Building 27). When this occurred, biased static measurements for fixed and removable alpha and beta contamination were collected. The investigation level for building surface beta scan surveys was 900 dpm/100 cm^2, which is 90 percent of the most restrictive beta emitter, as listed in Table 2-2. In all cases that 900 dpm/100 cm^2 was exceeded, biased static measurements for fixed and removable alpha and beta contamination were collected and evaluated.

The alpha and beta removable surface investigations were performed by collecting a swipe sample over those locations where static measurements were obtained to determine the fraction of removable activity present relative to the total activity. As listed in Table 2-2, these removable surface investigation levels were set at 20 percent of the values for total activity and are different than other investigation levels due to the lower release criteria for removable surface contamination.

4.4.2 Investigation Levels for Gamma Radiation Surveys

For gamma surveys, the investigation level was established as the reference area mean plus 3 σ, where sigma is the standard deviation of the gamma readings in the reference area. It should be noted that there are currently no established release criteria for building interior surfaces based on gamma radiation readings alone (since Cs-137 is also detectable by beta emission). Consequently, gamma surveys of building interior surfaces were performed only as an added measure to identify areas of gross contamination that would be an immediate health and safety concern and to facilitate the detection of any anomalies, such as gamma-emitting sources that may not emit alpha or beta radiation.

4.5 BUILDING FINAL STATUS SURVEYS

FSS activities were performed at Buildings 2 and 27 during the TCRA. Guidance in designing and conducting the FSS included MARSSIM (NUREG-1575; DoD et al. 2000), the Decommissioning Survey Guide (NUREG-1505; NRC 1998), and the Field Conditions Guide (NUREG-1507; NRC 1997). Sufficient information was collected during the performance of the fieldwork to identify situations that would have required immediate radiological attention or to support development of other project site activities.

The objective of the surveys was to demonstrate that residual radioactivity levels on building surfaces were less than the predetermined release criteria for the ROCs. In demonstrating that the objective had been met, the null hypothesis (H_o) was tested for residual contamination exceeding the release criterion. The alternative hypothesis (H_a) was then tested for residual contamination that met the release criterion.

4.6 REGULATED MATERIALS ASSESSMENTS AND ABATEMENT

TtEC retained Argus, a licensed asbestos/lead abatement contractor, to conduct regulated materials assessments in Building 2 and in the Building 27 South Shed and adjoining stair towers. The assessment activities in Building 2 and the Building 27 South Shed were initiated in August 2013 and September 2013, respectively, and included sample collection and analysis. The results of the Building 2 assessment confirmed the presence of asbestos in floor tile and in the associated mastic. The results of the Building 27 assessment confirmed the presence of asbestos in floor tile, insulation on piping and ventilation ducting, and roofing and exterior siding materials. The Building 27 assessment also identified lead-based paint (LBP) on walls. In addition, mercury-containing fluorescent light tubes and polychlorinated biphenyl (PCB)-containing light ballasts were identified in the South Shed. Assessment reports prepared by Argus to document its activities and findings are included in Appendix N.

Asbestos-containing materials (ACM) identified during the Argus assessments were abated to the extent necessary to support the TCRA activities. Abatement activities were executed in accordance with the Asbestos Abatement Work Plan, Revision 1 (Appendix G). The purpose of the asbestos abatement activities was to expose the original surfaces of the building in preparation for survey and remediation activities, and to remove any remaining ACM, as necessary, to permit deconstruction of the Building 27 South Shed. With the exception of the roofing and exterior siding materials, all of the ACM were wrapped and/or bagged and transferred to bins for disposal by the USAJMC contractor as LLRW. The asbestos-containing roofing and exterior siding were disposed of as asbestos waste without wrapping or bagging the material.

Mercury-containing fluorescent light tubes and PCB-containing ballasts were removed from the associated fixtures. The tubes were packaged in cartons and the ballasts were containerized in drums. The tubes and ballasts were recycled at a licensed off-site facility.

The presence of LBP and coatings and the potential associated hazards were addressed during radiological remediation activities, in compliance with EM 385-1-1 Section 06.B.05.b, WAC 296-62-07521, and TtEC's Lead Compliance Plan presented in Appendix D.

4.7 BUILDING 2

The following sections summarize the Building 2 FSS activities performed during the NAVSTA PS TCRA, provide an abbreviated history, describe the FSS results, and discuss regulatory concurrence for the unrestricted release of the structure. The details and results of the Building 2 radiological activities are presented in the Building 2 Final Status Survey Results (Attachment 1) document. The location of Building 2 within the context of former NAVSTA PS is depicted on Figures 1-3 and 3-1.

4.7.1 Description

Building 2 is located west of the NOAA facilities and south of NE NOAA Drive in the northwest portion of the former NAVSTA PS project site (Figure 3-1). Building 2 is a two-story steel-framed structure comprised of two former hangar spaces. The ground floor level of the building is constructed of a steel frame over a concrete floor. The northern portion of the structure is utilized for storage, offices, and restrooms. The central portion of the structure was most recently used as a recreation facility. Accessed by several staircases, the majority of the second floor of the building is unoccupied and includes two former instrument shops identified as the 1939 Instrument Shop and the 1941 Instrument Shop (Figure 4-1). These building features are depicted on Figure 4-1.

4.7.2 Background

Building 2 was constructed in 1938 and housed the Marine Corps Reserve motor pool and offices. The structure was an active aircraft hangar until the facility was decommissioned in 1970. The radiological history of Building 2 and the NAVSTA PS project site is summarized in Section 2.1.1. Historical DON records confirm that former NAVSTA PS routinely received shipments of Ra-226 for the maintenance of radioluminescent devices.

As described in Section 2.1.1, dose rate radiation surveys were performed in April (Argus 2009a) and May 2009 (Argus 2009b) under contract to Seattle Parks and Recreation. The Argus surveys did not identify any areas of radiation contamination in Building 2.

Shaw was retained by the DON to conduct radiological surveys in two former instrument shops identified as the 1939 Instrument Shop and the 1941 Instrument Shop on the second floor of

Building 2, as well as in Building 27. The survey fieldwork was conducted from April 2010 through December 2010 and is summarized in Section 2.5.2.1. The results of those surveys were presented in the RI Report (Shaw 2011) summarized in Section 2.5.2. According to the RI Report (Shaw 2011), the source of radiological contamination associated with Building 2 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 adjacent areas during janitorial cleanup activities involving wet mopping.

4.7.3 Building 2 Field Activities

In preparation for the Building 2 FSS, the second floor was divided into six Class 1 SUs (SU-01 and SU-03 through SU-07) and two Class 2 SUs (SU-02 and SU-08). Several areas were subdivided such that floors and wall areas up to 2 meters above the respective floor surface were considered Class 1 SUs. Class 1 SUs consisted of floor areas less than 100 m^2. Buffer areas around each group of Class 1 SUs, extending approximately 2 meters outward, were designated as Class 2 SUs, with a maximum total area of 1,000 m^2 for hard surfaces. Using a different random start point in each SU, systematic data collection locations were laid out using VSP. Table 3-2 summarizes each SU, class designation, and surface area in m^2. The general arrangement of the Class 1 and 2 SUs is shown on Figure 4-1. Each Class 1 and Class 2 SU was shown on individual figures provided with the Building 2 Final Status Survey Results (Attachment 1) document. Table 3-2 summarizes the Building 2 SU data.

4.7.3.1 Expanded Area Status Surveys

The areas to be surveyed in Building 2 were expanded due to the addition of Sr-90 as an ROC (along with Cs-137 and Ra-226) following completion of the historical radiological RI performed in 2010 and documented in the RI Report (Shaw 2011). These expanded survey areas included the southeast and northwest stairwells and the red tile and rear restrooms on the first floor (Figure 4-1), as well as a first floor weight room located at the southwest corner of the building.

Expanded survey activities, including alpha/beta scans, static measurements, and the collection of swipe samples, were performed in October and November 2013. None of the static or swipe measurements from these surveys exceeded the AEC Regulatory Guide 1.86 release criteria (AEC 1974). The results of these expanded survey activities are provided in the Building 2 Final Status Survey Results document.

4.7.3.2 Remediation of Previously Identified Contamination

TtEC performed status surveys in Building 2 to reacquire and verify the locations of contamination previously identified in the RI Report (Shaw 2011). Following the reacquisition and marking of the previously identified radiologically contaminated areas, remediation activities were performed, as appropriate. Survey activities were performed as described in Sections 4.1 and 4.3.

Each of the previously identified contaminated ventilation registers and associated ventilation ducts above the former 1941 Instrument Shop was disassembled, removed, and placed in bins for disposal by the USAJMC contractor as LLRW. One hundred percent scan surveys for alpha and beta radiation were conducted in September 2013 for the interior surfaces of the remaining air handling unit. Additional radiological surveys were performed at several locations along the ventilation system return lines. While performing the ventilation system surveys, particular emphasis was placed on collecting survey data from likely accumulation points and areas that could be expected to produce elevated scan measurements. None of the survey results for the ventilation system remaining in place in Building 2 exceeded the release criteria for the ROCs.

The second floor of Building 2 consists of two layers: a ¾-inch tongue and groove top layer, and a 2-inch car decking subfloor. During the TCRA activities, contaminated wood floor sections identified in the RI Report (Shaw 2011) were removed and placed in LLRW bins. In addition, interior walls adjacent to areas of previously identified elevated floor concentrations were removed to expose potential contamination between the bottom of the walls and the underlying floor surfaces. Remediation was completed by cutting and removing areas larger than the previously identified contaminated areas. All of the removed wood debris was placed in LLRW bins pending off-site disposal by the USAJMC contractor. Following the remediation efforts, an FSS was performed. No further areas of radiological contamination were discovered during the FSS activities.

Multiple iterations of remediation followed by remedial action support surveys were necessary in several Class 1 SUs to ensure that any residual radioactivity was below the release criteria for the ROCs. Approximately 107 m^2 of ¾-inch tongue and groove wooden floor identified in the RI Report (Shaw 2011) was remediated, which exposed the 2-inch car decking subfloor and joists. The contaminated wood debris that was generated was placed in LLRW bins pending off-site disposal. This remediation effort was followed by remedial action support surveys and additional remediation activities. The remedial action support surveys were performed as described in Sections 4.1, 4.3, and 4.4, followed by the collection of static measurements and swipe samples from each of the remediated areas. Further details related to the remediation efforts and remedial action support surveys were provided in the Building 2 FSS Results (Attachment 1) document.

During the TCRA, remediation activities were also performed on contaminated wall sections that had been identified in the RI Report (Shaw 2011). These contaminated sections included the south brick wall in the former 1939 Instrument Shop (SU-01) and north brick wall in the former 1941 Instrument Shop (SU-04 through SU-06) (Figure 4-1). Remediation activities were initiated by removing LBP from the wall surfaces using a chemical stripping agent. The residual surface radioactivity was then removed by mechanically abrading the surface of the affected area. During abrading activities, a vacuum equipped with a high-efficiency particulate air (HEPA) filter was used over the remediation area. Large area wipes were also collected throughout the remediation process to ensure that removable contamination was not inadvertently spread into adjacent areas.

The remediation activities were controlled in a manner such that airborne radioactivity was minimized, and air sample collection and analysis was performed during these operations to evaluate any resultant airborne contamination in accordance with the WDOH-approved Air Emissions Plan (Appendix B). The air sample analytical results did not exceed 10 percent of the derived air concentrations for members of the public and demonstrated that the annual dose did not exceed 10 mrem/y to the maximally exposed individual. Following remediation, no further contamination was identified above the release criteria either for the former 1939 Instrument Shop south brick wall or the former 1941 Instrument Shop north brick wall.

In total, approximately 132 m^2 of wood flooring, 206 m^2 of subfloor, 1 m^2 of wood joists, and 2 m^2 of wall were remediated from the Class 1 SUs during the TCRA activities for Building 2. Following the completion of remediation activities in the Class 1 SUs, FSS activities were performed, as described in Section 4.5.

4.7.3.3 Former Sink Drain Collector Line (Reach 1) Activities

According to the RI Report (Shaw 2011), Ra-226 contamination above the release criteria was identified inside the remaining portion of the aboveground sink drain line associated with the former 1941 Instrument Room. This line was removed and cut flush with the hangar floor prior to sealing the pipe at the floor level during the RI. With the removal of the aboveground portion of the former sink drain line, the focus of the TCRA activities was to address the collector line remaining beneath the hangar floor.

TtEC investigated the collector line to verify its position and routing prior to the planned removal activities. Through the use of a utility locating service and by potholing through the hangar floor, the location and flow direction in the collector line was confirmed to be opposite to that previously reported in the RI Report (Shaw 2011). The drain line actually exited the east side of Building 2, discharging into the storm drain system leading to Manhole MH-115 (Figure 6-2). Reach 1 was investigated to determine whether it could be cleaned in place, removed without affecting the structural integrity of the building, or abandoned in place.

After consideration, it was determined that the hydrojetting process developed for storm drain cleaning, video inspection, and gamma scan surveys of the interiors of the lines adjacent to Building 27 would be the most appropriate investigation methodology for the Building 2 subsurface Reach 1 collector line. Before beginning these activities, two roof drains connected to the Reach 1 collector line were permanently rerouted to drain into MH-134 on the west side of the structure, which eliminated all sources of inflow. These rerouted roof drains are discussed in Section 6.0.

To facilitate the hydrojetting operations, a temporary CB was installed to intercept the collector drain line where it exited Building 2. The purpose of the temporary CB was to provide equipment access into the drain line and supply an extraction point from which the sediment and cleaning water could be recovered as hydrojetting operations progressed. During the installation of the temporary CB, five soil and sediment samples were collected from within and adjacent to the collector drain line pipe and submitted to the ELAP-accredited laboratories for analysis by gamma spectroscopy and total strontium. No ROC concentrations above the release criteria were identified for the four samples collected from the material surrounding the Reach 1 collector line. However, analysis of one sediment sample collected from within the Reach 1 collector line identified the presence of 4.133 pCi/g of Ra-226. The soil and sediment sample analytical results are provided in Appendix E of the Building 2 Final Status Survey Results document (Attachment 1). Collectively, the sediment and soil sample analytical results indicated that, although contamination above the radionuclide-specific release criterion for Ra-226 was present inside of the Building 2 Reach 1 collector line, contamination did not penetrate into the surrounding soils.

Hydrojetting operations continued for the Reach 1 collector line until a video inspection confirmed that all visible sediment had been removed. Once the sediment was removed, a sewer inspection camera was used to record the condition of the sink drain line pipe. The video inspection did not identify any notable defects that would indicate the potential for release of contamination into the surrounding soil. Gamma scan surveys of the Reach 1 pipe interior were performed using a waterproof Ludlum Model 44-10-5 detector attached to a push camera. Interpreting the data collected during the gamma radiation survey presented several challenges since naturally occurring sources of gamma radiation, including Ra-226, are typically present in the environment, with radon gas and its progeny and potassium-40 as the greatest contributors to background gamma radiation concentrations. Naturally occurring radioactive materials are often present in differing concentrations within soil and construction materials, and gamma radiation levels may vary depending on whether the material is plastic, clay, or concrete. The soil depth and pipe geometry also affect background gamma radiation levels. In addition, water acts as a shield to radiation, and the presence of water may affect background radiation levels. Due to the variability of these factors within drain line systems, the selection of a single appropriate background reference area for piping was unrealistic. Consequently, the survey data set was segregated by material type and compared to the mean plus three times the standard deviation, or sigma, of its own data set.

During the gamma scan survey, 157 readings were collected along the 105-foot length of the sink drain line. None of the gamma scan results exceeded the investigation criteria (mean plus 3 σ of the gamma scan readings of each material type encountered within the pipe, where σ is the standard deviation of these readings.) Based on the video inspection and gamma scan results, no further activities were performed. Details related to the Building 2 Reach 1 hydrojetting and video camera inspections are provided in the Building 2 Final Status Survey Results document (Attachment 1). The temporary CB and the section of the drain line located outside the building were subsequently removed.

4.7.4 Final Status Survey Results

Building 2 FSS activities were initiated in October 2013 for the six designated Class 1 SUs and two Class 2 SUs. Using MARSSIM guidance (NUREG-1575; DoD et al. 2000), a comprehensive radiological survey was implemented for Building 2 using complete sets of alpha, beta, and gamma measurements. These measurements were obtained in the reference area and compared with the corresponding Building 2 SUs. Basic statistical quantities were calculated for the data in an effort to identify patterns, relationships, and anomalies. The data were reviewed by the TtEC RSOR to determine whether investigative levels had been exceeded. A detailed discussion of the survey instrumentation, MDCs, survey methodology, investigation levels, and building FSS procedures is provided in Section 4.0. Table 3-2 summarizes the static measurement data for each Building 2 Class 1 and 2 SU. Figure 4-1 shows the general arrangement of the Class 1 and 2 SUs for Building 2.

Building 2 alpha and beta survey data were converted to units of dpm/100 cm^2. The measurements were compared directly to background measurements after conversion of the background data from counts to disintegrations. None of the 20 systematic alpha/beta sample measurements collected from each SU exceeded the release criteria.

Complete sets of gamma scan readings and static measurements were obtained in the Building 2 SUs. None of the gamma measurements were greater than the investigation level. The gamma survey results are presented in the Building 2 Final Status Survey Results document (Attachment 1).

The maximum swipe measurement activity for the Building 2 SUs was less than 20 percent of the release criteria for each Class 1 and Class 2 SU. The maximum net alpha and beta removable contamination for any SU was 6.53 dpm/100 cm^2 for alpha activity (SU-06) and 75.57 dpm/100 cm^2 for beta activity (SU-05). The swipe measurement results for each SU are provided in the Building 2 Final Status Survey Results document (Attachment 1).

4.7.5 Building 2 Dose Modeling

The intent of the Building 2 FSS activities was to achieve unrestricted radiological release. The criteria for unrestricted release were the limits specified for Cs-137, Ra-226, and Sr-90 in AEC Regulatory Guide 1.86 (AEC 1974), and a net residual dose of less than 15 mrem/y. To accomplish this goal, it was necessary to provide a means for calculating residual dose to the critical group. However, the residual net mean surface area concentrations for both alpha and beta for Building 2 hard surfaces were less than zero in all SUs. Consequently, modeling for dose was unnecessary, as the net residual dose above background levels were essentially zero. As a result, no increased annual dose above background levels was anticipated, and the 15 mrem/y dose limit for unrestricted radiological release, exclusive of background, as specified in the Action Memorandum was achieved. In addition, the 12 mrem/y updated EPA guidance value (EPA 2014) for what is considered a protective dose was met. Based on these results, the DON recommended Building 2 for unrestricted release.

4.7.6 Regulatory Concurrence

WDOH performed verification surveys in Building 2 in June 2014. The results of the verification surveys indicated that all survey data were below regulatory limits set in the "average acceptable contamination levels." In a letter dated 27 January 2015, the WDOH Office of Radiation Protection formally released Building 2 for unrestricted use. A copy of this letter is provided in Appendix O.

4.8 BUILDING 27

The following sections summarize the Building 27 FSS activities performed during the NAVSTA PS TCRA, provide an abbreviated history, describe the FSS results, and discuss regulatory concurrence for the unrestricted release of the structure. The details and results of the radiological activities were presented in the Building 27 Final Status Survey Results document provided as Attachment 2. The location of Building 27 within the context of former NAVSTA PS is depicted on Figures 1-3 and 3-1.

4.8.1 Description

Building 27 is located northwest of the NOAA facilities and north of NE NOAA Drive in the northwest portion of the former NAVSTA PS project site. It is predominantly a steel-framed structure with a concrete floor slab on the ground floor. Originally constructed as an aircraft hangar, Building 27 includes a wood-framed structure (North Shed) along the north exterior face of the hangar area and four-story stair towers are situated at each corner of the hangar. The southeast and southwest stair towers provide access to the second floor and roof. A two-story wood-framed addition (South Shed) was present along the south exterior face of the hangar prior to being demolished as part of the TCRA. During construction of the South Shed, the secondary steel framing was removed from the hangar wall and replaced by a wooden wall, which resulted in the sharing of a common wall. The South Shed included two enclosed floors of storage rooms, offices, and restrooms.

4.8.2 Background

According to the RI Report (Shaw 2011), contamination was found above the RI project release criteria in the South Shed and the adjoining southwest and southeast stair towers. Tar paper separating two layers of the built-up wood flooring appeared to have impeded the migration of radiological contamination onto the lower wood subfloor layer, except at penetrations and locations where interior walls had been removed. At penetrations and those locations where walls had been removed, radiological contamination appeared to have migrated to the subfloor. In three locations where the subfloor was removed (Radium Room and two locations in the Safety Chief Room), radiological contamination had migrated to the underlying floor joists.

The source of radiological contamination in Building 27, according to the RI Report (Shaw 2011), likely originated from activities within the former Instrument Shop and appeared to have been spread throughout the South Shed, primarily on the second floor, during janitorial cleaning activities involving wet mopping.

Based on the information presented in the RI Report (Shaw 2011), survey and remediation activities were initiated by TtEC in 2013.

4.8.3 Building 27 Field Activities

In preparation for the FSS, the Building 27 South Shed was divided into 31 Class 1 SUs (SU-01 through SU-18, SU-20 through SU-22, SU-24, SU-25, and SU-27 through SU-34). Soil SU-20 resulted from the removal of the underground portion of the sink drain line. Building 27 also included three Class 2 SUs (SU-19, SU-23, and SU-26). SU-19 incorporated the majority of the South Shed ground floor pre-demolition concrete slab and SU-23 included much of the perimeter surfaces exposed by removing the interior wallboard above the concrete stem wall on the west, north, and east sides of the South Shed. Class 2 SU-26 incorporated portions of the attic/roof area following removal of the ventilation ducting. The general arrangement of the Building 27 Class 1 and 2 SUs is shown on Figures 4-2, 4-3, and 4-4. Several areas were subdivided such that floors and areas less than or equal to 2 meters above the respective floor surfaces were considered Class 1 SUs. Class 1 SUs consisted of floor areas less than 100 m^2 or soil/excavation areas of less than 2,000 m^2. Each Class 2 SU had a maximum total area of less than 1,000 m^2. Using a different random start point in each SU, systematic data collection locations were laid out using VSP with a random start point in a triangular grid pattern. Table 3-2 summarizes the class designation and the surface area in m^2 for each designated building surface SU. Table 3-3 summarizes the class designation and the surface area for soil SU-20. The individual Class 1 and Class 2 SUs are shown on figures provided in the Building 27 Final Status Survey Results document (Attachment 2).

4.8.3.1 Ancillary Surveys

Ancillary surveys were performed in anticipation of the Building 27 remediation and FSS activities. These surveys typically included the collection of scan readings, static measurements, and swipe samples, as appropriate.

At the beginning of the remediation and FSS activities, a large volume of trash and debris was present inside Building 27, primarily on the ground floor level. All trash and debris too small or porous to be radiologically surveyed were transferred to LLRW bins. To minimize the volume of LLRW for disposal, survey activities were performed for all large non-porous items present in the South Shed and stair towers, including fluorescent light fixtures, metal tables, cabinets, desks, chairs, an angle iron, doors, stage props, wooden stage panels, rebar, plywood, folding tables, plastic pipe, and a refrigerator. Since none of the material and equipment survey results exceeded the release criteria, the majority of the items were placed in trash bins and transferred to the local landfill for disposal. The mercury- and PCB-containing fluorescent light fixtures were disposed of at appropriate off-site facilities. The material and equipment survey reports are provided in the Building 27 Final Status Survey Results document (Attachment 2).

Status surveys of the Building 27 South Shed and stair towers were initiated in September 2013. These initial surveys were performed to ascertain those contaminated locations identified in the RI Report (Shaw 2011) and establish the preliminary boundaries of elevated areas. The elevated net alpha measurements identified ranged from 103 dpm/100 cm^2 to 688 dpm/100 cm^2, and the elevated net beta/gamma measurements ranged from 1,188 dpm/100 cm^2 to 5,483 dpm/100 cm^2. The maximum net alpha and net beta measurements were located on the Building 27 south shed second level wood flooring in the former instrument shop adjacent to the Scorsby room. These results can be found in Survey SP-SS-0003, located in Appendix C of the Building 27 Final Status Survey Results document (Attachment 2).

Beginning in October 2013, status surveys of the interior surfaces of the Building 27 quarterdeck and the southeast stair tower restroom were performed. None of the survey results identified the presence of contamination above the release criteria for the ROCs.

The ancillary survey results are presented in the Building 27 Final Status Survey Results document (Attachment 2). Trash and debris placed in LLRW bins were transferred to the USAJMC contractor for off-site disposal. A discussion of waste disposal activities and volumes is provided in Section 3.11.

4.8.3.2 Deconstruction and Remediation Activities

The remediation of some contaminated areas was performed during the Building 27 TCRA using a mechanical abrasion methodology. During abrading activities, a vacuum equipped with a HEPA filter was used over the remediation area and progress was checked periodically using a

Ludlum Model 2360 data logger connected to a Ludlum Model 43-93 scintillation detector. Large area wipes were also collected throughout the remediation process to ensure that removable contamination was not inadvertently spread into adjacent areas. The remediation activities were controlled in a manner such that airborne radioactivity was minimized, and air sample collection and analysis was performed during these operations to evaluate any resultant airborne contamination in accordance with the WDOH-approved Air Emission Plan provided as Appendix B.

The radiologically impacted wood flooring and ceiling materials identified in the RI Report (Shaw 2011) as well as the interior walls, ceiling boards, and electrical conduit and piping were removed prior to initiating the Building 27 South Shed FSS activities. The generated debris was placed in LLRW bins for off-site disposal by the USAJMC contractor. Details relating to the deconstruction, remediation, and field survey activities are provided in the Building 27 Final Status Survey Results document (Attachment 2).

4.8.3.3 Washington State Department of Health Identified Hotspots

TtEC surveyed the South Shed second floor walls (SU-01 through SU-04) prior to the removal of the wood flooring and joists. When the wooden floor layers were later removed, a narrow band of wood flooring (remnant floorboards) remained along the base of the walls. The second floor sill plate and baseboards were not resurveyed following the removal of the wood floor layers since the base of the walls was previously found to be free of contamination. However, during subsequent removal of the wood flooring and joists, the configuration of the areas available for survey changed. The WDOH performed verification surveys of the South Shed in July 2014. The WDOH surveys identified four locations on the South Shed walls that exceeded the release criterion for alpha contamination: two on the north common wall and two on the south wall. TtEC staff resurveyed the areas identified by the WDOH in July 2014. The survey results confirmed the presence of alpha and beta contamination. These areas were remediated and the debris was placed in LLRW bins for off-site disposal by the USAJMC contractor.

In addition, further actions were taken to determine the extent of identified contamination. These actions included:

- Performing surveys on the second floor level of the north common wall following removal of the remnant wood floorboards
- Removing the lower portion of the second floor wallboard
- Removing the wood blocking between floor joists
- Removing the South Shed first floor wallboard to expose and survey the interior of the walls

In response to the WDOH findings on the north common wall, TtEC staff cut the floorboards flush with the face of the wall sill plate and removed the loose floorboard remnants. The baseboard and the lower 1-foot of drywall above the second floor level also were removed to expose the inner wall surfaces. Subsequent surveys of the sill plate area and the area exposed by wallboard removal identified the presence of radiological contamination. These radiologically contaminated areas were remediated and then resurveyed as part of SU-22 (Figure 4-3) and no further radiological contamination was identified.

Wood blocking between the floor joists was also removed to facilitate access to the spaces (referred to as "cubbies") formed by the floor and rim joists. Subsequent surveys of the surfaces between the joists identified areas of radiological contamination. The contaminated areas were remediated and surveyed as part of SU-14. These surveys revealed no radiological contamination above the release criteria. The generated debris was placed in LLRW bins for off-site disposal by the USAJMC contractor.

Identification of the areas of radiological contamination by the WDOH at the second floor level of the north common wall and south wall of the South Shed raised concern that contamination may have spread to the inner surfaces of first floor walls due to the influx and migration of water along the interface between the second floor sill plate and the floorboards. In response to this concern, the wallboard was removed from all South Shed walls between the top of the concrete stem walls and underside of the second floor rim joist to expose the inner surfaces. The newly exposed surfaces on the walls common to the hangar space and stair towers were then surveyed as part of SU-23, SU-24, and SU-25 (Figure 4-2). The surveys revealed the presence of radiological contamination above the release criteria only in SU-25. These contaminated areas were remediated by removing non-load bearing studs. The debris generated during the remediation activities was placed in LLRW bins for off-site disposal by the USAJMC contractor.

The south wall of the South Shed was constructed with many windows that created areas in the exposed stud space too small to effectively survey. Extensive water damage also hindered surveying. Consequently, the decision was made to forego further survey efforts on the south wall and dispose of the wall materials as LLRW during the deconstruction of the South Shed. The debris generated by demolition of the south wall was placed in LLRW bins for off-site disposal by the USAJMC contractor.

In August 2014, the WDOH performed follow-up verification surveys in the South Shed and initial verification surveys in the stair towers. The WDOH verification surveys performed in the South Shed did not identify any areas of contamination exceeding the TCRA release criteria. However, the WDOH initial verification surveys in the stair towers identified radiological contamination exceeding the release criteria, primarily where the abrasive treads were embedded in the concrete landings. Remediation and remedial action support surveys were performed by in those areas where contamination had been identified by the WDOH. In addition, professional judgement survey scans were performed in the stair towers to determine the extent of identified contamination. Post-remediation surveys were performed in existing SUs that underwent additional remediation.

Detailed discussion and supporting documentation regarding the above activities are included in the Building 27 Final Status Survey Results document (Attachment 2).

4.8.3.4 Liquid Mercury

The TtEC Team began removing radiologically contaminated flooring material in SU-08 (Figure 4-4) on 11 November 2013. The flooring was comprised of 1-inch by 4-inch wood over 0.75-inch shiplap. While removing the top layer of flooring, a small quantity of uncontained mercury was uncovered on the lower flooring shiplap. Mercury was also observed on and around several communication cables that extended through floor penetrations in the immediate area. Upon discovery, work was discontinued in the affected area and area secured. Subsequently, less than 4 fluid ounces of mercury was collected, containerized, and transferred to the USAJMC contractor for laboratory analysis and disposed of as hazardous waste.

4.8.3.5 South Shed Deconstruction

In preparation for deconstruction of the Building 27 South Shed, the fire protection sprinkler system was temporarily de-energized to allow isolation of those sprinklers servicing the roof level of the South Shed from those that would be required to continue to provide service to areas within the hangar. Sprinklers at the second floor level of the South Shed previously had been de-energized to accommodate remediation efforts that were underway at that time. An active aboveground sanitary sewer line also required rerouting prior to implementing deconstruction activities. This active line passed through the southeast stair tower into the South Shed, where it penetrated the ground floor slab and continued underground and tied into the sanitary force main located just south of the building. To permit building deconstruction, the line was reconfigured at the south wall of the stair tower and was routed underground from there to the same tie-in point to the force main.

Deconstruction of the Building 27 South Shed began on 27 January 2015 and was completed on 27 February 2015. All deconstruction activities were performed in conformance with the Demolition Work Plan provided in Appendix I. Deconstruction activities were initiated by manually removing portions of the South Shed roof system adjacent to the hangar space to isolate the two structures. Workers used lifts positioned on the ground floor slab to access the roof level and remove the inner-bay roof system piece by piece with the non-friable asbestos-containing roofing materials intact, leaving only widely spaced joists to help stabilize the remaining portion of the structure. Shoring poles were used to provide additional temporary support. Mechanical equipment was then used to remove the outer bay, followed by the remainder of the inner bay. The final step was to cut any remnants of the roof and elevated floor members flush with the common wall.

At the time deconstruction began, FSS activities had not been performed for the following South Shed surfaces:

1. The south perimeter wall extending vertically from the top of the concrete stem wall to a height of 1.5 feet above the second floor level
2. The west perimeter wall section that spanned between the South Shed center support beam and the south perimeter wall, extending vertically from the top of the concrete stem wall to 1.5 feet above the second floor level
3. The interior wall that paralleled the west wall of the southeast stair tower and spanned between the south perimeter wall and the common wall between the South Shed and the hangar

These portions of the South Shed were removed and placed in LLRW bins for off-site disposal by the USAJMC contractor. Because of the manner in which the building was constructed, additional building material adjoining these elevated areas was also disposed of as LLRW. The remaining debris generated by deconstruction of the South Shed was disposed of off-site as non-LLRW debris.

Following deconstruction of the South Shed, the ground floor concrete slab and interior concrete stem wall surfaces were surveyed as Class 1 SUs (SU-27 through SU-34). These SUs are depicted on Figure 4-2. None of the FSS results for SU-27 or SU-29 through SU-34 indicated the presence of radiological contamination above the TCRA release criteria for the ROCs. One localized area of net alpha/beta contamination (less than 100 cm^2) was discovered in SU-28 on the concrete floor at 557 dpm/100 cm^2 and 1,634 dpm/100 cm^2, respectively. These results are provided in Appendix D of the Building 27 Final Status Survey Results document (Attachment 2). This area was remediated by scabbling the concrete. Following the remediation efforts, large area wipes were collected over a 1-meter radius area to ascertain whether loose surface contamination due to the dust generated during the scabbling operation was present. None of the post-remediation static or loose contamination measurements were above the release criteria. The concrete debris generated during the remediation efforts in SU-28 was placed in an LLRW bin for off-site disposal by the USAJMC contractor. The post-remediation survey results are provided in the Building 27 Final Status Survey Results document (Attachment 2).

4.8.4 Final Status Survey Results

Building 27 alpha and beta scans were conducted on 100 percent of the accessible surfaces in the Class 1 SUs and 50 percent of those in Class 2 SU-19 and SU-34. No logged alpha scan results were obtained for Class 2 SU-26 due to safety concerns associated with the structural integrity of the roof/attic. The density of static alpha/beta measurements in this SU was drastically increased from the minimum requirement of 0.27 static measurements per square meter to 5.25 static measurements per square meter. As specified in FCR 12, professional judgement static measurements were collected at 1-foot increments, and an unlogged survey of more than 50 percent of the surface area was performed.

Building 27 alpha and beta survey data were converted to units of dpm/100 cm^2. None of the FSS alpha/beta survey results identified the presence of ROC contamination, and the null hypothesis was rejected in all cases. The maximum alpha static measurement of 89 dpm/100 cm^2 was identified in SU-21 and the maximum beta static measurement of 774 dpm/100 cm^2 was found in SU-05. Table 3-2 summarizes the building FSS results. Table 3-3 summarizes the soil SU-20 analytical results. Alpha/beta static measurement results for each Building 27 SU and individual figures depicting the FSS systematic collection locations are provided in the Building 27 Final Status Survey Results document (Attachment 2).

Complete sets of gamma scan readings and static measurements were obtained in the Building 27 SUs. No gamma scan results were obtained for Class 2 SU-26 due to safety concerns associated with the structural integrity of the roof/attic. Gamma scan and static measurement data were evaluated to determine whether any measurements exceeded the investigation limit of 3σ plus mean background. The gamma survey results are presented in the Building 27 Final Status Survey Results document (Attachment 2).

Swipe measurements were obtained from each discrete systematic and biased sample point in each Building 27 SU. The maximum net alpha and beta removable contamination across all FSS systematic sample collection locations was 8.00 dpm/100 cm^2 in SU-24 and SU-27 for alpha activity and 123.73 dpm/100 cm^2 in SU-05 for beta activity. The maximum swipe measurement activity was less than 20 percent of the release criteria for each Class 1 and Class 2 SU. Swipe measurement results for each Building 27 SU and individual figures depicting the FSS systematic swipe collection locations in each of the SUs are provided in the Building 27 Final Status Survey Results document (Attachment 2).

4.8.5 Building 27 Dose Modeling

The intent of the Building 27 surveys was to achieve unrestricted release of the building. The criteria for unrestricted release of building surfaces were the limits specified for Cs-137, Ra-226, and Sr-90 in AEC Regulatory Guide 1.86 (AEC 1974). The criterion for unrestricted release of soil is based on dose modeling at 15 mrem/year. Using this limit, the RESRAD Industrial Worker scenario for soil/sediment with the radon pathway turned on and an occupancy factor of 0.115 indoor and 0.115 outdoor, or the Recreationist scenario with an outdoor occupancy factor of 0.059, whichever value is more restrictive, was selected. This resulted in DCGLs for Ra-226, Cs-137, and Sr-90 of 1.07 picocuries per gram (pCi/g), 25.63 pCi/g, and 9.45 pCi/g, respectively.

The corresponding release criteria (DCGL + background) for Ra-226, Cs-137, and Sr-90 are 1.41 pCi/g, 25.63 pCi/g, and 9.46 pCi/g, respectively. To accomplish this goal, it was necessary to provide a means for calculating residual dose to the critical group. For Building 27 hard surfaces, the mean net surface area concentrations for alpha and beta were less than zero in several SUs (SU-01 through SU-04, SU-07, SU-8, SU-10 through SU-13, SU-15, SU-16, and SU-19 through SU-25). Modeling for dose for these SUs was unnecessary, as the net residual dose above background levels was essentially zero. To calculate the residual dose for those SUs with mean net surface concentrations for alpha and beta that were greater than zero, RESRAD-BUILD Version 3.5 (for SU 05, SU-06, SU-09, SU-14, SU-17, SU-18, and SU-22 through SU-34) and RESRAD Version 7.0 (for SU-20) were used.

In the presence of multiple radionuclides, the unity rule was used to account for the multiple radionuclides contributing to the total dose. The maximum dose for the hard surface SUs in Building 27 was 0.086 mrem/y in SU-14. The dose modeling results for SU-20 are discussed in Section 5.4. The resultant modeled dose for all of the Building 27 SUs was below the 15 mrem/y limit as specified in the Action Memorandum, and the 12 mrem/y updated EPA guidance value (EPA 2014) for what is considered a protective dose. Based on these results, the DON recommended unrestricted release of Building 27. A summary of the final dose modeling results is presented in Table 3-2 for SU-01 through SU-19 and SU-21 through SU-34. A summary of the final dose modeling results is presented in Table 3-3 for soil SU-20. The dose modeling parameters and results are provided in the Building 27 Final Status Survey Results document (Attachment 2).

4.8.6 Regulatory Concurrence

In December 2014, the WDOH performed verification surveys of Building 27. The WDOH verified that the remediated and resurveyed areas on the South Shed common north wall, the southeast and southwest stair towers, and the northern half of the eastern and western wall surfaces were all below the TCRA release criteria. During a previous survey in July 2014, the WDOH verification survey results did not identify the presence of contamination on the south half of the east or west walls of the South Shed. In a letter dated 27 January 2015, the WDOH released the South Shed common north wall, the east and west walls, the southeast and southwest stair towers, the roof, and the south wall 1.5 feet above and up from the second floor boundary above the cubbies for unrestricted use. In addition, the WDOH concurred that the remainder of the south wall should be disposed of as LLRW. A copy of the WDOH release letter is included as Appendix O.

4.9 FORMER WELDING AREA SCOPING SURVEYS

From a review of historic NAVSTA PS documents, the DON identified areas in Buildings 2, 11, and 40 (Figure 1-3) where past welding operations likely had taken place. Due to the potential historical use of thoriated tungsten welding rods in these buildings, the DON conducted further investigation of these areas. In response, work instructions for scoping surveys were developed and scoping surveys were performed. The work instructions for the scoping surveys and the survey reports for Buildings 2, 11, and 40 are included in Appendices C and P.

The action limits for Th-232 were obtained from Table 1 of AEC Regulatory Guide 1.86 (AEC 1974). The specified action limits for Th-232 were:

- 1,000 dpm/100 cm^2 average net above reference area for the mean of all static measurements
- 3,000 dpm/100 cm^2 above the material-specific reference area for any single static measurement
- 200 dpm/100 cm^2 for removable alpha surface contamination

These action limits were applied during the Buildings 2, 11, and 40 former welding area surveys. The reference area background measurements for Th-232 are presented in Table 3-1.

4.9.1 Building 2 Scoping Survey

The Building 2 welding area was located on the first floor near the southeast corner of the structure inside Room 102, and measured approximately 15 feet by 21 feet. The welding area is shown on a Building 2 floorplan included in Appendix C. A concrete trench with a steel grate cover recessed into the floor of Room 102 passed through the former welding area. At the time of the scoping survey, this 18-inch-deep trench was nearly full of water and contained no apparent sediment.

In accordance with the Work Instruction, a scoping survey was performed on 17 December 2014 in the Building 2 welding area. A Ludlum Model 2360 data logger and Ludlum 43-93 detector were used to collect two-minute alpha and beta/gamma static measurements at 12 locations in a rectangular grid within the welding area. In addition, a swipe sample was collected at each of the 12 discrete locations, and the samples were analyzed using a Ludlum Model 2929 to identify the potential presence of removable alpha/beta surface contamination. To ensure a representative comparison, the non-impacted areas in Building 2 were used as the background reference area. None of the alpha/beta static measurements or swipe sample results exceeded the action limits, and no further action was taken in Room 102. Additionally, all of the results were below the TCRA release criteria for Ra-226, Cs-137 and Sr-90. The survey results (SP-SS-040) are provided in Appendix P.

According to historical drawings, the 18-inch-deep floor trench that passed through Room 102 drained to an oil/water separator located outside Building 2. No alpha or beta/gamma static measurements were collected from the oil/water separator since it contained approximately 3 feet of standing water. Because the volume of sediment in the 18-inch-deep trench was insufficient to sample, the accumulated sediment in the oil/water separator was sampled. The sample was collected by agitating the water in the oil/water separator to mobilize the sediment resting on the bottom and pumping the water through a sock filter. The sediment sample collected from the sock filter was first analyzed for Th-232 by alpha spectroscopy (DOE Method A-01-R). Because there was no formal TCRA release criterion for Th-232, the reference area background values were used for comparison (Table 3-1). The result of 0.206 pCi/g was less than the average of the results (0.353 pCi/g) for Th-232 for the reference area background soil samples. The sample was then analyzed for the ROCs at the ELAP-accredited laboratories using EPA Methods 901.1 and 905.0. None of the analytical results for the ROCs exceeded the release criteria. The sediment sample analytical reports for the oil/water separator are provided in Appendix P.

4.9.2 Building 11 Scoping Survey

The former Building 11 welding room measured approximately 20 feet by 30 feet. The floor consisted of tightly fitting wood blocks over a concrete subfloor, with a layer of leveling sand between the wood blocks and concrete. The scoping survey for the Building 11 welding area was performed by TtEC staff on 28 August 2014. Reference area measurements for concrete, wood, and metal were collected from non-impacted areas outside the welding room of Building 11 to obtain a representative background for comparison. Two-minute alpha and beta/gamma static measurements were collected at 10 discrete locations on the exposed upper surface of the Building 11 wood blocks using a Ludlum Model 2360 data logger and 43-68 gas-flow proportional detector. The static measurements were collected at three locations in corners of the room, and the other seven locations were spaced around the perimeter of the room. The wood blocks and leveling sand were then removed at each location, and a static measurement was collected from the concrete subfloor surface. Static measurements were also logged on the side of each wooden block. This resulted in a total of 3 alpha and beta/gamma static measurements at each location for a total of 30 systematic measurements. Static/swipe measurements were also collected from four additional locations on top of steel plates, approximately equally spaced in the center of the welding room. In addition, a swipe sample was collected at each discrete location and analyzed for removable alpha and beta/gamma surface contamination using a Ludlum Model 2929. All static measurements and swipe sample results were below the thorium action limits. Additionally, all of the results were below the TCRA release criteria for Ra-226, Cs-137 and Sr-90. The survey results (SP-SS-037) are presented in Appendix P.

A 10-point composite sample of the leveling sand was collected and analyzed for Th-232 by gamma spectroscopy using actinium-228, as secular equilibrium was likely achieved. The composite sample was also analyzed for the TCRA ROCs. The composite sample consisted of sand from each static/swipe location. Gamma spectroscopy results for the leveling sand sample were evaluated taking into account that “sand” typically contains comparatively elevated naturally occurring concentrations of Th-232 compared to soil. Because there was no formal TCRA release criterion for Th-232, the Th-232 reference area background values were used for comparison (Table 3-1). The Th-232 analytical result of 0.0541 pCi/g was less than the average of the results (0.353 pCi/g) for Th-232 for the reference area background soil samples. In addition, no analytical results exceeding the release criteria for the ROCs were identified in the composite sample. The laboratory analytical results are provided in Appendix P.

4.9.3 Building 40 Scoping Survey

The former Building 40 welding room measured approximately 9 feet by 32 feet and had a concrete floor. The scoping survey was performed in the former welding room by TtEC staff on 27 August 2014. Reference area measurements for concrete were collected within Building 11 to obtain a representative background comparison for the Building 40 welding room survey. Two-minute static measurements for alpha and beta/gamma were taken at 14 discrete locations using a Ludlum Model 2360 data logger and 43-68 gas-flow proportional detector. In addition, a swipe sample was collected at each discrete location and analyzed using a Ludlum Model 2929. Nine survey locations were in corners of the room, and the other five locations were approximately equally spaced around the center of the room. None of the alpha or beta/gamma static/swipe measurements exceeded the action limits. The survey results (SP-SS-0038) are provided in Appendix P.

This page intentionally left blank.

5.0 PROJECT SITE SOIL AND STORM DRAIN OVERVIEW

The RI activities documented in the RI Report (Shaw 2011) identified radionuclides at elevated concentrations in the soil and storm drain systems adjacent to Building 27. The work described in the RI Report was the basis for the TCRA scope of work performed by TtEC. The following sections provide an overview of the FSS activities performed during the TCRA, including activities conducted at Building 27 soil SU-20, elevated areas associated with Buildings 2, 12, and 27 (SU-01 through SU-12 and HS-07), storm drain cleaning, inspection and gamma scan survey activities, additional sediment sample collection and analysis, and support for the electrical system upgrades. Those FSS elements common to soil SU-20 (Building 27) and the areas associated with Buildings 2, 12, and 27, as well as the storm drain cleaning operations are described below. Also, those overview activities described in Section 3.0 are applicable to the survey work performed at NAVSTA PS during the TCRA. For the soil and storm drain discussions in the following sections, "SU" collectively refers to the 14 designated SUs (SU-01 through SU-12, Building 27 SU-20, and HS-07), the locations of which are shown on Figure 5-2.

5.1 SOIL AND SEDIMENT RELEASE CRITERIA

The DON determined that actual or threatened releases of radiological contaminants from the NAVSTA PS project site could present a risk to public health, welfare, or the environment, and that this threat could be abated and eliminated by performing a TCRA. Consequently, the DON took steps to ensure that residual radioactivity within the NAVSTA PS project site did not result in individuals being exposed to unacceptable levels of radiation or radioactive materials. This decision was documented in the Action Memorandum (DON 2013), which is summarized in Section 2.5.3. The FSS activities for soil and sediment were conducted for the NAVSTA PS project site using MARSSIM guidance (NUREG-1575; DoD et al. 2000). Table 2-1 identifies the TCRA ROCs along with their associated half-lives and principal types of radiation. Table 2-2 presents the ROC release criteria for soil and sediment.

5.1.1 Investigation Levels for Radiological Surveys

Investigation levels are specific levels of radioactivity used to indicate when additional investigation may be necessary. Investigation levels also serve as a QC check. When determining an investigation level using a statistically based parameter (for example, standard deviation), the following may be considered: survey objectives, underlying radionuclide distributions (normal, log-normal, nonparametric), data population descriptors (standard deviation, mean, median), and prior survey and historical information. When an investigation level was exceeded, the measurement would have been confirmed to ensure that the initial measurement actually exceeded a particular investigation level. This involved taking further measurements to confirm the initial result, and, as appropriate, to quantify the area of elevated residual radioactivity through collection and analysis of biased soil samples for gamma spectroscopy analysis.

The investigation levels for all alpha and beta contamination surveys were set at the release criteria listed in Table 2-2. The alpha and beta loose surface investigations were performed by collecting a swipe sample over those hard surface locations where static measurements were obtained to determine the fraction of removable activity present relative to the total activity. The loose surface investigation levels were set at 20 percent of the values for total (fixed plus removable) activity. The investigation level for gamma scan surveys was set at three standard deviations (plus 3σ) above the mean gamma readings measured in the reference area.

5.2 SOIL FINAL STATUS SURVEYS

The objective of the soil SU FSS activities conducted for the TCRA was to demonstrate that identified residual radioactivity levels inside the excavation (exposed sidewalls and bottoms) and within the materials used as backfill met the release criteria. The FSS activities were performed in accordance with the Work Plan (Attachment 5), the Task-Specific Plan for the Building 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys (TtEC 2013b), and Task-specific Plan for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys (TtEC 2013a). The MARSSIM (DoD et al. 2000), the Survey Guide (NUREG-1505; NRC 1998), and the Field Conditions Guide (NRC 1997) were used as guidance in designing the FSS activities. In general, FSSs for every excavated soil SU included a 100 percent surface scan and systematic and biased static or direct measurements. Static surface radiation measurements were collected at each systematic sample location prior to the collection of the soil sample to identify the potential presence of gross contamination.

Scan surveys and systematic sampling were performed for the 14 SUs during the TCRA. SUs varied in size but did not exceed 300 m^2 in surface area. Systematic soil samples, and biased soil samples, when necessary, were collected from SU-01 through SU-12, SU-20, and HS-07 to ensure a minimum of one sample was collected from each excavation sidewall. Table 3-3 summarizes the area, classification, and FSS and dose modeling results for each designated soil SU.

Each of the 14 SUs was mapped using computer-aided design software. The excavation centerline was plotted with walls flattened into a two-dimensional plane. VSP software was used to determine the locations of systematic sample points based on a random start point and a triangular grid. A minimum of 10 systematic sample collection locations were selected for each of the 14 SUs. Individual figures showing the FSS systematic sample collection locations for each of the 14 SUs are included in the Building 27 Final Status Survey Results (Attachment 2) and the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.2.1 Final Status Survey Field Measurements

Background measurements used for the gamma scans and gamma statics were obtained from the reference area located southeast of Building 27 (Figure 3-1). The soil SU gamma scan ranges, investigation level, and static measurement values were provided in the Building 27 Final Status Survey Results report (Attachment 2) and the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.2.1.1 Gamma Scan Surveys

One hundred percent of the accessible surface areas of the 14 SUs were scanned using Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detectors coupled to Ludlum Model 2350-1 data loggers. The gamma scans were performed in accordance with the SOPs provided in the Work Plan (Attachment 5). The intent of the gamma scan surveys was to determine whether residual radiological contamination was present.

The gamma scan surveys were performed with the detector held approximately 10 centimeters (4 inches) away from the excavation sidewalls and bottom. The detector was moved back and forth across the travel path while scanning, producing a serpentine scan pattern. No readings above the investigation level were identified during the performance of gamma scans in any of the 14 SUs.

For gamma scan surveys, the 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 shown in Equation 8-5 from the Work Plan (Attachment 5).

5.2.1.2 Gamma Static Surveys

Static measurements were collected at systematic and biased locations in the 14 soil SUs. Each excavation had a minimum required static measurement density of approximately 20 measurements per 1,000 m^2 of area. Static gamma measurements were collected at the specified systematic locations in each excavation. For several sample locations within the excavations, it was not feasible to collect a static gamma measurement due to high groundwater levels. Consequently, an ex situ gamma static measurement was collected from the systematic soil sample retrieved from each of these locations. For gamma static surveys, the MDCR was calculated in cpm using Equation 8-12 from the Work Plan (Attachment 5).

5.2.2 Soil Survey Unit Final Status Surveys

Systematic soil samples were collected from the sidewalls and bottom of each excavated soil SU after establishing a grid that did not exceed 300 m^2 over the exposed soil surface. Soil samples were collected at systematic and biased (when used) sampling locations in each of the 14 SU excavations. One hundred percent of the FSS systematic soil samples were analyzed by gamma spectroscopy, including analysis of Ra-226 through the ingrowth of bismuth-214 (Bi-214) approaching secular equilibrium, and radiochemical separation and beta counting for total strontium/Sr-90 in accordance with the Work Plan (Attachment 5). In the case of strontium analysis, the samples were first analyzed for total strontium, which includes Sr-89 and Sr-90. Total strontium results less than the Sr-90 release criterion were conservatively reported as Sr-90. However, if the total strontium result had been larger than the Sr-90 result, the sample would have been further analyzed using the Sr-90 sample analysis procedure described in Section 5.3.3 Since none of the 14 SU total strontium results for the individual samples exceeded the TCRA action limit, Sr-90 analysis was unnecessary.

Each soil sample was initially analyzed by gamma spectroscopy for screening purposes by the DoD ELAP-accredited laboratory (Curtis & Tompkins) to aid in making time-critical radiological remediation decisions. These samples were then analyzed for definitive data to be used for the FSS and final release of the 14 SUs. A sample from each location was also submitted to a DoD ELAP-accredited off-site laboratory (TestAmerica, Richland) for total strontium analysis. The FSS laboratory analytical results were then used for dose modeling.

Both soil sample screening and definitive laboratory analytical results are provided in the Building 27 Final Status Survey Results document (Attachment 2) and the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3). Information concerning flags associated with the laboratory data and a discussion of uncertainty can be found in Section 5.3. Table 3-3 summarizes the FSS results and modeled dose to support the recommended radiological release of NAVSTA PS project site.

5.2.3 Backfill Material

Backfill material for the TCRA SUs was obtained from the CalPortland Company. Prior to delivering the material (referred to as common borrow) to the project site, 10 samples (11-Backfill-011 through -020) were collected from the backfill material supplier. All 10 backfill material samples were analyzed at the DoD ELAP-accredited laboratory (Curtis & Tompkins) by gamma spectroscopy. In addition, one soil sample (11-Backfill-011) was submitted to the DoD ELAP-accredited laboratory (Test America, Richland) for total strontium analysis. One backfill material sample (11-Backfill-011) was also analyzed for volatile organic compounds (VOCs), semivolatile organic compounds, pesticides, PCBs, total petroleum hydrocarbons, metals (including mercury), and hexavalent chromium in accordance with the Work Plan (Attachment 5). The radiological analytical results from these soil samples were used when performing dose modeling for the 14 SUs. A summary of the backfill sample gamma spectroscopy and total strontium results is presented in Table 5-1. Laboratory reports are provided in Appendix Q.

5.3 LABORATORY ANALYSIS

The following sections discuss sample preparation, gamma spectroscopy analysis and flags, total strontium analysis, counting uncertainty, and data assessment performed during the TCRA for soils.

5.3.1 Sample Preparation

Soil samples for radiological analysis were collected in the field by trained and qualified radiological technicians. When soil samples were collected in the field, approximately four times the amount of sample needed for gamma spectroscopy analysis was placed into a ZipLoc® bag for subsequent drying by laboratory personnel. An 8-ounce jar of the sample material was collected for total strontium analysis.

The field technician who collected the samples shipped them to the off-site laboratories using the chain-of-custody (COC) procedure described in the Work Plan (Attachment 5). Each sample was verified to contain identical information on the sample container and the associated COC form when received at the laboratory.

Once the samples were received by the laboratories, each sample was verified to contain less than 10 percent moisture content by weight when massed. Samples with moisture in excess of the 10 percent limit were dried in a laboratory oven. Once the moisture content was determined to be less than 10 percent, the sample was passed through consecutively smaller sieves, ending at a number 40, to screen for any foreign materials that may have been present.

An aliquot of the remaining materials was then placed and sealed in a 250-milliliter “tuna can” geometry necessary for analysis by the screening laboratory team. Time-critical remediation decisions were based on the conservative results from the screening gamma spectroscopy results. The DoD ELAP-accredited Curtis & Tompkins laboratory analyzed the samples directly for Ra-226 using the EPA 901.1 MOD/DOE Health and Safety Laboratory 4.3.5.2 method and analysis of the 46.09 percent abundant Bi-214 609.31 keV gamma energy peak (Kocher 1981) after a 21-day in-growth period to allow the sample to approach secular equilibrium after having been sealed in the tuna can geometry.

The final definitive data Ra-226 results were calculated and reported from the 46.09 percent abundant 609.31 keV gamma spectrum line of Bi-214 after an in-growth period of greater than 21 days to allow the Bi-214 to approach secular equilibrium with Ra-226, or were conservatively calculated using the same Bi-214 gamma energy peak after a 21-day in-growth period to allow the sample to approach secular equilibrium after having been sealed in the tuna can geometry. The 8-ounce jar of soil was submitted to the DoD ELAP-accredited TestAmerica, Richland laboratory for total strontium analysis. Total strontium was analyzed first due to a quicker turnaround time by the laboratory. None of the soil samples analyzed exceeded the action limit for total strontium. Consequently, further analysis for Sr-90 was unnecessary.

The laboratory screening and definitive data for the 14 soil SUs are included in the Building 27 Final Status Survey Results document (Attachment 2) and the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.3.2 Gamma Spectroscopy Analysis

Gamma spectroscopy analysis was performed on soil samples using EG&G ORTEC® detector systems equipped with beryllium end caps (windows), which allowed for enhanced quantification of low-energy gammas (such as Ra-226). Hardware features included a high-purity germanium gamma photon detector supported by a multi-channel analyzer and analysis software. Instrument hardware was calibrated using a multi-energy NIST-traceable source ranging from 50 keV to 2.6 MeV. Soil sample laboratory results were reported in pCi/g. Table 5-2 presents a summary library for gamma spectroscopy analysis at the DoD ELAP-accredited laboratory (Curtis & Tompkins).

The gamma vision software produced a report once the analysis was complete. Each report included a summary that also identified flags (or symbols) that may be associated with each radionuclide, if appropriate. These flags and their associated meanings are presented below:

- **# – All peaks for activity calculation had bad shape.** The peak did not have a proper Poisson shape. These peaks are suspect, and the activity was calculated using a Simpson's Rule type of approximation.
- A **– Activity printed, but activity < MDA.** The activity calculation performed on the peaks for the isotope of concern yields a lower value than the calculation for the minimum detectable activity (MDA). This identifies that a calculation was performed and the peaks were found, but the resulting activity was lower than the MDA.
- B **– Activity printed, but activity < Critical Level.** The activity calculation performed on the peaks for the isotope of concern yields a lower value than the calculation for the critical level. This identifies that a calculation was performed and the peaks were found, but the resulting activity was lower than the critical level.
- U **– Result is less than the sample detection limit.** The activity calculation performed on the peaks for the isotope of concern yields a lower value than the calculation for the method detection limit (MDL). This identifies that a calculation was performed and the peaks were found, but the resulting activity was lower than the MDL.
- b **– Noncompliant.** The activity was less than the MDA and the MDA was above the project site MDA; the analyte was not indicated on the COC as a radionuclide of concern; therefore, corrective action or longer count time is not required.

- J – **Result is greater than the sample detection limit, but less than the reporting limit.** The calculation performed on the peaks for the isotope of concern yields a higher value than the calculation for the MDL. This identifies that a calculation was performed and the peaks were found, but the resulting activity reported was lower than the required MDL specified in the Work Plan (Attachment 5).

5.3.3 Total Strontium/Strontium-90 Analysis

The DoD ELAP-accredited laboratory, Test America, Richland, determined total strontium and Sr-90 through separation and isotopic measurement. For soils, the strontium was transferred from the soil into a liquid matrix prior to precipitation as insoluble carbonate. Interferences from calcium and other radionuclides were removed by one or more precipitations of the strontium carrier as strontium nitrate. Diethylene triamine pentaacetic acid was added to the samples precipitated as sulfates to further remove interferences. Barium and radium were removed as chromate. The yttrium-90 daughter of Sr-90 was removed using a hydroxide precipitation step. The yttrium-90 daughter grew in again and was then separated with stable yttrium carrier as hydroxide and finally precipitated as oxalate and beta counted. Total strontium and Sr-90 were counted for beta particle activity by gas flow proportional counters.

In all cases, the samples were analyzed for total strontium, which includes Sr-89 and Sr-90, and the results were less than the Sr-90 release criterion. In all cases where the total strontium result was less than the Sr-90 release criterion, this result was conservatively reported at the Sr-90 result. However, if the total strontium result had been larger than the Sr-90 result, the sample would have been further analyzed using the Sr-90 sample analysis procedure described above.

In total, 100 percent of the excavation soil samples and 10 percent of the backfill material samples were submitted for total strontium analysis at TestAmerica, Richland. The results of total strontium analysis were reported in pCi/g and are included in the Building 27 Final Status Survey Results document (Attachment 2) and the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3). Table 3-2 summarizes the definitive total strontium analytical results for the 14 soil SUs.

5.3.4 Laboratory Counting Uncertainty

Measurement of radioactivity involves some degree of inherent uncertainty. The uncertainty quoted is the standard deviation of the average, obtained from the statistical uncertainties of the individual measurements. This uncertainty results from the combination of all possible inaccuracies in the measurement process, including such factors as the reading of the result, peak integration interpretation, peak background determination, the calibration of the measurement device, numerical rounding errors, and the random nature of radioactivity. Individual radioactivity measurements are accompanied by a plus or minus (±) value, which is an uncertainty term known as either the two-sigma counting error or the two-sigma total propagated analytical uncertainty.

Total propagated uncertainty includes both counting uncertainty and analytical uncertainty. Because measuring a radionuclide requires a process of counting random radioactive emissions from a sample, the counting uncertainty gives information on what the measurement might be if the same sample were counted again under identical conditions. The counting uncertainty implies that approximately 95 percent of the time, a recount of the same sample would give a value somewhere between the reported value minus the counting uncertainty and the reported value plus the counting uncertainty.

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.

5.3.5 Data Assessment

Laboratory data were assessed to determine whether the objective of the survey process was met. The assessment process consisted of four data phases: verification, validation, evaluation, and quality assessment. Assessment of TCRA laboratory data ensured the objective of the survey, final unrestricted release, was met.

5.4 BUILDING 27 SU-20

The former Radium Room sink at the second floor level of the South Shed drained through an exposed aboveground pipe to the first floor level, where it penetrated the floor slab and continued beneath the slab to a storm drain CB identified as CB-3. The exposed portion of the drain pipe had been removed during the RI activities; however, the remaining belowground portion of the drain pipe was still in place.

The portion of the sink drain pipe remaining in place belowground was removed during the TCRA Building 27 fieldwork in in April 2014 in accordance with the Work Plan (Attachment 5). To access the sink drain line, the concrete floor slab was saw-cut within the planned excavation boundaries. The pipe was then exposed and removed. The excavation continued to a minimum of 1 foot below the pipe. The generated concrete debris and excavated materials were placed in LLRW bins pending off-site disposal by the USAJMC contractor. Figure 4-2 shows the location of the excavation within Building 27.

During excavation of the sink drain line, the top of an abandoned 2-inch-diameter pipe was exposed that crossed the southern portion of the trench. To ensure that no radiological contamination was present, alpha/beta static measurements were collected along the 2-inch-diameter pipe and along the exposed saw-cut edges of the concrete floor slab using a Ludlum

Model 2360 data logger coupled with a Ludlum Model 43-93 detector. In addition, swipe samples were collected from each of the static measurement locations and analyzed for removable alpha/beta contamination using a Ludlum Model 2929. None of the survey results identified the presence of ROC concentrations above the release criteria. These survey results are provided in the Building 27 Final Status Survey Results document (Attachment 2).

Following excavation of the subsurface sink drain line, 10 systematic soil samples were collected from the sidewalls and bottom of the trench and submitted to the DOD ELAP-accredited laboratories for gamma spectroscopy and total strontium analysis. None of the soil sample analytical results identified contamination above the radionuclide-specific release criterion. The excavated sink drain line trench was designated Class 1 SU-20 (Figure 4-2). With the concurrence of the RASO, the SU-20 trench was backfilled on 11 June 2014 with approved backfill material. The backfill material used during the TCRA is discussed in Section 5.2.3. The SU-20 data package provided in the Building 27 Final Status Survey Results document (Attachment 2) includes a figure showing the dimensions of the excavation and systematic soil sample collection locations, as well as the screening and definitive laboratory analytical results. Table 3-3 summarizes the FSS soil sample analytical results.

5.4.1 SU-20 Dose Modeling

Dose modeling was performed for SU-20, as described in Section 3.8.2. The default RESRAD Version 7.0 parameters were used for SU-20, with three exceptions: 1) the actual surface area of the SU was used, 2) the distance of the length parallel to the aquifer was changed to the square root of the actual surface area for the SU, and 3) the net ROC concentrations above background were used. Additionally, Pb-210 was modeled at secular equilibrium with the Ra-226 activity to ensure that the dose contribution from the entire Ra-226 decay chain was included. As shown in Table 3-3, the maximum excavation net residual dose in SU-20 was 0.2831 mrem/y, while the maximum backfill material net residual dose was 1.758 mrem/y.

5.5 AREAS ASSOCIATED WITH BUILDINGS 2, 12, AND 27

Under contract with the DON, TtEC performed work to resolve radiological issues identified in the RI Report (Shaw 2011) including the removal, characterization, remediation, and FSS results for soil and storm drain lines associated with Buildings 2, 12, and 27 (South Shed) during the TCRA. The work activities are outlined in greater detail in the following paragraphs and the results are documented in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

Based on the results of the radiological remedial investigation described in the RI Report (Shaw 2011), multiple areas in the vicinity of Buildings 2, 12, and 27 were designated as potential soil contamination areas. Four of these areas were located in the grass-covered spaces along the south and west sides of Building 27, while another area was located in the grass north of the NE

NOAA Drive overpass. Two potentially contaminated areas were located north of Building 12; one to the north in a grass space and one to the northeast in an asphalt-paved area. In addition, two potentially contaminated areas were located adjacent to the south side of Building 2.

During the RI (Shaw 2011), sediment samples were collected from sanitary sewers and storm drain MHs and CBs. According to the RI Report (Shaw 2011), CB-1, CB-3, and CB-5 exhibited elevated levels of Ra-226. In addition, the RI Report (Shaw 2011) concluded that Ra-226 contamination above the RI cleanup criteria was present in the following areas:

- Historically unpaved (nontarmac) areas south and west of Building 27. The vertical extent of this contaminated soil appeared to be limited to a layer 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.
- Limited areas along the north side of Building 12 and the south and east side of Building 2. The vertical extent of this contaminated soil appeared to be limited to a thin layer typically less than 2 feet bgs.
- A single discrete item (radioactive button) removed from the soil along the east side of Building 2.

5.5.1 Characterization

TtEC performed characterization activities based on the conclusions provided in the RI Report (Shaw 2011) and the recommendations included in the Action Memorandum (DON 2013). The intent of the characterization activities was to fully delineate the extent of contamination while minimizing the total volume of waste generated during remediation activities. The characterization activities included performing GWSs to refine and supplement data generated during the previous RI and collecting soil samples from hand-augered, near-surface borings for laboratory analysis. Table 5-3 provides a summary of the analytical results associated with the characterization survey soil boring samples that were collected.

As described in Section 2.5.2.4, numerous soil areas (HSs) were identified in the RI Report as requiring further action based on the results of the RI, GWSs and soil/sludge laboratory analytical results (Shaw 2011). According to the RI Report (Shaw 2011), the analytical results identified the presence of radiological concentrations exceeding the remedial investigation release criteria.

The characterizations activities performed by TtEC during the TCRA were based on the RI Report conclusions (Shaw 2011), MARSSIM guidance, and/or scoping survey results. The primary objectives of the characterization surveys were to:

- Assess the nature and extent of the radiological contamination, if present
- Collect sufficient data to support evaluation of remedial alternatives and technologies

- Evaluate whether the survey strategy could be optimized for use in the FSS
- Provide input to the FSS design

The following sections describe the GWS and soil boring sample collection activities performed during the characterization surveys for the TCRA. Figure 5-1 shows the characterization locations within the NAVSTA PS project site.

5.5.1.1 Gamma Walkover Surveys

GWSs were performed during the TCRA to verify the elevated locations provided in the RI report (Shaw 2011) and ensure that no elevated radiological activity was present on or near the ground surface that could present a risk to workers at the site. The GWSs were performed using a Ludlum Model 2350-1 data logger (or equivalent) equipped with a Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector. Scan measurements were obtained as described in Section 5.2.1.1.

These initial GWSs were performed August, September, October, and November 2013 in areas to the south and east of Building 2, to the north and northeast of Building 12, to the south and west of Building 27, and in an area adjacent to the NE NOAA Drive overpass. The GWS results are provided in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

A GWS was performed in February 2014 on an area northeast of Building 12, immediately adjacent to the NE NOAA Drive south retaining wall. Based on the results of the GWS, two surface soil samples were collected in the grassy area adjacent to the retaining wall in locations where elevated gamma readings had been collected. These soil samples were submitted to the DoD ELAP-accredited laboratories for gamma spectroscopy and total strontium analyses. None of the analytical results identified the presence of ROC concentrations above the release criteria.

Figures depicting the GWS results and investigative soil sample locations and the laboratory analytical reports for the two investigative surface soil samples are included in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.5.1.2 Soil Borings

TtEC initiated TCRA activities for the NAVSTA PS boring locations that were proposed, but not sampled, during the RI. In preparing for sampling activities, a registered land surveyor staked or otherwise marked these 42 boring locations according to the coordinates provided in the RI Report (Shaw 2011). These boring locations are shown on Figure 5-1. Although 42 boring locations were identified for further investigation, one boring location (Boring 45) was not investigated due to conditions in the field differing from the coordinate data provided in the RI Report (Shaw 2011), which erroneously placed this boring in the street well away from any area of elevated activity identified during the RI GWSs. In addition, some soil boring locations identified in the RI Report were shifted slightly during the TCRA to avoid obstacles.

The soil boring and sampling activities were performed in accordance with the Work Plan (TtEC 2013a). In general, 2-inch-diameter hand augers were used to collect soil at each boring location. From each boring, 6-inch-long soil segments were retrieved from the ground surface to the full depth of the borings. In accordance with the Work Plan (Attachment 5), the borings did not extend beyond a depth of 8 feet or below groundwater. Upon recovery from the boring hole, the soil was removed from the hand auger and placed onto clean plastic sheeting. Each soil segment was field screened for gamma count rate using a Ludlum 2350-1 data logger with a 44-10 NaI detector, and visually examined to verify that soil from a shallower sample interval had not sloughed onto the segment just collected. This visual inspection ensured that each discrete soil sample was representative of the material recovered from a given depth. In addition, screening for VOCs was performed using a photoionization detector. The VOC screening involved monitoring the breathing zone air to ensure worker health and safety during sample collection activities. No elevated readings were noted.

Soil borings were hand augured to a maximum depth of 8 feet bgs. Refusal was encountered at a number of the boring locations at depths ranging from 2.5 feet to 6.5 feet bgs. Groundwater was encountered at a depths ranging from 1 foot to 7.5 feet bgs.

None of the field screening readings collected during the soil boring sampling activities produced gamma count rates above the mean plus 3 σ investigation level. Since no elevated gamma count rates were noted, one soil sample was collected from each of the 41 hand-augured borings at the location of the highest gamma count. The samples were submitted to the DoD ELAP-accredited laboratories for gamma spectroscopy and total strontium analyses in August 2013. Each soil boring location was backfilled with bentonite chips following completion of the sampling activities.

The laboratory analytical results identified radiological concentrations above the release criteria for the ROCs in 2 of the 41 soil samples. Ra-226 was identified at a concentration of 10.41 pCi/g in the soil sample collected from Boring 10, located southwest of Building 27 at a depth interval of 0.0 to 0.5 feet bgs. In addition, the soil sample collected from the 0.5 to 1 foot bgs depth interval in Boring 55, located in the asphalt-paved area west of Building 2 and northeast of Building 12 showed the presence of Ra-226 activity at 1.479 pCi/g. These areas were remediated as part of the SU-04 and SU-07 excavation activities.

5.5.2 Remedial Actions

The characterization activities performed by TtEC and the results of the RI around Buildings 2, 12, and 27 identified Ra-226 concentrations above the radionuclide-specific release criterion.

The investigations also identified isolated occurrences of Cs-137 contamination that were below the release criteria, and low levels of Sr-90 in storm and sink drain lines. Remedial actions were performed by TtEC from October 2013 through May 2014 to remove contaminated storm drain piping in the vicinity of Buildings 2 and 27 and contaminated soil associated with areas of elevated surface activity (HSs) in the areas around Buildings 2, 12, and 27. Following the completion of remedial actions in these areas, new replacement storm drain systems were installed and disturbed areas were restored as discussed in Section 6.1.

The HS locations included HS-01 through HS-12 and SU-02 and SU-04 (Figure 5-2). SU-02 was located on the west side of Building 27 at the location of Boring 10, which was associated with a contaminated soil sample analytical result of 10.41 pCi/g Ra-226, as described in Section 5.5.1.2. SU-04 was an area with elevated gamma scan readings identified during GWS activities, and was most likely an area where mop water had been discarded on the west side of Building 27 during historical janitorial activities. Neither SU-02 nor SU-04 was associated with storm drain piping removal activities.

The general approach to removing the 14 designated HSs (HS-01 through HS-12, SU-02, and SU-04) included excavation of the elevated areas of surface activity as well as the soil in a 1-foot radius around each HS. The material was loaded directly from the excavation into bins for disposal by the USAJMC contractor as LLRW. Once excavation for a given HS was complete, the exposed sidewalls and bottoms were surveyed using a Ludlum 44-10 detector coupled with a Ludlum 2350-1 data logger to ensure that no residual contamination remained. These survey activities included the collection of gamma scan readings and static measurements. In addition, soil samples were collected and submitted to the DoD ELAP-accredited laboratories for analysis. No post-excavation surveys for HS-10 through HS-12 were performed since these locations were subsequently incorporated into SU-09 for the FSS. Based on the results of the post-excavation surveys and soil sample analytical results, the HS locations either were designated for further remediation or proceeded directly to FSS activities. Table 3-3 summarizes the soil analytical results and dose modeling results for each soil SU.

Concrete surfaces associated with HS-02, HS-04, HS-05, and HS-06 were also surveyed during the TCRA. None of the survey measurements for the concrete surfaces exceeded the release limits. The survey reports were presented in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

No post-excavation survey measurements or soil sample analytical results above the release criteria were identified for HS-01 through HS-06 or SU-04. The survey results and soil sample analytical results were presented in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3). Table 3-3 summarizes the soil analytical results and dose modeling results for each soil SU.

Following excavation, HS-01 through HS-06 and HS-08 through HS-12 were incorporated into SUs either for the completion of further remediation or for FSS activities. HS-07 retained its designation throughout the FSS activities due to field conditions and the limitation of Class 1 SUs to 2,000 m^2 or less. Table 3-3 identifies the excavated HS locations and associated SUs for FSS activities.

Elevated survey measurements and/or soil sample analytical results were identified for HS-07, HS-08, HS-09, and SU-02. In addition, a radiological device was found at HS-10, as described in Section 3.10. The following sections describe the additional excavation and survey activities performed for these locations prior to initiating FSS activities.

5.5.2.1 Hotspot HS-07 Remediation

This survey unit underwent three iterations of remediation/sampling. After the initial excavation, 10 post-remediation biased samples were collected and submitted to the DoD ELAP-accredited laboratories for analysis. None of the soil sample analytical results identified the presence of Cs-137 or Sr-90 concentrations above the radionuclide-specific release criterion. However, one of the soil sample analytical results collected from the south wall of the excavation indicated the presence of Ra-226 contamination in Sample 11-EXC-HS07-009 at 3.015 pCi/g. Based on this analytical result, additional soil was removed and placed in a LLRW bin for off-site disposal by the USAJMC contractor.

Following this first iteration of remediation and sampling, systematic sample collection locations were selected for the HS-07 excavation using the most current version of VSP software (Gilbert et al. 2001) based on a random start point and triangular grid pattern (Figure 5-2). Ten soil samples were collected from the systematic locations and submitted to the laboratories for analysis. Two of the soil sample analytical results collected from the south wall of the excavation identified Ra-226 contamination in Samples 11-EXC-HS07-014 and 11-EXC-HS07-018 at 1.761 pCi/g and 6.155 pCi/g, respectively. Additional soil was removed and placed in a LLRW bin for off-site disposal by the USAJMC contractor.

Following this second iteration of remediation and sampling, FSS activities were performed as described in Sections 5.2 and 5.5.3. The radiological survey results and laboratory analytical reports for HS-07 are provided in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.5.2.2 Hotspot HS-08 Remediation

For HS-08, five soil samples were collected from the sidewalls and bottom of the excavation and submitted to the laboratories for analysis (Figure 5-2). None of the soil sample analytical results identified the presence of Cs-137 or Sr-90 above the release criteria. However, analysis of one soil sample (11-EXC-HS08-001) collected from the bottom of HS-08 identified the presence of

Ra-226 contamination at 2.738 pCi/g. Based on this soil sample analytical result, additional soil was removed and placed in a LLRW bin pending off-site disposal by the USAJMC contractor. Following this remediation effort, three biased soil samples were collected and analyzed. None of these analytical results identified the continued presence of Ra-226 contamination.

Following completion of the excavation, remediation, and sampling activities, HS-08 was incorporated into SU-08 for the FSS (Figure 5-2). The FSS activities are described in Sections 5.2 and 5.5.3. The radiological survey results and laboratory analytical reports for HS-08 are provided in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.5.2.3 Hotspot HS-09 Remediation

Five soil samples were collected from the HS-09 excavation and submitted to the DoD ELAP-accredited laboratories for analysis (Figure 5-2). None of the soil sample analytical results identified the presence of Cs-137 or Sr-90 above the release criteria. However, the analytical results identified the presence of Ra-226 concentrations above the release criterion in soil samples 11-EXC-HS09-003, -004, -005 at 2.46 pCi/g, 3.59 pCi/g, and 10.94 pCi/g, respectively. The remediation of HS-09 contamination was delayed because it was situated within the footprint of designated SU-12, and further excavating would have resulted in undermining electrical equipment that was slated for removal as part of an electrical system upgrade project by a contractor for Seattle Parks and Recreation (the electrical system upgrade is discussed in Section 5.8). Consequently, HS-09 was remediated as part of the excavation and remediation of SU-12 once the electrical equipment and associated concrete foundation were removed.

5.5.2.4 Hotspot HS-10 Remediation

According to the RI Report (Shaw 2011), three localized areas of elevated activity were identified during the RI GWS activities. These three areas, located in the paved area west of Building 27, were designated as HS-10, HS-11, and HS-12, (Figure 5-2). TtEC initiated excavation of these three HSs in May 2014. As described in Section 3.10, radiological device DS-0001 (SP-DS-0001) was found in soil approximately 4 inches below the asphalt surface in HS-10 during the excavation activities. No such objects were identified in HS-11 or HS-12.

Following removal of DS-0001, TtEC continued excavating HS-10 to a minimum of 1 foot around the device location. The asphalt and soils generated during excavation of HS-10, as well as that from HS-11 and HS-12, were placed in LLRW bins pending transfer to the USAJMC contractor for off-site disposal. HS-10, HS-11, and HS-12 excavations were subsequently incorporated into the SU-09 FSS activities (Figure 5-2). The FSS activities for SU-09 are described in Sections 5.2 and 5.5.3.

5.5.2.5 Survey Unit SU-02 Remediation

Analysis of the soil sample collected during the characterization activities from Boring 10 identified the presence of Ra-226 contamination at 10.41 pCi/g, as described in Section 5.5.1.2. Following the initial excavation in January 2014, survey and soil sample collection activities were performed. The survey measurements did not indicate the presence of elevated gamma readings. Ten soil samples were collected from biased locations and submitted to the laboratories for analysis. None of the analytical results identified the presence of ROC concentrations above the release criteria.

Based on these results, systematic sample collection locations were selected for SU-02 using the most current version of VSP software (Gilbert et al. 2001) based on a random start point and triangular grid pattern. Ten soil samples were collected from the systematic locations in SU-02 and submitted to the laboratories for analysis. However, the analytical results for two samples (11-EXC-SU02-014 and -015) identified the presence of Ra-226 contamination at 2.592 pCi/g and 3.153 pCi/g, respectively. Both elevated samples were collected from the west wall of the SU-02 excavation. Based on these results, further excavation was performed and the soil was placed in a LLRW bin pending off-site disposal by the USAJMC contractor. Following these remediation efforts, FSS activities were performed for SU-02 as described in Sections 5.2 and 5.5.3.

5.5.2.6 Storm Drain System Remediation

Storm drain system removal efforts focused on those areas identified in the RI Report as needing further action (Shaw 2011), as well as the results of the characterization activities performed by TtEC during the TCRA, including the following:

- Piping extending from CB-2 located adjacent to the Building 27 South Shed, downstream through CB-1, and terminating at the 24-inch-diameter drain line extending from MH-135 to MH-136. Approximately 97 linear feet of piping and 169 cubic yards of material were removed and placed in LLRW bins pending off-site disposal by the USAJMC contractor. This excavation was designated as SU-01 for the FSS activities.
- Piping extending from the south face of the Building 27 South Shed, continuing through CB-3, and terminating downstream at MH-141. This line was a continuation of the belowground SU-20 sink drain segment discussed in Section 5.4. This excavation was separated into SU-03 and SU-12 due to the presence of energized electrical equipment, which required that removal of the storm drain line be completed in phases. During the excavation of SU-03, approximately 140 linear feet of piping and 239 cubic yards of material were removed and placed in LLRW bins pending off-site disposal by the USAJMC contractor. During the excavation of SU-12 approximately 33 linear feet of

piping and 40 cubic yards of material were removed and placed in LLRW bins pending off-site disposal by the USAJMC contractor.

- Piping extending from CB-5, located on the west side of Building 27, downstream through CB-6 and CB-7, and terminating at CB-8. Approximately 266 linear feet of piping and 380 cubic yards of material were removed and placed in LLRW bins pending off-site disposal by the USAJMC contractor. This excavation was designated as SU-10 for the FSS activities.
- Piping extending along the east side of Building 2 and terminating downstream at MH-115. This line was a continuation of the Reach 1 sink drain collector line discussed in Section 4.7.3.3. This excavation was separated into SU-05 and SU-11 for the FSS activities. During the excavation of SU-05, approximately 50 linear feet of piping and 171 cubic yards of material were removed and placed in LLRW bins pending off-site disposal by the USAJMC contractor. During the excavation of SU-11, approximately 92 linear feet of piping and 77 cubic yards of material were removed and placed in LLRW bins pending off-site disposal by the USAJMC contractor.

The locations of the storm drain piping excavated during the TCRA and designated SUs are identified on Figure 5-2.

Radiological surveys and soil sample collection activities were performed during the TCRA for each of the excavated storm drain SUs. With the exception of SU-12, no ROC concentrations above the release criteria were identified in the storm drain SUs. Consequently, SU-01, SU-03, SU-05, SU-10, and SU-11 proceeded to FSS activities, as described in Sections 5.2 and 5.5.3. The results of the surveys and the laboratory analytical reports are provided in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

The storm drain piping associated with SU-12 was originally scheduled to be abandoned in place due to the presence of an overlying electrical equipment. However, since work was being performed by the Seattle Parks and Recreation’s contractor to upgrade the electrical system, the transformer was deactivated and radiologically surveyed. Survey results were found to be below AEC Regulatory Guide 1.86 limits (AEC 1974) and the transformer was released to the electrical contractor and removed from the area. The concrete pad beneath the transformer was removed to allow access to the storm drain pipe. Once the concrete pad was removed, TtEC excavated the SU-12 storm drain line to a depth of 1 foot below the pipe. The excavated soil, piping, and concrete debris from the electrical pad were placed in a LLRW bin pending off-site disposal by the USAJMC contractor. The electrical system upgrade survey activities are described in Section 5.8.

Survey activities were performed at the completion of the SU-12 excavation and none of the measurements exceeded the plus 3 σ investigation level of 6,646 cpm. Using the most current version of VSP software (Gilbert et al. 2001) and based on a random start point and triangular grid pattern, 10 systematic soil samples were collected and submitted to the laboratories for analysis. In addition, due to the former location of HS-09 within SU-12, three biased soil samples were collected and analyzed. Five soil sample analytical results (11-EXC-SU12-001, -002, -010, -011, and -013) identified the presence of Ra-226 contamination at concentrations ranging from 2.292 pCi/g to 3.949 pCi/g. Based on these results, additional soil was removed from the SU-12 excavation and placed in LLRW bins pending off-site disposal by the USAJMC contractor. Following these remediation activities, a FSS was performed for SU-12. The FSS activities are described in Sections 5.2 and 5.5.3. The survey results and the soil sample analytical reports are included in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.5.3 Soil Survey Unit Final Status Surveys

Fourteen Class 1 FSS soil SUs, including SU-01 through SU-12, SU-20, and HS-07, were designated during the TCRA. The SU-20 survey activities are summarized in Section 5.4. Following the initial excavation of each HS and SU, post-remediation biased soil samples were collected to ensure that no residual radiological contamination above the release criteria remained. In several instances, multiple HSs were combined to form SUs, as identified in Table 3-3. Class 1 survey activities, which included the collection of gamma scan readings and static measurements, were performed for each SU. The gamma scan ranges, investigation level, and static measurement values for the SUs were provided in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

Following the survey activities, the SUs were digitally rendered, and sample collection locations were selected using the most current version of VSP based on a random start point and a triangular grid pattern (Gilbert et al. 2001). Figures depicting each excavated SU and the systematic sample collection locations for the FSS were presented in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3). Each SU was subjected to a Class 1 survey using a maximum area of 300 m^2. The final surface areas of SU-01 through SU-12 and HS-07 following excavation and remediation activities are shown in Table 3-3.

5.5.4 Dose Modeling Results

Dose modeling was performed for each of the SUs (SU-01 through SU-12, SU-20 and HS-07). Dose modeling results are summarized in Table 3-3. None of the modeling for the SUs or backfill material resulted in a net residual dose above the 15 mrem/y limit as specified in the Action Memorandum, or the 12 mrem/y updated EPA guidance value (EPA 2014) for what is considered a protective dose. The maximum SU net residual dose of 1.973 mrem/y was calculated for SU-12. A maximum backfill material net residual dose of 7.039 mrem/y was calculated for SU-03. Based on these results, no further dose modeling was performed. The backfill material and SU RESRAD reports are provided in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

5.6 STORM DRAIN LINE CLEANING AND ASSOCIATED ACTIVITIES

Additional actions were taken by the DON as part of the TCRA to address radiological contamination associated with storm drain systems located in the vicinity of Building 27. These storm drains, shown in Figure 5-3, were identified as requiring further action based on sediment sampling and scan survey results documented in the RI Report (Shaw 2011). A summary of the RI Report findings is provided in Section 2.5.2. Although the results of analysis of sediment collected from the MH-141 and MH-160 during the RI were below the RI release criterion for each ROC, the Ra-226 concentrations in the sediment samples exceeded the more stringent criterion later established for the TCRA. Since the RI Report identified the presence of Ra-226 concentrations exceeding the TCRA release criterion in sediment samples collected from MH-141 and MH-160, TtEC cleaned, inspected, and performed gamma scan surveys of the affected storm drain systems during the TCRA fieldwork.

TtEC performed these storm drain line cleaning activities and associated activities in accordance with the Accident Prevention Plan/Site Safety and Health Plan (TtEC 2013c), and the Final Work Instruction for Storm Drain Line Cleaning and Associated Activities (TtEC 2014), in conjunction with the Work Plan (Attachment 5). The plans were reviewed and approved by the Washington State Department of Ecology and WDOH as the governing regulatory agencies. A copy of the Final Work Instruction is provided in Appendix C and the Work Plan is summarized in Section 2.5.4. The scope of work for the storm drains requiring further evaluation included:

- Sediment Removal/Inspection: Removing accumulated sediment from the storm drain lines identified in Figure 5-3 using the hydrojetting process, documenting the condition of each line using a video camera system, and cleaning and assessing the condition of each MH and the CBs associated with these storm drain lines
- Gamma Scan Surveys: Following cleaning and inspection, performing a gamma scan survey of the interior of the storm drain lines, MHs, and CBs
- Sediment and Water Processing: Managing the sediment and wastewater generated during the hydrojetting process, analyzing sediment samples for the ROCs, and characterizing wastewater samples for proper disposition
- Soil Core Sampling: Reviewing the inspection and gamma scan survey results and recommending locations for soil core sample collection to the DON. With DON concurrence, collecting soil cores and analyzing samples for the ROCs
- Performing air monitoring for radiological constituents
- Maintaining control of radiological materials throughout the TCRA activities

During the planning phase, approximately 1,800 feet of storm drain lines in the vicinity of Building 27 were divided into reaches (Reach 2 through 11). A reach was defined as a section of subsurface pipe between two consecutive MHs or CBs that could be isolated to facilitate sediment removal. Following sediment removal, a video inspection and gamma scan survey activities were conducted. As identified on Figure 5-3, the defined reaches for the NAVSTA PS storm drain cleaning and other associated activities included:

Reach 2	MH-141 to CB-13
Reach 3	MH-141 to MH-1007
Reach 4	MH-141 to MH-137
Reach 5	CB-1011 to MH-137
Reach 6	MH-137 to MH-160
Reach 7	CB-11 to MH-136
Reach 8	MH-135 to MH-136
Reach 9	MH-1005 to MH-136
Reach 10	MH-1005 to MH-160
Reach 11	MH-160 to Lake Washington Outfall

Reach 1 was an additional 105-foot section of drain line piping associated with Building 2. A summary of the Building 2 TCRA and FSS activities, including Reach 1, is provided in Section 4.7.

5.6.1 Storm Drain Cleaning

Each of the storm drain lines (reaches) identified on Figure 5-3 and in Section 5.6 was cleaned using hydrojetting equipment consisting of a truck-mounted vacuum unit and material holding tank, high-pressure pump, clean water tank, and jet hose reel. This equipment employed a jetting nozzle and high-pressure water pump to mobilize and flush accumulated sediment toward one end of the pipe, where it was then extracted using the vacuum unit. The work areas around the upstream and downstream MHs were secured with temporary fencing and a baseline GWS was conducted prior to covering the work area with sheet plastic and placing storm water controls along the perimeter. Copies of these baseline surveys are included in Appendix R. The area was then posted as an RCA with access controlled by an RCT. With the exception of the active pipe reach, pipes entering/exiting the upstream and downstream MHs were isolated using mechanical or pneumatic plugs to prevent sediment slurry from escaping the reach to be cleaned. The storm drain cleaning process is detailed in the Report of Storm Drain Line Cleaning and Associated Activities presented as Attachment 4.

Sediment samples were collected from two MHs in association with the storm drain cleaning activities. One sediment sample was collected from MH-1007, located at the western terminus of Reach 3 because the storm line cleaning was unable to remove a root ball located downstream of this structure. The second sediment sample was collected from the storm drain line pipe in Reach 11 prior to the Lake Washington Outfall (Figure 5-3) because the presence of high water levels in the downstream reach prevented the video inspection from confirming that 100 percent of the sediment had been removed during the storm line cleaning activities. Both sediment samples were submitted to the ELAP-approved laboratories for analysis in accordance with the approved SAP and Work Plan (Attachment 5). The analytical results did not identify the presence of ROC concentrations above the release criteria. The laboratory analytical reports were provided in the Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4).

When the work activities (hydrojetting, video inspection, and gamma scan surveys) at a given MH or CB were complete, all equipment was surveyed to ensure no contamination was present. Once cleared, the equipment was relocated to the next work area and the sheet plastic covering the ground surface in the work area was removed. A GWS was then performed over the area and the results of this survey were compared to the baseline GWS. No residual surface contamination was identified. The GWS results are included in Appendix R.

Hydrojetting progressed in a downstream direction from the high points of the storm drain systems to the outfall at Lake Washington. Because the active pipe reach was isolated from the balance of the system by plugging, bypass pumping was implemented to divert stormwater flow around the active reach. In conjunction with pipe hydrojetting, the associated MHs and CBs were also cleaned. This operation involved removing accumulated sediment using the vacuum truck and a high-pressure water jet to removed materials adhering to the MH and CB surfaces. Recovered sediment and water generated during the hydrojetting process were routinely transferred to waste holding tanks and the clean water tanks were refilled from a nearby fire hydrant.

5.6.2 Storm Drain Inspection

The interior of each storm drain line reach was inspected following completion of hydrojetting operations using a wheel- or crawler-mounted sewer inspection camera equipped with a pan and tilt head, which allowed the operator to perform a real-time inspection of the full periphery of the pipe. The supporting audio/video recording and closed circuit television equipment enabled the inspection to be recorded and played back. The camera traveled the length of the pipe reach at a moderate rate, with the operator stopping forward travel, when necessary, to inspect and document the condition of the pipe. In a few isolated sections of pipe, there was limited success in capturing clear video images due to the presence of water in the storm drain line. In addition, the video camera was unable to record the condition of an approximately 12-foot-long section of

Reach 7 due to the presence of grout intrusion at a pipe joint that blocked the path of the camera unit. However, TtEC staff were able to conduct the gamma scan survey by manually pulling the detector through this reach.

Infiltration points, intersecting pipes, and defects were identified during the inspection activities and located by footage and clock reference. In conjunction with the video inspection of the storm drain line systems, accessible areas of the MHs and CBs were visually inspected for evidence of deterioration or damage. All observed surfaces appeared to be in satisfactory condition.

An audio/video recording was produced for each pipe reach. Summary figures for each pipe reach, a plan view of the pipe location and length, the associated MH and CB identification used to designate each pipe reach, and the storm water flow direction overlaid on satellite image are included in the Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4). These figures also include photographs showing pipe defects identified during the inspections. These data subsequently were used to determine soil sample collection locations, described in Section 5.6.4.

5.6.3 Storm Drain Gamma Scan Surveys

Storm drain line gamma scan survey activities began following removal of sediment and review of the video inspection results for each reach. Gamma scanning was performed using a waterproofed Ludlum Model 44-10-5 NaI detector coupled to a Ludlum Model 2350-1 data logger using a waterproof data cable. As the detector moved through the pipe, gamma scan readings were recorded along with location information.

The Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4) includes summary figures for each pipe reach, including the gamma scan data collected. A summary of the storm drain line gamma scan data is provided in Table 5-4. The results of the gamma scan surveys, in conjunction with the inspection results discussed in Section 5.6.2, provided the basis for determining soil core sample collection locations.

Gamma scan surveys for MHs and CBs were performed using a Ludlum Model 44-10 detector coupled to a Ludlum Model 2350-1 data logger. Accessible interior surfaces of the MHs and CBs were scanned, the highest and lowest readings observed were recorded, and one-minute static counts were performed at the locations of the highest scan readings. Table 5-5 summarizes the MH and CBs gamma scan and static survey results. These results indicated that the observed activity levels were typical for structures of the material type and geometry surveyed.

Interpreting data from gamma radiation surveys presented several challenges due to a number of variable factors within the storm drain line system, as described in the Report of Storm Drain

Line Cleaning and Associated Activities (Attachment 4). Due to these variabilities, the selection of a single appropriate background reference area for the piping runs was unrealistic.

The survey data set was compared to the mean plus 3 times the standard deviation, or σ, of its own data set. A mean plus 3 σ investigation value was calculated for each material type present within the pipe reach. Because of the variability with the in situ storm drain lines, the survey data for each reach were compared to the mean plus 3 σ value for each material type within its own data set. Changes in material type were confirmed using video data and observation.

During the gamma scan surveys, 2,468 readings were logged from within the pipe. Of these readings, 7 exceeded the mean plus 3 σ of the data set of a specific material type within a given reach. These included 1 exceedance in each of 4 separate pipe reaches (Reaches 5, 6, 7, and 10) and 3 exceedances in Reach 8. The maximum sigma value observed was 5.15 (in Reach 10). The remaining 6 exceedances had sigma values ranging from 3.00 sigma (in Reach 6) to 3.48 sigma (in Reach 8). None of these exceedances were clustered in a manner that would indicate the likely presence of contamination. Assuming that the gamma scan data followed a normal distribution, a number of exceedances should be observed even for surveys of material known to be free of contamination.

Assuming a normal distribution, 99.73 percent of the data points should fall within three standard deviations of the mean; 0.135 percent of the data points can be predicted to fall below mean minus 3 σ, and 0.135 percent of the data points can be predicted to fall above mean plus 3 σ. The fraction of exceedances for the entire storm drain line gamma scan data set was 0.284 percent.

There were four instances in which a noteworthy change in the average gamma cpm levels was observed that did not correspond to a noticeable change in the pipe material type (i.e., the material remained the same, but the average background levels changed).

This phenomenon was observed in the following reaches:

1. Reach 4 – A noticeable change in the gamma cpm levels from an average of 8,196 cpm to an average of 10,389 cpm was observed 225 feet from MH-141; however, no material change was noted. The difference in the average gamma scan cpm level may have been due to a difference in the source of the raw materials used to manufacture the pipe or backfill around the pipe during installation.
2. Reach 6 – A noticeable change in the gamma cpm levels from an average of 7,688 cpm to an average of 10,423 cpm was observed 45 feet from MH-137; however, no material change was noted. The difference in the average gamma scan cpm level may have been due to a difference in the source of the raw materials used to manufacture the pipe or backfill around the pipe during installation.

3. Reach 8 – A noticeable change in the gamma cpm levels from an average of 4,004 cpm to an average of 4,885 cpm was observed 41 feet from MH-135; however, no material change was noted. The higher average gamma cpm level for a portion of the pipe was likely due to the overlying concrete slab and rock backfill material used in the restoration of the storm drain south of Building 27.
4. Reach 11 – A noticeable change in the gamma cpm levels from an average of 2,938 cpm to an average of 1,292 cpm was observed 26 feet from MH-160 at the approximate location where the pipe transitioned from concrete pipe installed by the DON to HDPE pipe reportedly installed to extend the shoreline.

Although the gamma scan results can be influenced by a number of factors, the higher average gamma scan data for portions of these storm drain reaches did not appear to be directly related to changes in pipe material type. Upon completing the storm drain cleaning, video inspection, and gamma scanning activities, TtEC evaluated these data and presented the information to the DON with recommendations for soil coring locations; these activities are summarized in Section 5.6.4.

5.6.4 Soil Core Sampling

Based on the evaluation of the inspection and gamma scan survey results, eight locations immediately adjacent to the storm drain line reaches were selected for the collection of soil cores (Figure 5-3). The core location selection criteria focused on those areas where inspections identified breaches in the storm drain pipe or MH and/or areas where the gamma scan survey results identified either exceedances of the mean plus 3 σ of the data set and/or changes in the average gamma readings with no apparent change in material type. Table 5-1 of the Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4) identifies the reason each core location was selected. The target depth of each soil core was 1 foot below the bottom of the adjacent storm drain pipe or component. If the core advanced to a depth below the estimated bottom of pipe, the 6-inch soil interval spanning the estimated depth to bottom of pipe was selected for sampling. If the core could not advance to, or if soil could not be recovered from, the estimated depth to bottom of pipe, the deepest 6-inch soil interval was sampled. As discussed below, one or more additional soil intervals were sampled at some core location because gamma measurements collected at those depth intervals exceeded the measurements from the target interval depths. Detailed information related to the selected core sample locations and depths was provided in the Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4).

Core recovery to the planned depth was achieved at the majority of selected locations. At core location 4, soil recovery was limited to a depth of 4 feet below the bottom of the tarmac due to the sandy composition of the soil and high groundwater level. At core location 6, coring could not continue beyond a depth of 2.5 feet below the bottom of the Building 27 South Shed floor slab due to interference caused by a large buried concrete mass. Shifting the core location in an attempt to avoid the obstruction was unsuccessful, and no further attempts were made to shift and core deeper. Located along Reach 3, core location 1 was situated in a busy city street where sight distance was poor. Due to safety concerns, no coring was done at this location. However, analysis of a sediment sample collected from inside upstream MH-1007 did not identify the presence of ROC concentrations above the release criteria, and no mean plus 3 σ exceedances were identified during the gamma scan survey of the Reach 3 pipe.

Following core recovery, gamma static measurements were logged at 6-inch intervals along the length of each core using a Ludlum Model 44-10 NaI detector coupled to a Ludlum Model 2350-1 data logger to identify any soil exhibiting an elevated gamma activity level. At core locations 2, 3, 5, 7, and 8, one soil sample was collected at each location at a depth of approximately 6 inches below the bottom of the pipe. The intent of sample collection at these depths was to focus the investigation on locations where contamination in the surrounding soil would most likely occur. At core locations 5, 7, and 8, one or more additional soil samples were collected (4 samples total) for analysis; these samples were collected from depth intervals either above or below the target interval depth where gamma data collected along the cores exceeded those measurements from the target interval depths. At core locations 4 and 6, where sample recovery at the target depth was not achieved, the soil from the deepest 6-inch interval was sampled.

Two soil boring locations (Locations 6 and 7) were associated with Reach 8 (MH 135 to MH 136). Soil boring location 7 was selected due to a hole in the pipe that was observed during the pipe video inspection. The soil boring at location 6 was selected due to a gamma scan measurement of 4,910 cpm (3.09 σ), which is above the 3 σ investigation level. This gamma exceedance also coincided with holes in the pipe. These two soil boring locations were located 13 and 29 feet, respectively, downstream of CB 1, which would be the likely source of contamination for this line. One sample was collected and analyzed from each of these soil borings, and all of the results were below the project release criteria. During the gamma scan survey of Reach 8, an elevated measurement (5,018 CPM/3.48 σ) was also observed 225 feet downstream of MH 135 beneath Building 27. Given its location, the available Reach 8 data was evaluated and a soil boring was determined to be unjustified at this location based on the following: 1) the gamma count observed at this location was comparable to what was observed at soil boring location 6, 2) two favorable soil boring samples were collected upstream (and closer to the source of contamination), 3) and no contamination was identified as a result of analyzing sediment from downstream MH 136 during the RI (Shaw 2011).

In total, 11 soil samples were collected and analyzed for the ROCs in accordance with the approved SAP and Work Plan (Attachment 5), and all results were below the TCRA release criteria (Table 2-2). The highest reported results were 0.591 pCi/g Ra-226, 0.0238 pCi/g Cs-137, and 0.301 pCi/g total strontium. The laboratory analytical data is provided in the Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4).

5.6.5 Sediment and Water Processing

Sediment and water generated by the hydrojetting process were managed at the centralized waste storage and processing RCA, which included 4 sediment dewatering boxes and 12 wastewater storage tanks within secondary containment (Figure 5-3). The dewatering boxes consisted of open-top containers with suspended mesh inserts and filter fabric liners, which allowed bulk sediment to be retained while water drained into the annular space below. The hydrojetting rig backed up to a dewatering box, and, to the extent feasible, discharged directly through a valve and hose at the rear of the holding tank. The rear door (tailgate) of the hydrojetting rig was gradually opened and the balance of the wet sediment was allowed to discharge into the dewatering box. Once sediment was dewatered to the extent practicable, the material was placed in LLRW bins and an absorbent polymer powder was added, as necessary, to further stabilize the sediment for transport.

Ten 5-point composite sediment samples were collected periodically (approximately every 10 cubic yards) from random locations distributed across the sediment material placed in each LLRW bin. The five discrete sediment samples composing each of the 10 composite samples were collected at the surface and at a 12-inch depth, or smaller intervals, depending on the volume of sediment in the LLRW bin. None of the composite samples submitted to the ELAP-approved laboratories for ROC analyses identified the presence of contamination above the release criteria. The highest reported results were 0.9757 pCi/g Ra-226, 0.1146 pCi/g Cs-137, and 0.367 pCi/g total strontium. The sediment laboratory analytical reports are included in Report of Storm Drain Line Cleaning and Associated Activities (Attachment 4).

The storm drain hydrojetting and dewatering process generated an estimated 126 cubic yards (13 LLRW bins) of polymer-stabilized sediment (Table 3-4). The prepared bins were then transferred to the USAJMC contractor for off-site disposal as LLRW. Section 3.11 summarizes the waste disposal activities performed during the TCRA, and the LLRW reports are provided in Appendix W.

Accumulated water in the annular space of the dewatering boxes was pumped to nearby wastewater storage tanks within the RCA. The water from each of the holding tanks was sampled and analyzed for chemicals and radionuclides. As described in Section 3.6, the wastewater was subsequently discharged to the sanitary sewer in conformance with the King County Wastewater Treatment Division, Industrial Waste Program Letter of Authorization #11515. Copies of the wastewater analytical results and the Letter of Authorization are provided in Appendix M.

5.7 ADDITIONAL STORM DRAIN SYSTEM SEDIMENT

At the request of the DON, sediment samples were collected during the TCRA activities from MH-115 and a CB adjacent to Building 12. Located near the northeast corner of Building 2 (Figure 5-3), MH-115 was part of the storm drain system that received flow from the Building 2 former radium room sink. Analysis of sediment collected from the drain line upstream of MH-115 identified the presence of Ra-226 at 4.133 pCi/g, which exceeds the release criterion. Two sediment samples (11-INV-SU05-MH-001 and -002) were collected from MH-115 and submitted to the ELAP-accredited laboratories for analysis by gamma spectroscopy and total strontium. The analytical results did not identify the presence of ROC concentrations above the release criteria. The maximum Ra-226, Cs-137, and total strontium results for sample these samples were 0.4176 pCi/g, 0.06359 pCi/g, and -0.0975 pCi/g, respectively. The portion of the drain line located upstream of MH 115 and outside of Building 2 was either removed, or removed and replaced, as part of soil SU-05 or SU-11. The soil survey activities for SU-05 and SU-11 are described in Section 5.5. The laboratory analytical reports are provided in Appendix S.

One sediment sample was collected during the TCRA activities from a CB located near the northeast corner of Building 12 due to its proximity to HS-04 (SU-07) (Figure 5-3). The soil survey activities for SU-07 are described in Section 5.5.2.1. This sediment sample (11-INV-B12CB-001) was submitted to the laboratories for analysis by gamma spectroscopy and total strontium. The analytical results of the ROCs showed concentrations were below the release criteria. The Ra-226, Cs-137, and total strontium results for this sample were 0.6347 pCi/g, 0.1807 pCi/g, and 0.114 pCi/g, respectively. The laboratory analytical reports are provided in Appendix S.

5.8 ELECTRICAL SYSTEM UPGRADE SURVEYS

During the TCRA fieldwork, a contractor working for Seattle Parks and Recreation was upgrading the underground high-voltage electrical system. The upgrade work required that the contractor excavate or otherwise perform work in proximity to areas of known radiological contamination within the TCRA RCA that had been established along the west side of Building 27. Other electrical upgrade work was located in areas where radiological contamination potentially existed based on historical operations. In these circumstances. TtEC, under contract with the DON, performed sampling and/or survey activities in the electrical contractor excavations and other areas to assess the presence or absence of elevated ROC concentrations.

Survey activities were performed by TtEC staff on 24 April 2014 in a trench excavation located west of Building 27. The electrical system upgrade excavation activities had exposed the top of a 36-inch-diameter storm drain line suspected of containing elevated levels of Ra-226. The survey activities consisted of collecting gamma static measurements on top and to each side (east and west) of the storm drain line. Each gamma static measurement was below the investigation level. Three soil samples were also collected at the approximate locations of the static measurements and submitted to the laboratory for analysis by gamma spectroscopy. The samples collected from each side of the pipe were collected from a depth of approximately 1.5 feet to 2 feet below the trench bottom. None of the analytical results for the three soil samples identified the presence of ROC concentrations above the release criteria (Table 2-2). The survey and sample analytical results are included in Appendix T.

Survey activities were performed by TtEC staff inside and on the upper surfaces of an electrical manhole located near the southwest corner of Building 27. The survey activities consisted of one gamma static measurement collected inside the manhole, two alpha/beta static/swipe samples collected on the underside of the manhole lid, and two alpha/beta static/swipe measurements taken on the embedded frame that supported the lid. The gamma static measurement result was below the investigation level and none of the alpha/beta static/swipe measurements exceeded the TCRA release criteria (Table 2-2). The survey results are included in Appendix T.

During the electrical upgrade activities, the contractor excavated a trench and stockpiled the soil in an area west of Building 11 that likely had been formerly used as a sludge drying area as part of sewage treatment plant formerly located in this area. TtEC collected six soil samples from the excavation and two soil samples from the stockpiled soil. The soil samples were collected on 19 June 2014 and submitted to the laboratories for gamma spectroscopy analysis and total strontium. None of the analytical results for the eight soil samples identified the presence of ROC concentrations above the release criteria (Table 2-2). The analytical results and a figure showing the location of the historical sludge drying beds are included in Appendix T.

6.0 SITE RESTORATION

Site restoration and storm drain system installation activities were performed following completion of the TCRA activities. Restoration efforts were initiated for the project site after receiving the RASO's concurrence that the results of the surveys and soil sample analytical results had confirmed that no residual ROC concentrations exceeded the release criteria. The excavated project site areas were backfilled using clean imported material. These materials included common borrow (unprocessed naturally occurring soil or gravel that is free of deleterious material), quarry spalls (2-inch to 4-inch stone), drain rock (pipe bedding), and 1.25-inch minus crushed gravel. Topsoil was used as the surface layer in those areas to be revegetated. The common borrow and topsoil sources were verified to be clean through laboratory analysis, as specified in the SAP and the Work Plan (Attachment 5). Due to the large particle size of the remaining imported materials, laboratory analysis of these materials was not performed. The following sections describe the site restoration and storm drain system installation activities.

6.1 STORM DRAIN SYSTEM INSTALLATION

Two new storm drain systems were installed adjacent to Building 27: one south of the building and one west of the building. These systems replaced storm drain system components that were removed during the TCRA remediation efforts. Figure 6-1 identifies the locations of the new storm drain systems and shows the applicable Washington State Department of Transportation (WSDOT) Standard Plan specification for the components comprising the new systems (i.e., pipe, catch basins, frames, and grates). A new section of storm drain pipe was also installed near the northeast corner of Building 2 to replace a pipe section that was removed, as shown on Figure 6-2.

Shallow groundwater caused soil in some excavated storm drain trenches to be saturated and correspondingly unstable. Consequently, those excavations where storm drain system installation activities were to be performed were first stabilized using a packed layer of coarse angular aggregate, as necessary. Aggregate used to bed and surround the new pipe was non-moisture-sensitive, round aggregate having minimal fines. The addition of this aggregate material stabilized the pipe in place with little or no compaction required. A minimum of 6 inches of aggregate bedding material was placed above and below the pipes during installation.

Above the pipe aggregate bedding, the backfill material type used varied depending on location. For the new storm drain line installed south of Building 27, crushed gravel was placed in the excavation to the ground surface level and graded in place to promote drainage to the newly installed CBs. For the new storm drain line installed west of Building 27, controlled-density fill (a lean sand-cement mixture) was used as the primary fill material in the northern portion of the trench. In this area, approximately 4 inches of crushed gravel was compacted over the controlled-density fill to prepare the area for pavement restoration. The southern portion of the trench, which was situated within an unpaved area, was backfilled with common borrow. The excavation for the new storm drain pipe near the northeast corner of Building 2 was also backfilled with common borrow.

Two sections of the storm drain system were removed, but not replaced: one section was located southwest of Building 27 (Figure 6-1) and one was located east of Building 2 (Figure 6-2). As a result of the TCRA, these storm drain lines were no longer necessary, and were eliminated. The trench east of Building 2 was backfilled with common borrow, followed by approximately 4 inches of crushed gravel. The material was compacted over the common borrow to prepare the area for subsequent pavement restoration. For the trench southwest of Building 27, the shallow eastern portion of the trench was backfilled with crushed rock. Due to trench depth and saturated unstable ground conditions, the western portion of the trench was backfilled with quarry spalls to within 2 feet of the pavement subgrade. The remainder of the trench was backfilled with crushed gravel in 1-foot lifts. Field density testing was performed on the crushed gravel in accordance with ASTM D6938-15 (ASTM 2008) since this portion of the trench was in an area subject to vehicular traffic. The field density test results are provided in Appendix U.

6.2 SOIL REMEDIATION AREAS

Soil remediation excavations in unpaved, non-traffic areas south and west of Building 27 were generally backfilled using common borrow. Common borrow was also used to shape and improve the original condition of the slopes adjacent to Building 27. Excess quarry spalls used to stabilize the ground surface around Building 27 during construction were buried beneath the common borrow along the slopes adjacent to the structure. Excavations in paved areas west of Building 27 and in the vicinity of Building 12 were backfilled with crushed gravel, which was compacted in preparation for pavement restoration. Remediation of HSs in the grassy areas at the south end of Building 2 were also backfilled with common borrow. The common borrow backfill material is described in Section 5.2.3 and the laboratory analytical results are provided in Table 5-1. The common borrow backfill material laboratory analytical reports are provided in Appendix Q.

6.3 GROUND SURFACE FEATURES

In general, the final site restoration grades were prepared to blend with surrounding grades and substantially match surface conditions that existed prior to disturbing the area. However, some grade and contour changes were warranted in non-traffic areas adjacent to Building 27 to ensure proper drainage, reduce the potential for erosion, and improve the appearance of the areas. Areas that were vegetated prior to the TCRA activities were restored with topsoil and grass seed. Straw matting was installed in those areas where erosion was a potential concern.

Areas that were asphalt-paved prior to the TCRA were restored with a minimum of 3 inches of WSDOT Class B hot mix asphalt concrete over a prepared crushed gravel base. The surrounding pavement was prepared for paving by saw-cutting the material to remove the ragged edges. An asphalt tack coat was then applied to the edges of the existing pavement and the joints between existing and new asphalt concrete pavement sections were sealed with an asphalt emulsion. Areas in the concrete tarmac were restored using unreinforced concrete to match the thickness of the adjoining tarmac section.

6.4 BUILDING 27 SOUTH WALL AND STAIR TOWERS

As described in Section 2.5.11, NAVSTA PS was divided into two historic districts: the Sand Point Historic District and the Naval Air Station Seattle National Register of Historic Places District. Building 27 was listed as a contributing structure in both districts. In preparation for the TCRA, the DON contacted the SHPO and requested SHPO concurrence with its finding that the TCRA would have an adverse effect on historic properties, further requesting initiation of consultation in the preparation of a Memorandum of Agreement to address the adverse effects. Relative to the planned actions at Building 27, SHPO responding that, in its opinion, demolition of the South Shed would have ‘no adverse effect’ on Building 27. However, this determination opinion was only valid if the south end wall was treated appropriately to meet the Secretary of the Interior’s Standards.

Following SHPO’s determination, TtEC prepared a LPB Certificate of Approval application proposing the demolition of the South Shed and detailing plans for restoring the Building 27 south wall and stair towers to meet Historic Preservation Act requirements. TtEC and the DON presented the proposed plan at a meeting with the LPB’s architectural committee on October 31, 2014. Based on the committee’s review, the proposal was forwarded for board review. TtEC and the DON presented the proposal to the board on November 19, 2014, at which time the application was approved. The Certificate of Approval application and LPB approval letter are included in Appendix H.

Key elements of the Building 27 restoration project included:

- Installing wood blocking and lag screws on the second floor and roof levels of the former South Shed to secure the common wall to the structural timber members inside the Building 27 hangar
- Installing wood framing in wall openings to be abandoned
- Installing steel reinforcement and placing concrete to close off unneeded openings in the common stem wall, and restoring the stem wall on the south face of the southeast stair tower, which was removed during construction of the South Shed

- Constructing new wall framing between the top of the stem walls and the third floor on the south and west faces of the southeast stair tower
- Installing poly sheeting at the exterior face of the wall framing
- Installing plywood sheathing and a moisture barrier
- Installing corrugated metal siding and trim
- Extending existing polyvinyl chloride (PVC) downspouts to the ground level
- Installing a subsurface piping system to collect water from the downspouts and direct it to the nearby storm drain system (Figure 6-1)

The Building 27 stair tower landings are constructed of concrete and the stairs between the landings consist of steel framing and abrasive metal treads. Abrasive treads are also embedded along the edge of each concrete landing. Surveys performed during the TCRA identified ROC concentrations above the release criteria on the stairs and landings on all levels of the towers, which were remediated using mechanical abrasion. Because attempts to address contamination using mechanical abrasion on the stair treads were unsuccessful, all stair treads were removed and replaced with new abrasive treads. The removed stair treads were placed in LLRW bins and transferred to the USAJMC contractor for off-site disposal.

6.5 MONITORING WELL REPAIR

Flush-mounted monitoring well MW-10 is located on the east side of Building 2 in an area that was excavated during the TCRA activities to remove a radiologically impacted storm drain line associated with the former Radium Room sink in Building 2. Removal activities associated with this impacted storm drain line are discussed in Section 5.5 and addressed in the Final Status Survey Report for Areas Associated with Buildings 2, 12, and 27 (Attachment 3).

Although the MW-10 riser and grout seal remained intact following excavation of the storm drain line, the well cover and annular bentonite fill above the level of the grout seal were disturbed during fieldwork. In conjunction with backfilling the trench after removing the impacted storm drain line, an 8-inch-diameter PVC sleeve was installed over the riser pipe. The annular space was backfilled with bentonite chips and the watertight cover was secured in place with concrete. The MW-10 repair report is provided in Appendix V.

6.6 FINAL FIELD INSPECTION

Representatives from NAVFAC NW performed the final inspections of the NAVSTA PS project site on 26 April 2015 and 5 May 2015. A final site walk was conducted with representatives from NAVFAC NW and Seattle Parks and Recreation on 12 May 2015. A copy of the final inspection report is provided in Appendix W. As described in Section 3.12, demobilization from the NAVSTA PS project site occurred in July 2015.

7.0 CONCLUSIONS AND RECOMMENDATION

This AAR was prepared to describe and summarize the results of the TCRA performed for Building 2, Building 27, and areas associated with Buildings 2, 12, and 27, and the storm drain cleaning activities that were conducted to support the NAVSTA PS project site. This TCRA was performed to protect the public health and welfare and the environment from actual or potential releases of radiologic contaminants. The DON with the support of the RASO provided project oversight during the removal action activities. The TCRA was conducted in accordance with the DON's Environmental Restoration Program using the CERCLA process. Regulatory oversight was provided by the Washington State Department of Ecology, as the lead regulatory agency, and the WDOH. The TCRA activities followed the substantive requirements of CERCLA and the NCP.

7.1 CONCLUSIONS

7.1.1 Building 2

Several iterations of remediation of contaminated materials were performed in Building 27, followed by remedial action support surveys, biased surveys, and the FSS. Alpha/beta and gamma scans were conducted on 100 percent of the accessible surfaces in the Class 1 SUs and 50 percent of the accessible surfaces in the Class 2 SUs in Building 2. In addition, complete sets of 20 alpha and beta static measurements were recorded in each Class 1 and Class 2 SU. None of the systematic FSS static measurements exceeded the release criteria.

The intent of the survey was to achieve unrestricted release for Building 2. The survey results were statistically analyzed using the WRS test to determine whether residual radioactivity was present and whether conditions within the SUs met the release criteria for unrestricted use. The criteria for unrestricted release of building surfaces were the limits specified for Cs-137, Ra-226, and Sr-90 in AEC Regulatory Guide 1.86 (AEC 1974). The criterion for unrestricted release of soil was based on dose modeling at 15 mrem/year. To accomplish this goal, it was necessary to provide a means for calculating residual dose to the critical group. However, the residual net mean surface area concentrations for both alpha and beta for Building 2 hard surfaces were less than zero in all SUs. Therefore, modeling for dose was unnecessary, as the net residual dose above background levels was essentially zero. Consequently, no increased annual dose above background levels is anticipated, and the 15 mrem/y dose limit specified in the Action Memorandum, and the 12 mrem/y updated EPA guidance value (EPA 2014) for what is considered a protective dose for unrestricted release, has been achieved. Based on these results, the DON recommended Building 2 for unrestricted release.

WDOH performed verification surveys in Building 2 in June 2014. The results of the verification surveys indicated that all survey data were below regulatory limits set in the "average acceptable contamination levels." In a letter dated 27 January 2015, the WDOH Office of Radiation Protection released Building 2 for unrestricted use. A copy of this letter is provided as Appendix O.

Hydrojetting was employed to clean the interior of the Reach 1 collector line in which analysis confirmed the presence of Ra-226 exceeding the release criterion. The interior of the pipe was then video inspected to verify that all visible sediment had been remove and assess the physical condition of the pipe. The video inspection identified no notable defects that indicated contaminants had been released into the surrounding soil. Gamma scan readings collected from the Reach 1 collector following the hydrojetting activities did not identify any results above the investigation criteria for each material type encountered. Based on the video inspection and gamma scan results, no further action was deemed necessary.

7.1.2 Building 27 South Shed

Several iterations of remediation of contaminated materials were performed in Building 27, followed by remedial action support surveys, biased surveys, and the FSS. The survey results were statistically analyzed using the WRS test to determine whether residual radioactivity was present and whether conditions within the SUs met the release criteria for unrestricted use. The criteria for unrestricted release of building surfaces were the limits specified for Cs-137, Ra-226, and Sr-90 in AEC Regulatory Guide 1.86 (AEC 1974). The criterion for unrestricted release of soil was based on dose modeling at 15 mrem/year. No increased annual dose above background levels was detected in any SU. Based on these results, the DON recommended Building 27 for unrestricted release.

The WDOH verification surveys performed in December 2014 for Building 27 confirmed that the remediated and resurveyed areas on the South Shed common north wall, the southeast and southwest stair towers, and the northern half of the eastern and western wall surfaces were all below the release criteria. The WDOH's 27 January 2015 letter released the South Shed common north wall, the east and west walls, the southeast and southwest stair towers, the roof, and the south wall (1.5 feet above the second floor boundary above the cubbies) for unrestricted use. In addition, the WDOH concurred that the remainder of the south wall should be disposed of as LLRW.

Deconstruction of the Building 27 South Shed began on 27 January 2015 and was completed on 27 February 2015. Following deconstruction of the South Shed, the ground floor concrete slab and interior concrete stem wall surfaces were surveyed as Class 1 SUs. The surveys identified only one localized area of net alpha/beta contamination (less than 100 cm^2). This area was remediated and resurveyed. None of the post-remediation static or loose contamination measurements indicated the presence of activity above the TCRA release criteria.

7.1.3 Areas Associated with Buildings 2, 12, and 27

GWSs, surveys, and sampling were performed in the areas surrounding Buildings 2, 12, and 27. Remedial actions for were performed to remove contaminated soil in the vicinity of Buildings 2, 12, and 27 and storm drains and CBs associated with Buildings 2 (east side) and 27 (south and west sides). FSS activities were performed for 13 SUs, including HS-07 and none of the systematic sample results indicated the presences of ROCs above the release criteria. Based on these results, each of the 13 SUs was backfilled and the area restored.

Dose modeling using RESRAD revealed that the potential dose of SU-01 through SU-12 and HS-07 was less than the release criterion of 15 mrem/y TEDE, as specified in the Action Memorandum, and the 12 mrem/y updated EPA guidance value (EPA 2014) for what is considered a protective dose. A maximum SU net residual dose of 1.973 mrem/y was calculated for SU-12. A maximum backfill material net residual dose of 7.039 mrem/y was calculated for SU-03. The results of the dose modeling support free release.

7.1.4 Storm Drain Line Cleaning and Associated Activities

The analysis of sediment samples collected from MHs during the RI identified the presence of Ra-226 at concentrations exceeding the TCRA release criterion in the 36-inch-diameter storm drain line located west of Building 27. In addition, localized areas of elevated gamma activity were identified in the 24-inch-diameter storm drain that passes beneath Building 27. Once the storm drains had been cleaned, they were inspected and gamma scan surveyed. None of the mean plus 3 σ exceedances identified during the scan survey were clustered in a manner that would indicate the likely presence of contamination. Based on an evaluation of the inspection and gamma scan results, eight locations were selected for the collection of soil cores immediately adjacent to the storm drain lines. Ten samples were collected from seven of the sites and analyzed for the ROCs. None of the analytical results identified the presence of ROCs above the project release criteria.

7.2 RECOMMENDATION

The TCRA at the Former NAVSTA PS project site was conducted in accordance with the DON's Environmental Restoration Program using the process identified in CERCLA (as amended by SARA). The TCRA activities followed the substantive requirements of CERCLA and the NCP. TtEC performed the radiological material TCRA activities under WDOH-issued RML WN-L0244-1. This AAR documents the radiological materials TCRA tasks identified in the scope of work completed under Contract No. N62473-10-D-0809 and CTO No. 0011 for BRAC under NAVFAC NW.

The RAOs for the former NAVSTA PS project site established in the Action Memorandum (DON 2013) for the TCRA were achieved, including:

- Provide protection of human health and the environment through the removal of soil contaminated with concentrations of Ra-226, Cs-137, and/or Sr-90 exceeding the project release criteria.
- Provide protection of human health and the environment through the removal/ replacement of storm drain lines or CBs containing sludge contaminated with concentrations of Ra-226, Cs-137, and/or Sr-90 exceeding the project release criteria.
- Provide protection of human health through the removal of impacted building materials and equipment with known radiological contamination exceeding the project release criteria.
- Dispose of non-LLRW in a permitted landfill and LLRW in a licensed LLRW waste disposal facility.

WDOH performed verification surveys in Building 2 that identified no further radiological contamination. Based on the remediation efforts, biased survey and FSS results, and deconstruction of the Building 27 South Shed, no further radiological contamination was identified in association with Building 27. Demolition of the south wall was completed during deconstruction of the South Shed, and the demolition debris was placed in LLRW bins and disposed of off-site. The information and data presented in this AAR, and each of the three FSS reports, the results of the storm drain hydrojetting process, and the dose modeling results confirm that the TCRA resulted in a reduction of the potential dose to levels below the RAOs, and no further action is required. In a letter dated 27 January 2015, the WDOH Office of Radiation Protection released Buildings 2 and 27 for unrestricted use.

8.0 REFERENCES

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. Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments in Support of Decommissioning. E 1893–97.

—————. 2008. Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth). D6938-15.

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. August.

DON (Department of the Navy). 2013. Final Action Memorandum, Time-Critical Removal Action, Former Naval Station Puget Sound, Seattle, Washington. May 24.

EPA (Environmental Protection Agency). 2014. Distribution of the Radiation Risk Assessment at CERCLA Sites: Q&A. Publication Number OSWER 9285.6-20.

—————. 2014. CAP88-PC Version 4.0. EPA 402-R-14-004. U. S. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington DC. September.

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.

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, 1st edition.

Kocher, D.C., 1981. Radioactive Decay Data Tables: A Handbook of Decay Data for Application to Radiation Dosimetry and Radiological Assessments. Technical Information Center, U.S. Department of Energy.

NCRP (National Council on Radiation Protection and Measurements). 1993. The National Council on Radiation Protection and Measurements, Report Number 116.

NRC (Nuclear Regulatory Commission). 1997. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. NUREG/CR-1507 Final.

——————. 1998. A Nonparametric Statistical Methodology for the Design and Analysis of the Final Status Decommissioning Survey. NUREG-1505. Rev. 1.

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

TtEC (Tetra Tech EC, Inc.). 2013a. Final Task-specific Plan for the Buildings 2 and 27 Remedial Action Support and Final Status Surveys. Radiological Materials Time-Critical Removal Action at Former Naval Station Puget Sound, Seattle, Washington. July.

——————. 2013b. Final Task-specific Plan for the Buildings 2, 12, and 27 Soil/Storm Drain Remediation and Final Status Surveys. Radiological Materials Time-Critical Removal Action at Former Naval Station Puget Sound, Seattle, Washington. July.

__________. 2013c. Accident Prevention Plan/Site Safety and Health Plan, Radiological Materials Time-Critical Removal Action. Former Naval Station Puget Sound, Seattle, WA. July.

——————. 2014. Final Work Instruction for Storm Drain Cleaning and Associated Activities. Former Naval Station Puget Sound. October.

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

USACE (U.S. Army Corps of Engineers). 2008. Health and Safety Requirements Manual EM385-1-1. September 15.

Wallo, A., M. Moscovitch, J.E. Rodgers, D. Duffey, and C. Soares. 1994. Investigations of Natural Variations of Cesium-137 Concentrations in Residential Soils. The Health Physics Society 39th Annual Meeting, June 28. McLean, Virginia: The Health Physics Society.

Yu, C., et al. 2010. User's Manual for RESRAD-BUILD Version 3.5. ANL/EAD/03-1Argonne National Laboratory, Argonne, IL. February 25.

———————. 2014. User's Manual for RESRAD Version 7. ANL/EAD-4, Argonne National Laboratory, Argonne, IL. February 25.

This page intentionally left blank.

TABLES

This page intentionally left blank.

TABLE 2-1
RADIONUCLIDES OF CONCERN

Radionuclide	Half-life[a]	Radiations
Cesium-137	30.17 years	Beta/gamma (β^-,γ)
Radium-226	1,600 years	Alpha/gamma (α,γ)
Strontium-90	28.6 years	Beta (β^-)

Notes:

[a] Half-life values were obtained from Table 2-1 of the TSP for the Building 2 and 27 Remedial Action Support and FSS and Table 2-1 of the TSP for the Buildings 2, 12 and 27 Soil/Storm Drain Remediation and FSS.

Abbreviations and Acronyms:
FSS – Final Status Surveys
TSP – Task-specific Plan

This page intentionally left blank.

TABLE 2-2
RELEASE CRITERIA FOR RADIONUCLIDES OF CONCERN[a]

Radionuclide	Structures Total Surface Activity Release Criteria[b] (dpm/100 cm^2)	Dose (mrem/y)	Soil/Sediment Release Criteria[c] (pCi/g)
Cesium-137	5,000	1.64	25.63
Radium-226	100	1.71	1.41
Strontium-90	1,000	0.685	9.46

Notes:

[a] Based on Final Action Memorandum Time-Critical Removal Action, Former Naval Station Puget Sound, dated 24 May 2013.

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

[c] Release criterion for soil/sediment is the summation of the dose-based concentration guideline (15 mrem/year) and the reference area sample mean background.

Abbreviations and Acronyms:

cm^2 – square centimeter
dpm – disintegrations per minute
mrem/y – millirem per year
pCi/g – picocuries per gram

This page intentionally left blank.

TABLE 3-1
REFERENCE AREA SOIL MEASUREMENTS[a]

Sample ID	Collection Date and Time	Radium-226 Activity[b] (pCi/g)	Cesium-137 Activity (pCi/g)	Total Strontium Activity (pCi/g)	Thorium-232 Activity[c] (pCi/g)
11-BG-001	7/30/2013 11:32	0.3895	0.003562	0.053	0.3258
11-BG-002	7/30/2013 11:40	0.3698	-0.0005979	-0.0185	0.1581
11-BG-003	7/30/2013 11:59	0.4009	-0.008669	-0.00813	0.4018
11-BG-004	7/30/2013 12:04	0.3446	0.03852	0.0728	0.3812
11-BG-005	7/30/2013 11:49	0.2978	0.002707	-0.0293	0.3157
11-BG-006	7/30/2013 12:27	0.2761	-0.00007457	-0.000655	0.4333
11-BG-007	7/30/2013 12:33	0.2271	-0.005661	0.0978	0.2786
11-BG-008	7/30/2013 12:37	0.3322	-0.009737	0.0153	0.3487
11-BG-009	7/30/2013 12:42	0.4344	0.007256	0.0243	0.4747
11-BG-010	7/30/2013 12:48	0.3379	-0.005186	-0.0609	0.3584
11-BG-011	7/30/2013 12:53	0.3171	0.001231	0.0444	0.2476
11-BG-012	7/30/2013 12:59	0.3585	0.0193	-0.0568	0.4767
11-BG-013	7/30/2013 13:11	0.4013	-0.003857	0.0309	0.3563
11-BG-014	7/30/2013 13:15	0.3606	-0.00002396	0.0249	0.3492
11-BG-015	7/30/2013 13:20	0.3253	0.003744	-0.00553	0.4211
11-BG-016	7/30/2013 13:25	0.3143	0.01155	0.00533	0.4366
11-BG-017	7/30/2013 13:28	0.3649	0.0006586	0.0515	0.3737
11-BG-018	7/30/2013 13:33	0.2821	-0.007076	-0.00172	0.397
11-BG-019	7/30/2013 13:34	0.323	0.008261	-0.0247	0.2416
11-BG-020	7/30/2013 13:39	0.2829	-0.006593	-0.0158	0.2894
Reference Area Sample Average:		0.337	0.0025	0.0099	0.3533
Dose-Based Guideline (pCi/g):		1.07	25.63	9.45	NA
Total (pCi/g):		1.41	25.63	9.46	0.35

Notes:

[a] Reference area location for soil background is located southeast of Building 27 and north of NE NOAA Drive.

[b] By bismuth-214

[c] By actinium-228. Thorium-232 was not selected as a radionuclide of concern for the time-critical removal action.

Abbreviations and Acronyms:

ID – identification

pCi/g – picocuries per gram

This page intentionally left blank.

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

Building	Survey Unit	Class	Surface Area (m^2)	Biased/Investigative Survey Results: Total Static/Swipe Locations	Biased/Investigative: Alpha Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative: Alpha Maximum Swipe Measurement (dpm/100 cm^2)	Biased/Investigative: Beta Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative: Beta Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Survey Results: Total Static/Swipe Locations	Final Status: Alpha Net Mean Static Measurement (dpm/100 cm^2)	Final Status: Alpha Maximum Swipe Measurement (dpm/100 cm^2)	Final Status: Beta Net Mean Static Measurement (dpm/100 cm^2)	Final Status: Beta Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
2	SU-01	1	89.4	243	45.29	6.09	208.99	73.44	20	-9.28	2.80	-194.49	73.40	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
2	SU-02	2	27	15	-3.67	3.26	-85.53	63.86	20	-10.04	3.30	-253.12	63.90	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
2	SU-03	1	52.8	112	15.91	5.88	140.60	67.32	20	-10.72	3.00	-173.93	67.30	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
2	SU-04	1	86	365	671.98	6.31	10,714.10	71.58	20	-6.95	-0.40	-326.98	61.20	Multiple rounds of remediation were performed prior to conducing the FSS	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

Building	Survey Unit	Class	Surface Area (m^2)	Biased/Investigative Survey Results: Total Static/Swipe Locations	Biased/Investigative: Alpha Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative: Alpha Maximum Swipe Measurement (dpm/100 cm^2)	Biased/Investigative: Beta Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative: Beta Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Survey Results: Total Static/Swipe Locations	Final Status: Alpha Net Mean Static Measurement (dpm/100 cm^2)	Final Status: Alpha Maximum Swipe Measurement (dpm/100 cm^2)	Final Status: Beta Net Mean Static Measurement (dpm/100 cm^2)	Final Status: Beta Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
2	SU-05	1	91.4	204	1,181.17	6.09	1,840.24	75.57	20	-6.32	6.10	-383.28	57.20	Multiple rounds of remediation were performed prior to conducing the FSS	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
2	SU-06	1	94.1	243	422.28	6.53	709.58	63.38	20	-8.25	2.80	-350.32	53.20	Multiple rounds of remediation were performed prior to conducing the FSS	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
2	SU-07	1	98.94	75	30.60	6.09	-13.49	65.72	20	-10.83	6.10	-335.96	56.70	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
2	SU-08	2	71.17	44	40.39	6.31	-16.23	68.12	20	-6.61	6.30	-271.36	48.20	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels is anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

Building	Survey Unit	Class	Surface Area (m^2)	Biased/Investigative Survey Results: Total Static/Swipe Locations	Biased/Investigative Alpha: Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Biased/Investigative Beta: Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Survey Results: Total Static/Swipe Locations	Final Status Alpha: Net Mean Static Measurement (dpm/100 cm^2)	Final Status Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Beta: Net Mean Static Measurement (dpm/100 cm^2)	Final Status Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
27	SU-01	1	93.98	4	-3.67	2.83	5,245.90	73.70	10	-9.30	-0.20	-120.00	73.70	Remediation was performed prior to conducting the FSS	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-02	1	93.9	29	24.48	6.53	249.11	84.08	20	-6.85	3.00	-97.38	61.70	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-03	1	93.87	5	4.90	3.26	88.63	89.67	20	-7.34	3.00	-37.38	89.70	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-04	1	74.89	1	4.90	2.83	-130.21	52.15	20	-8.14	2.80	-140.69	52.20	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

Building	Survey Unit	Class	Surface Area (m^2)	Biased/Investigative Survey Results: Total Static/Swipe Locations	Biased/Investigative Alpha: Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Biased/Investigative Beta: Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Survey Results: Total Static/Swipe Locations	Final Status Alpha: Net Mean Static Measurement (dpm/100 cm^2)	Final Status Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Beta: Net Mean Static Measurement (dpm/100 cm^2)	Final Status Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
27	SU-05	1	70.23	170	440.65	13.47	5,173.68	123.73	20	-9.38	-0.20	74.21	123.70	Multiple rounds of remediation were performed prior to conducing the FSS	0.026
27	SU-06	1	60.72	108	259.98	19.32	5,345.43	72.12	20	-5.39	3.00	125.28	63.90	Multiple rounds of remediation were performed prior to conducing the FSS	0.0428
27	SU-07	1	67.46	8	0.98	30.50	48.51	63.06	20	-12.34	2.80	-73.23	63.10	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-08	1	72.28	381	5,581.99	9.36	42,589.98	95.79	20	-6.54	3.00	-156.82	69.40	Multiple rounds of remediation were performed prior to conducing the FSS	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-09	1	70.12	73	756.23	9.36	35,248.69	93.39	20	2.89	3.00	19.51	93.40	Multiple rounds of remediation were performed prior to conducing the FSS	0.0294

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

Building	Survey Unit	Class	Surface Area (m^2)	Biased/Investigative Survey Results: Total Static/Swipe Locations	Biased/Investigative Alpha: Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Biased/Investigative Beta: Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Survey Results: Total Static/Swipe Locations	Final Status Alpha: Net Mean Static Measurement (dpm/100 cm^2)	Final Status Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Beta: Net Mean Static Measurement (dpm/100 cm^2)	Final Status Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
27	SU-10	1	99.96	1	-13.46	6.09	-413.79	36.72	20	-11.51	6.10	-240.17	36.70	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-11	1	99.96	3	6.12	2.83	-348.13	34.86	20	-8.57	2.80	-222.67	32.70	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-12	1	99.96	2	-18.36	2.83	-450.26	32.73	20	-10.77	2.80	-227.04	32.70	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-13	1	93.51	0	NA	NA	NA	NA	20	-12.00	2.83	-272.27	28.74	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

Building	Survey Unit	Class	Surface Area (m^2)	Biased/Investigative Survey Results: Total Static/Swipe Locations	Biased/Investigative: Alpha Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative: Alpha Maximum Swipe Measurement (dpm/100 cm^2)	Biased/Investigative: Beta Maximum Static Measurement (dpm/100 cm^2)	Biased/Investigative: Beta Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Survey Results: Total Static/Swipe Locations	Final Status: Alpha Net Mean Static Measurement (dpm/100 cm^2)	Final Status: Alpha Maximum Swipe Measurement (dpm/100 cm^2)	Final Status: Beta Net Mean Static Measurement (dpm/100 cm^2)	Final Status: Beta Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
27	SU-14	1	47.28	237	1,665.07	84.31	1,593.60	192.09	27	11.21	5.10	-129.31	93.00	Multiple rounds of remediation were performed prior to conducting the FSS	0.086
27	SU-15	1	83.12	5	-8.57	3.05	-329.90	47.36	20	-12.73	2.80	-417.61	47.40	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-16	1	30.96	0	NA	NA	NA	NA	20	-3.43	3.26	-200.60	47.63	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-17	1	77.09	40	20.07	3.26	4,760.26	65.19	20	-2.20	3.30	78.23	49.20	Remediation was performed prior to conducting the FSS	0.0278
27	SU-18	1	100.00	29	152.27	3.26	12,795.25	67.05	20	5.39	3.30	-257.32	27.70	Remediation was performed prior to conducting the FSS	0.0429

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

				Biased/Investigative Survey Results					Final Status Survey Results						
					Alpha		Beta			Alpha		Beta			
Building	Survey Unit	Class	Surface Area (m^2)	Total Static/Swipe Locations	Maximum Static Measurement (dpm/100 cm^2)	Maximum Swipe Measurement (dpm/100 cm^2)	Maximum Static Measurement (dpm/100 cm^2)	Maximum Swipe Measurement (dpm/100 cm^2)	Total Static/Swipe Locations	Net Mean Static Measurement (dpm/100 cm^2)	Maximum Swipe Measurement (dpm/100 cm^2)	Net Mean Static Measurement (dpm/100 cm^2)	Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
27	SU-19	2	932.37	19	11.02	6.31	-119.81	94.99	20	-2.75	6.10	-330.44	19.20	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-21	1	59.5	34	55.08	9.58	12.95	74.50	20	-1.22	6.10	-340.84	46.80	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-22	1	48	769	853.58	43.33	1,775.73	114.20	27	-0.10	4.70	-179.97	49.00	Remediation was performed prior to conducting the FSS	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-23	2	214.12	210	63.57	11.12	398.15	70.68	27	-4.34	4.70	-245.33	45.40	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.

TABLE 3-2
BUILDING SURVEY UNIT DATA SUMMARY

Building	Survey Unit	Class	Surface Area (m^2)	Biased/Investigative Survey Results: Total Static/Swipe Locations	Alpha: Maximum Static Measurement (dpm/100 cm^2)	Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Beta: Maximum Static Measurement (dpm/100 cm^2)	Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Final Status Survey Results: Total Static/Swipe Locations	Alpha: Net Mean Static Measurement (dpm/100 cm^2)	Alpha: Maximum Swipe Measurement (dpm/100 cm^2)	Beta: Net Mean Static Measurement (dpm/100 cm^2)	Beta: Maximum Swipe Measurement (dpm/100 cm^2)	Comments	Modeled Net Residual Dose (mrem/y)
27	SU-24	1	55.38	68	89.95	10.54	256.34	75.01	27	-0.91	8.00	-22.99	75.00	NA	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-25	1	62.97	96	221.84	21.47	759.13	85.11	27	-5.23	4.70	-226.37	13.00	Remediation was performed prior to conducting the FSS	Modeling for dose was unnecessary since the residual net mean surface area alpha/beta results were less than zero. No increased annual dose above background levels was anticipated and the 15 mrem/y dose limit criterion for unrestricted release was achieved.
27	SU-26	2	33.9	178	36.77	9.36	400.93	95.26	NA	-0.89	0.06	95.80	2.70	FSS performed in accordance with FCR-12. Refer to Section 4.8.4 for further details.	0.0294
27	SU-27	1	87.04	9	22.74	8.00	116.95	59.14	27	7.01	8.00	-7.37	59.10	NA	0.0554
27	SU-28	1	85.11	17	556.60	5.07	1,634.14	59.14	27	8.78	5.10	44.83	59.10	Remediation was performed prior to conducting the FSS	0.0855
27	SU-29	1	87.15	21	22.74	5.07	53.73	62.75	27	7.01	5.10	75.34	37.50	NA	0.0828
27	SU-30	1	86.94	23	52.40	10.93	160.41	81.26	27	-5.06	5.90	42.45	81.30	NA	0.0154
27	SU-31	1	84.27	13	22.74	5.46	168.31	55.30	27	-7.57	5.50	37.50	55.30	NA	0.0135
27	SU-32	1	85.12	9	17.80	2.54	172.26	44.48	27	-7.57	2.50	113.60	37.30	NA	0.0411
27	SU-33	1	75.07	12	27.68	2.73	168.31	66.11	27	-7.07	2.50	135.25	66.10	NA	0.0479
27	SU-34	1	62.94	11	87.00	2.73	310.55	77.89	27	3.63	2.50	96.11	62.50	NA	0.0613

Abbreviations and Acronyms:
cm^2 – square centimeter
dpm – disintegrations per minute
FSS – Final Status Survey
m^2 – square meter
mrem/y – millirem per year
NA – not applicable

TABLE 3-3
SOIL SURVEY UNIT DATA SUMMARY

							Final Status Survey Soil Sample Analytical Results												Dose Modeling Results	
							Cesium-137				Radium-226				Total Strontium					
Survey Unit	Associated Hotspot	Associated Building or Area	Surface Area (m^2)	Class	Total Soil Samples Collected	Total FSS Soil Samples	Mean (pCi/g)	Standard Deviation (pCi/g)	Median (pCi/g)	Maximum[a] (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Median (pCi/g)	Maximum[a] (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Median (pCi/g)	Maximum[a] (pCi/g)	Industrial Worker Scenario[b] (mrem/y)	Recreational Scenario[b] (mrem/y)
HS-07	HS-07	Building 27	100.30	1	36	16	0.008	0.021	0.003	0.085	0.418	0.092	0.425	0.433	0.024	0.160	-0.029	0.387	6.942	0.106
SU-01	NA	Building 27	114.00	1	18	18	0.006	0.018	-0.001	0.050	0.564	0.214	0.474	0.877	0.042	0.069	0.044	0.149	1.830	0.114
SU-02	NA	Building 27	32.00	1	32	10	-0.002	0.004	-0.002	0.006	0.429	0.071	0.419	0.295	0.115	0.143	0.108	0.315	2.746	0.086
SU-03	NA	Building 27	280.00	1	20	20	-0.001	0.005	0.000	0.009	0.453	0.094	0.431	0.437	-0.016	0.075	-0.018	0.105	7.039	0.117
SU-04	NA	Building 27	42.00	1	10	10	0.011	0.033	0.000	0.104	0.531	0.057	0.534	0.394	0.071	0.069	0.090	0.151	3.390	0.091
SU-05	NA	Building 2	184.00	1	20	20	0.009	0.017	0.002	0.059	0.402	0.060	0.392	0.341	0.050	0.188	0.089	0.423	7.005	0.113
SU-06	HS-01 HS-02	63rd Avenue NE	10.16	1	10	10	0.029	0.060	0.003	0.162	0.408	0.055	0.387	0.269	0.088	0.143	0.094	0.326	1.215	0.061
SU-07	HS-03 HS-04	Building 12	56.96	1	10	10	-0.002	0.006	-0.002	0.005	0.422	0.052	0.432	0.251	0.000	0.125	0.012	0.200	4.327	0.097
SU-08	HS-05 HS-06 HS-08	Building 27	28.61	1	10	10	0.003	0.010	0.002	0.022	0.364	0.060	0.370	0.254	0.003	0.086	0.001	0.130	2.526	0.083
SU-09	HS-10 HS-11 HS-12	Building 27	13.38	1	16	16	-0.003	0.005	-0.004	0.009	0.417	0.054	0.420	0.291	0.021	0.157	0.035	0.255	0.152	0.025
SU-10	NA	Building 27	300.00	1	20	20	0.003	0.016	0.000	0.064	0.471	0.053	0.465	0.324	0.078	0.302	0.154	0.550	1.093	0.074
SU-11	NA	Building 2	124.00	1	19	19	-0.002	0.005	-0.001	0.006	0.350	0.051	0.348	0.211	0.005	0.150	-0.032	0.421	6.962	0.108
SU-12	HS-09	Building 27	47.00	1	25	12	0.020	0.034	0.008	0.117	0.609	0.214	0.581	0.717	-0.088	0.219	-0.122	0.236	1.973	1.134
SU-20	NA	Building 27	17.27	1	10	10	0.000	0.006	0.000	0.008	0.585	0.158	0.540	0.985	-0.033	0.109	-0.007	0.123	0.283	0.086

Notes:
[a] Maximum measurement minus the minimum reference area measurement.
[b] Residual dose of backfilled excavation. Since SU-01, SU-09, SU-10, and SU-12 were not backfilled, the final excavation dose was modeled.

Abbreviations and Acronyms:
FSS – Final Status Survey
m^2 – square meter
mrem/y – millirem per year
pCi/g – picocuries per gram

This page intentionally left blank.

TABLE 3-4
WASTE DISPOSAL SUMMARY

Waste Stream	Estimated Volume	Disposition
Common trash and debris	200 cubic yards	Recology Cleanscapes
Construction debris[a]	100 cubic yards	Recology Cleanscapes
Non-LLRW demolition debris	73.38 tons	Regional Disposal
LLRW debris	245 tons	USAJMC Contractor[b]
LLRW asbestos	18 tons	USAJMC Contractor[b]
Non-LLRW asbestos	25 tons	Chemical Waste Management
LLRW soil/sediment	1,658 tons	USAJMC Contractor[b]
Stormwater (site dewatering)	49,891 gallons	Sanitary Manhole 225
Storm drain hydrojetting water	159,180 gallons	Sanitary Manhole NOAA 1
Concrete debris[a]	60 cubic yards	Recology Cleanscapes
Fluorescent light tubes[a]	0.16 ton	EcoLights Northwest
PCB light ballasts[a]	0.61 ton	EcoLights Northwest
LLRW devices	2 items	USAJMC Contractor[b]
Liquid mercury	< 4 fluid ounces	USAJMC Contractor[b]

Notes:
[a] Recycled material.
[b] Waste was transferred to the U.S. Army Joint Munitions Command contractor for final disposition.

Acronyms and Abbreviations:
LLRW – low-level radioactive waste
PCB – polychlorinated biphenyls
USAJMC – U.S. Army Joint Munitions Command

This page intentionally left blank.

TABLE 5-1
COMMON BORROW BACKFILL SAMPLE RESULTS AND AVERAGE VALUES

Sample ID	Collection Date and Time	Radionuclides of Concern		
		Cs-137 Activity (pCi/g)	Ra-226 Activity (pCi/g)	Total Strontium Activity (pCi/g)
11-BACKFILL-011	8/28/2013	-0.00938	0.5095	0.203
11-BACKFILL-012	8/28/2013	0.0001865	0.603	-
11-BACKFILL-013	8/28/2013	0.008153	0.6009	-
11-BACKFILL-014	8/28/2013	-0.00941	0.5055	-
11-BACKFILL-015	8/28/2013	0.0005416	0.634	-
11-BACKFILL-016	8/28/2013	-0.0007753	0.536	-
11-BACKFILL-017	8/28/2013	-0.006167	0.577	-
11-BACKFILL-018	8/28/2013	0.0002197	0.5022	-
11-BACKFILL-019	8/28/2013	0.007032	0.4383	-
11-BACKFILL-020	8/28/2013	0.002825	0.5763	-
Common Borrow Sample Average:		-0.0007	0.5483	-
Common Borrow Sample St Dev:		0.0061	0.06	-
Common Borrow Sample Median:		0.0002	0.5562	-

Notes:
[a] By bismuth-214
[b] Total Strontium samples were not collected for sample IDs 11-BACKFILL-12 thru -20.

Abbreviations and Acronyms:
Cs-137 – cesium-137
ID - Identification
pCi/g – picocuries per gram
Ra-226 – radium-226
Std Dev – standard deviation

This page intentionally left blank.

TABLE 5-2
SUMMARY LIBRARY FOR GAMMA SPECTROSCOPY ANALYSIS AT THE LABORATORY

Nuclide	Energy	Percent	Half-life		Nuclide	Energy	Percent	Half-life		Nuclide	Energy	Percent	Half-life	
Ac-228	338.4	12.01%	6.13	hr	Cs-137	661.66	84.62%	30.1	y	Pb-214	77.11	10.70%	26.8	min
Ac-228	463	4.40%	6.13	hr	Eu-152	121.78	29.24%	12.7	y	Pb-214	87.2	3.70%	26.8	min
Ac-228	794.95	4.25%	6.13	hr	Eu-152	344.3	27.00%	12.7	y	Pb-214	241.92	7.47%	26.8	min
Ac-228	911.07	29.00%	6.13	hr	Eu-152	411.09	2.26%	12.7	y	Pb-214	295.22	19.20%	26.8	min
Ac-228	968.9	17.46%	6.13	hr	Eu-152	778.9	12.99%	12.7	y	Pb-214	351.99	37.10%	26.8	min
Am-241	26.99	2.50%	433	y	Eu-152	964	14.58%	12.7	y	Pb-214	785.95	1.09%	26.8	min
Am-241	59.54	36.30%	433	y	Eu-152	1,408.08	21.21%	12.7	y	Ra-226	186.2	3.28%	1600	y
Bi-212	727.17	11.80%	60.55	min	Eu-154	123.1	40.46%	8.5	y	Th-230	67.67	0.37%	7.54E+04	y
Bi-212	785.42	2.00%	60.55	min	Eu-154	723.3	19.70%	8.5	y	Th-230	143.87	0.05%	7.54E+04	y
Bi-212	1,620.56	2.75%	60.55	min	Eu-154	1,274.80	35.50%	8.5	y	Th-230	253.73	0.01%	7.54E+04	y
Bi-214	609.32	46.09%	19.9	min	K-40	1,460.80	10.70%	1.28E+09	y	Th-234	63.29	4.84%	578.4	hr
Bi-214	665.45	1.56%	19.9	min	Pa-234	131.28	20.00%	6.7	hr	Th-234	92.8	2.77%	578.4	hr
Bi-214	768.36	4.89%	19.9	min	Pa-234	883.24	15.00%	6.7	hr	Tl-208	583.14	86.00%	3.1	min
Bi-214	934.05	3.17%	19.9	min	Pa-234	946	12.00%	6.7	hr	Tl-208	860.47	12.00%	3.1	min
Bi-214	1,120.28	15.04%	19.9	min	Pb-210	46.54	4.25%	22.3	Y	Tl-208	2,614.47	100.00%	3.1	min
Bi-214	1,377.65	4.02%	19.9	min	Pb-212	74.81	9.60%	10.64	hr	U-235	143.76	10.50%	3.80E+06	y
Bi-214	1,407.98	2.48%	19.9	min	Pb-212	77.11	17.50%	10.64	hr	U-235	163.35	4.70%	3.80E+06	y
Bi-214	1,509.19	2.19%	19.9	min	Pb-212	87.2	6.30%	10.64	hr	U-235	185.05	54.00%	3.80E+06	y
Bi-214	1,764.51	15.92%	19.9	min	Pb-212	238.63	43.10%	10.64	hr					
Co-60	1,173.23	99.86%	5.272	y	Pb-212	300.09	3.27%	10.64	hr					
Co-60	1,332.51	99.98%	5.272	y										

Abbreviations and Acronyms:

Ac-228 – actinium-228
Am-241 – americium-241
Bi-212 – bismuth-212
Bi-214 – bismuth-214
Co-60 – cobalt-60
Cs-137 – cesium-137
Eu-152 – europium-152
Eu-154 – europium-154
hr – hour
K-40 – potassium-40
min – minute
Pa-234 – proactinium-234
Pb-210 – lead-210
Pb-212 – lead-212
Pb-214 – lead-214
Ra-226 – radium-226
Th-230 – thorium-230
Th-234 – thorium-234
Tl-208 – thallium-208
U-235 – uranium-235
y – year

This page intentionally left blank.

TABLE 5-3
SUMMARY OF CHARACTERIZATION SURVEY
SOIL BORING SAMPLE ANALYTICAL RESULTS

Boring No.	Sample Identification	Collection Date	Cs-137 (pCi/g)	Ra-226[a] (pCi/g)	Total Strontium (pCi/g)
2	11-02-SC-B-1.5-2.0	8/6/2013	-0.0004943	0.4537	0.101
3	11-03-SC-B-0.5-1.0	8/7/2013	0.03398	0.2968	-0.0987
4	11-04-SC-B-0.5-1.0	8/12/2013	0.06256	0.5505	0.162
6	11-06-SC-B-1.0-1.5	8/8/2013	0.01226	0.416	-0.103
7	11-07-SC-B-1.5-2.0	8/12/2013	0.02237	0.3902	0.112
9	11-09-SC-B-1.0-1.5	8/8/2013	-0.002174	0.4621	0.126
10	11-10-SC-B-0.0-0.5	8/12/2013	0.4962	10.41	0.0696
11	11-11-SC-B-2.5-3.0	8/12/2013	0.0005595	0.528	-0.0644
13	11-13-SC-B-0.0-0.5	8/12/2013	0.03169	0.9398	0.07
14	11-14-SC-B-2.0-2.5	8/12/2013	0.03896	0.6297	0.196
15	11-15-SC-B-2.5-3.0	8/12/2013	0.0199	0.3069	0.0909
20	11-20-SC-B-2.5-3.0	8/8/2013	0.002807	0.3926	-0.0524
21	11-21-SC-B-1.0-1.5	8/8/2013	0.003481	0.5079	-0.0384
26	11-26-SC-B-4.0-4.5	8/7/2013	0.5081	0.5937	0.2
27	11-27-SC-B-2.0-2.5	8/13/2013	0.002906	0.4128	-0.135
31	11-31-SC-B-1.0-1.5	8/7/2013	0.05134	0.3773	0.346
32	11-32-SC-B-1.5-2.0	8/12/2013	0.005086	0.5653	0.0886
33	11-33-SC-B-1.5-2.0	8/12/2013	0.00582	0.5388	-0.0238
34	11-34-SC-B-1.0-1.5	8/12/2013	0	0.4253	0.124
35	11-35-SC-B-2.0-2.5	8/12/2013	0	0.4639	-0.0178
36	11-36-SC-B-1.5-2.0	8/12/2013	0.0004384	0.3544	-0.0317
37	11-37-SC-B-3.5-4.0	8/12/2013	-0.0006456	0.4422	0.0219
38	11-38-SC-B-1.5-2.0	8/12/2013	0.0005592	0.4411	0.0225
39	11-39-SC-B-2.0-2.5	8/12/2013	0.003897	0.4851	-0.115
40	11-40-SC-B-0.5-1.0	8/14/2013	0.006522	0.2948	0.318
41	11-41-SC-B-0.5-1.0	8/14/2013	0.001331	0.4058	0.196
42	11-42-SC-B-2.5-3.0	8/15/2013	-0.007405	0.4225	0.0825
43	11-43-SC-B-2.5-3.0	8/15/2013	-0.002009	0.4181	0.0889
44	11-44-SC-B-0.5-1.0	8/14/2013	0.003874	0.3547	-0.0344
46	11-46-SC-B-1.0-1.5	8/15/2013	0.02163	0.3488	0.14
47	11-47-SC-B-3.0-3.5	8/15/2013	0.01097	0.4077	-0.0264
48	11-48-SC-B-3.0-3.5	8/15/2013	0.001475	0.6137	0.0155
50	11-50-SC-B-2.0-2.5	8/19/2013	0	0.4869	0.15
52	11-52-SC-B-4.0-4.5	8/19/2013	-0.002406	0.4564	0.211
53	11-53-SC-B-3.0-3.5	8/19/2013	-0.0002057	0.4143	0.495
54	11-54-SC-B-2.0-2.5	8/19/2013	-0.001256	0.5647	0.242
55	11-55-SC-B-0.5-1.0	8/19/2013	0.03259	1.479	0.043
57	11-57-SC-B-6.5-7.0	8/19/2013	-0.0003802	0.3301	0.0256
58	11-58-SC-B-0.0-0.5	8/19/2013	0.4138	0.4696	-0.0897
59	11-59-SC-B-1.5-2.0	8/19/2013	0	0.4276	0.0774
62	11-62-SC-B-1.0-1.5	8/19/2013	0	0.3262	0.0355

Notes:
[a] By bismuth-214

Abbreviations and Acronyms:
Cs-137 – cesium-137
pCi/g – picocuries per gram
Ra-226 – radium-226

This page intentionally left blank.

TABLE 5-4
STORM DRAIN LINE GAMMA SCAN DATA SUMMARY

Reach #	Upstream Structure	Downstream Structure	Pipe Length (feet)	Pipe Diameter (inches)	Background Type	Background Mean	Background Mean + 3 Sigma	Max Gamma CPM Reading	Total # of Counts	Quantity of Mean + 3 Sigma Exceedances
2	CB-13	MH-141	42	36	Concrete	4,334	5,309	4,980	79	0
3	MH-1007	MH-141	50	36	Concrete	5,124	6,035	5,881	120	0
4	MH-141	MH-137	320	36	VCP 1	8,196	10,352	10,240	233	0
					VCP 2	10,389	13,040	12,173	88	0
5	MH-1011	MH-137	180	18	VCP	7,513	9,285	9,293	229	1
6	MH-137	MH-160	240	36	VCP 1	7,688	9,607	9,071	47	0
					VCP 2	10,423	12,449	12,450	195	1
7	CB-11	MH-136	190	8	VCP	6,145	7,761	7,874	432	1
8	MH-135	MH-136	320	24	CMP 1	3,158	4,004	4,013	48	1
					CMP 2	4,058	4,885	5,018	388	2
					VCP/MH	7,532	11,202	9,222	18	0
9	MH-136	MH-1005	164	24	VCP	9,246	12,440	11,380	181	0
10	MH-1005	MH-160	230	24	Concrete	5,170	6,296	7,101	115	1
					VCP	8,850	11,008	10,485	122	0
11	MH-160	Outfall	82	42	Concrete	2,938	4,291	3,737	38	0
					HDPE	1,292	2,148	1,841	135	0
								Total:	2,468	7

Abbreviations and Acronyms:
CMP – corrugated metal pipe
CPM – counts per minute
HDPE – high-density polyethylene
Max - Maximum
VCP – vitrified clay pipe

This page intentionally left blank.

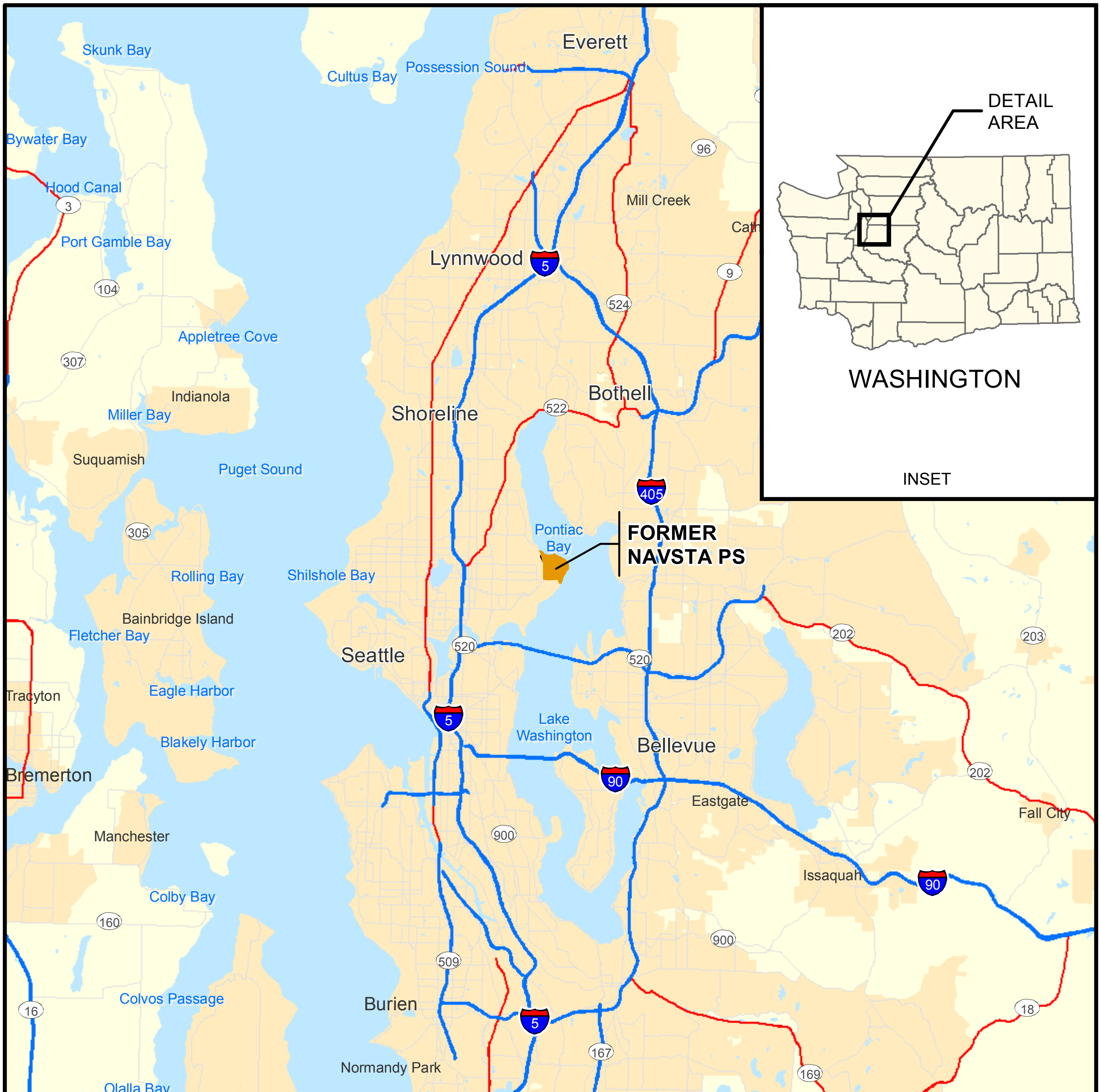
TABLE 5-5
MANHOLE AND CATCH BASIN
GAMMA SCAN AND STATIC SURVEY RESULTS SUMMARY

Structure	Gamma Counts Per Minute		Gamma Counts (1 minute)
	Minimum	Maximum	
MH-135	9,400	11,600	11,055
MH-1007	4,300	5,200	4,864
CB-13	3,800	4,600	4,253
MH-141	4,900	5,800	5,495
MH-137	4,600	5,400	4,965
MH-1011	2,600	3,200	2,908
MH-160	3,400	4,100	3,753
MH-1005	6,100	7,500	6,974
MH-136	5,100	6,000	5,918
CB-11	4,800	6,000	5,641

This page intentionally left blank.

FIGURES

This page intentionally left blank.



LEGEND

1 STATE HIGHWAY

5 INTERSTATE HIGHWAY

WATER

NAVSTA PS Naval Station Puget Sound

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

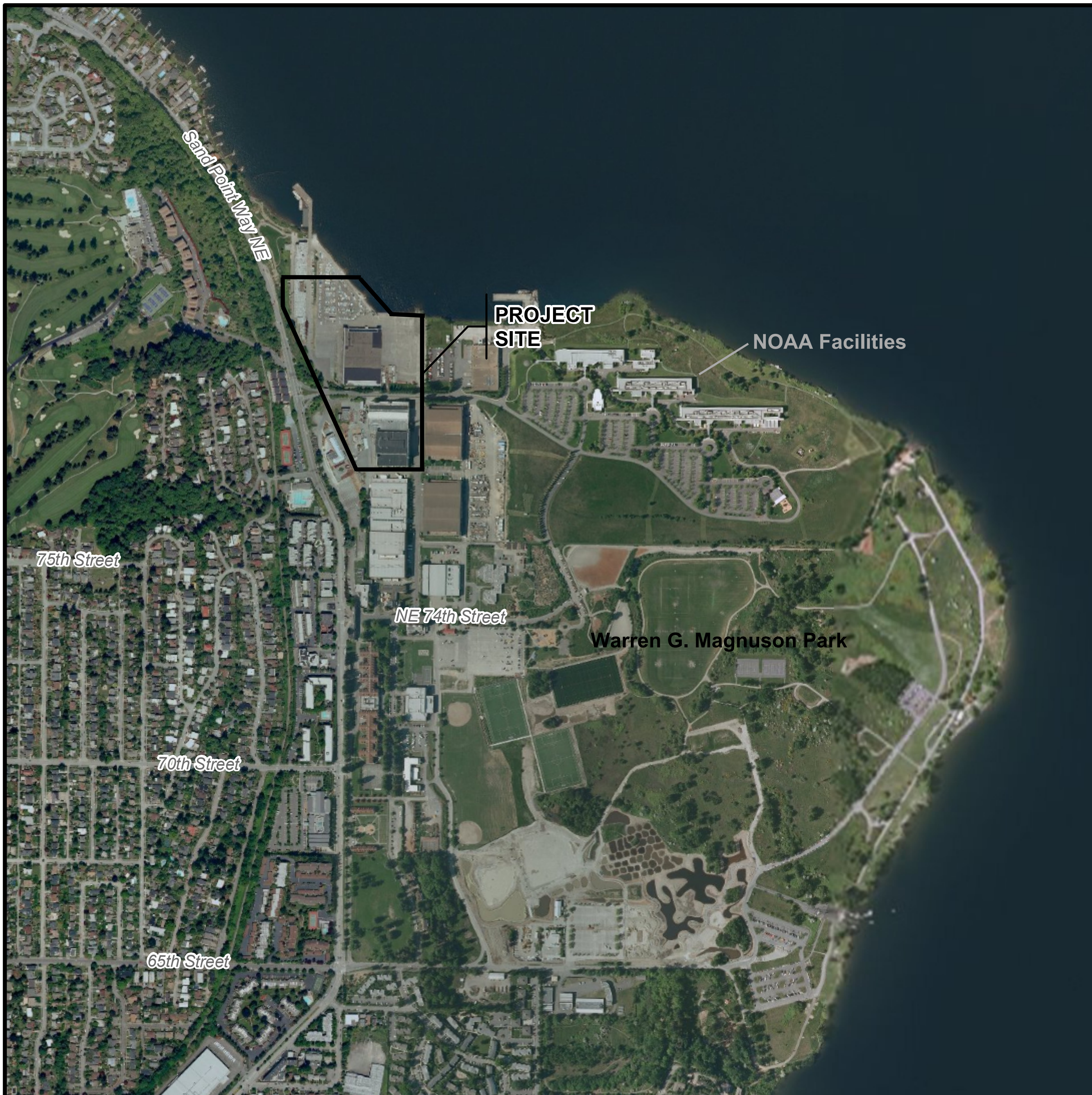
FIGURE 1-1

REGIONAL LOCATION MAP

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7560.mxd

TETRA TECH EC, INC.



LEGEND

NAVSTA PS PROJECT SITE

1,000 0 1,000 Feet

N

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

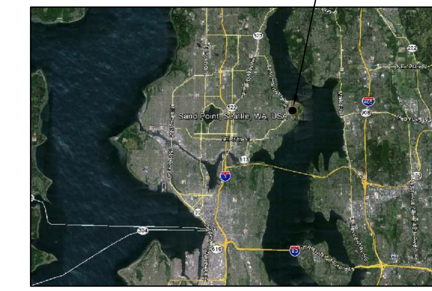
FIGURE 1-2

PROJECT SITE LOCATION AERIAL VIEW

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION: 0
AUTHOR: MS
FILE NUMBER: R7561.mxd

TETRA TECH EC, INC.



KEY PLAN

NOT TO SCALE

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 1-3

PROJECT SITE BUILDINGS

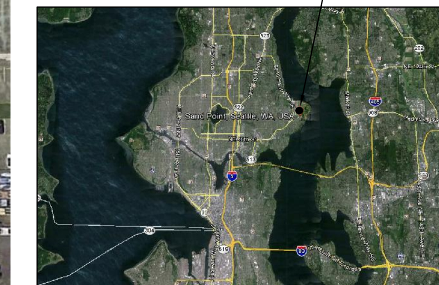
FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

Z:\106-40440011 SANDPOINT\CAD\FINAL PROJECT REPORTS\SP_FSS_FIGURE 1-3_01-26-16.DWG
PLOT/UPDATE: JAN 26 2016 07:52:53

FORMER SAND POINT NAVAL STATION



KEY PLAN

LEGEND

REFERENCE AREA LOCATION

NOT TO SCALE

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 3-1

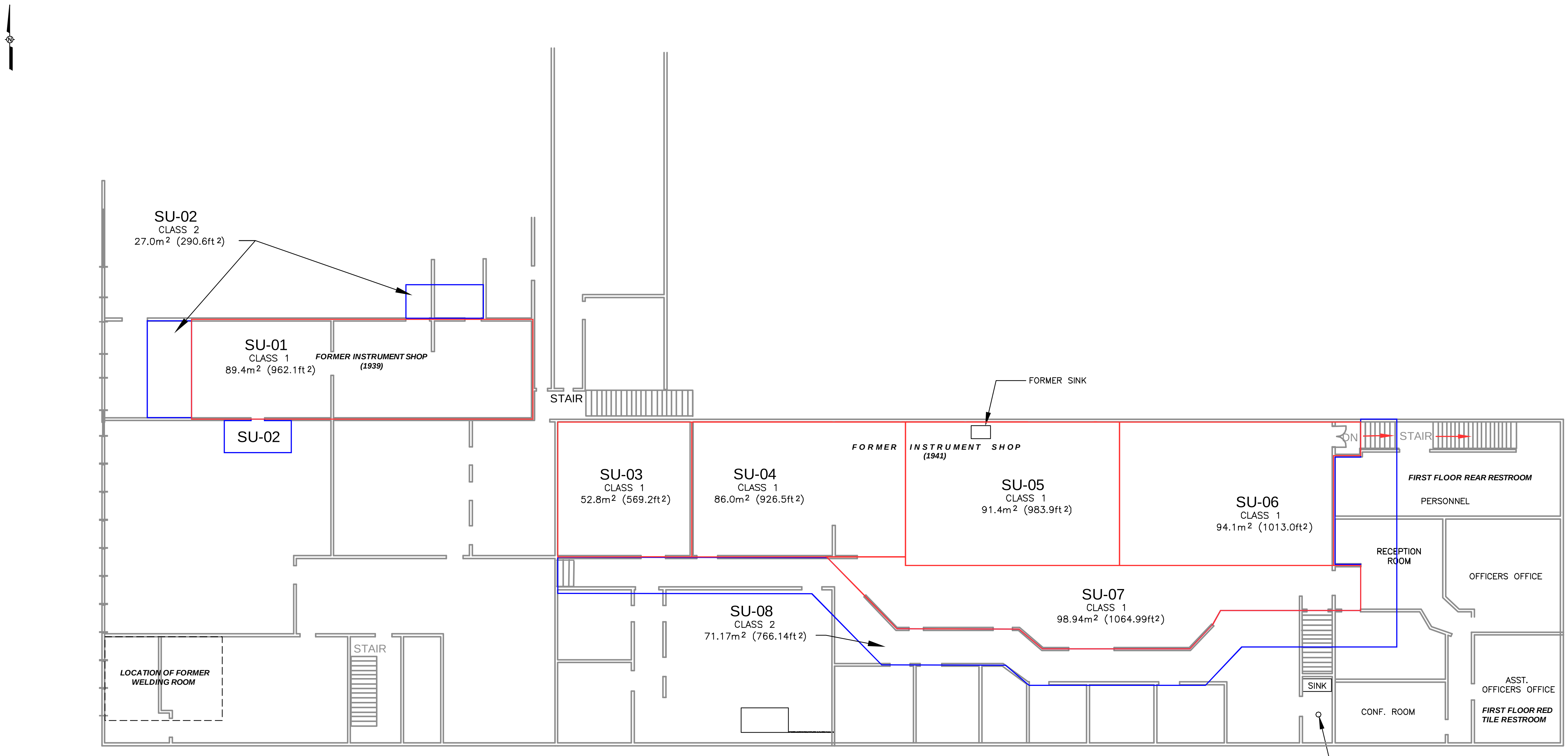
PROJECT SITE REFERENCE AREA LOCATIONS

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

Z:\106-40440011 SANDPOINT\CAD\FINAL PROJECT REPORTS\PROJECT SITE REFERENCE AREA LOCATIONS_FSS_FIGURE 3-1_01-26-16.DWG
PLOT/UPDATE: FEB 15 2016 05:56:18



SECOND FLOOR PLAN

LEGEND:

AREA EXCEEDING CLEANUP CRITERIA IN RADIOLOGICAL REMEDIAL INVESTIGATION REPORT (SHAW 2011)

CLASS 1 SURVEY

CLASS 2 SURVEY

SU SURVEY UNIT

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

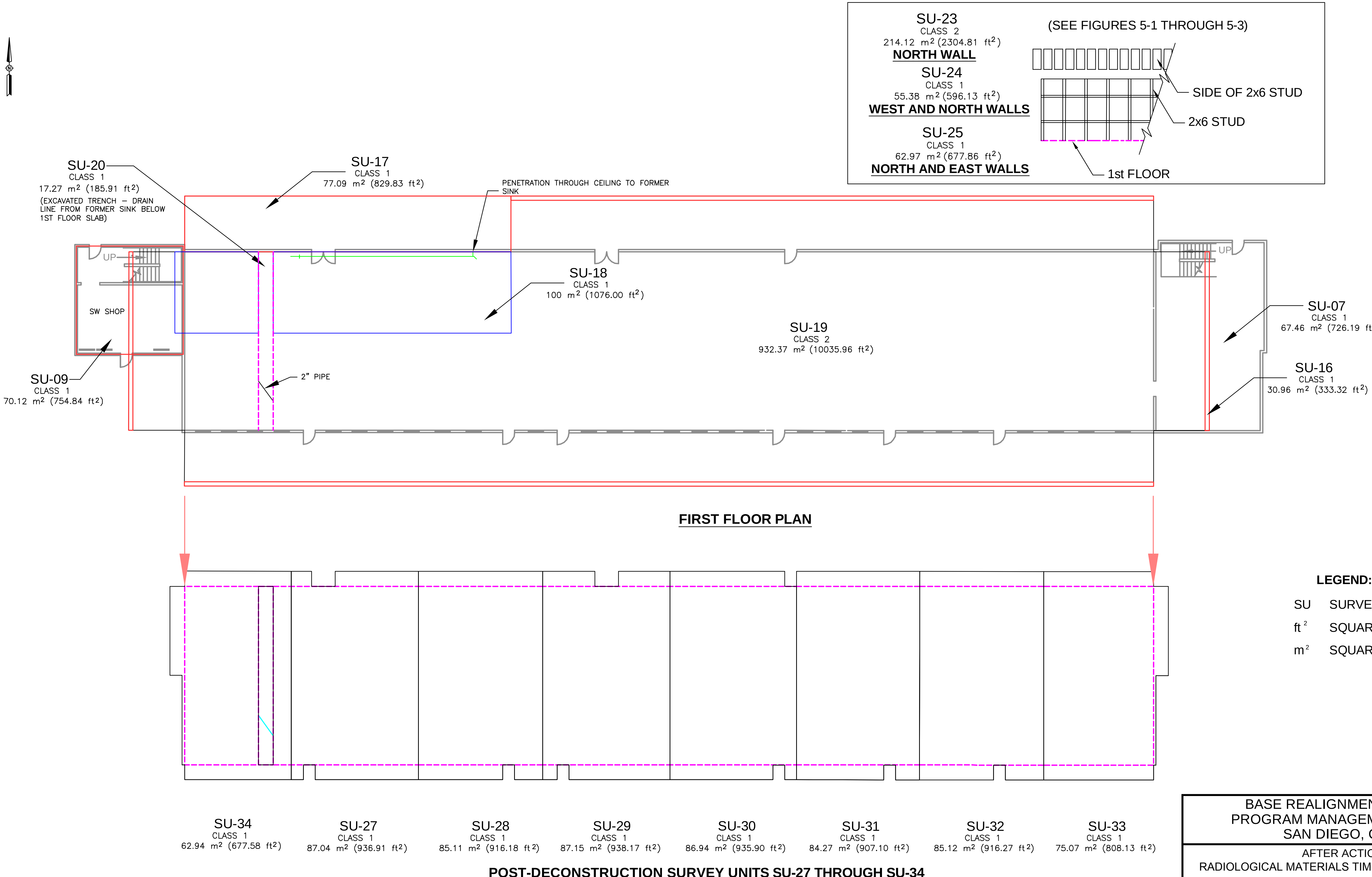
FIGURE 4-1

BUILDING 2 CLASS 1 AND 2 SURVEY UNITS
GENERAL ARRANGEMENT
FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

Z:\106-40440011 SANDPOINT\CAD\FINAL PROJECT REPORTS\BUILDING 2 FIGURE 4-1_01-05-16.DWG
PLOT/UPDATE: JAN 05 2016 09:20:50



LEGEND:

SU SURVEY UNIT

ft^2 SQUARE FEET

m^2 SQUARE METERS

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

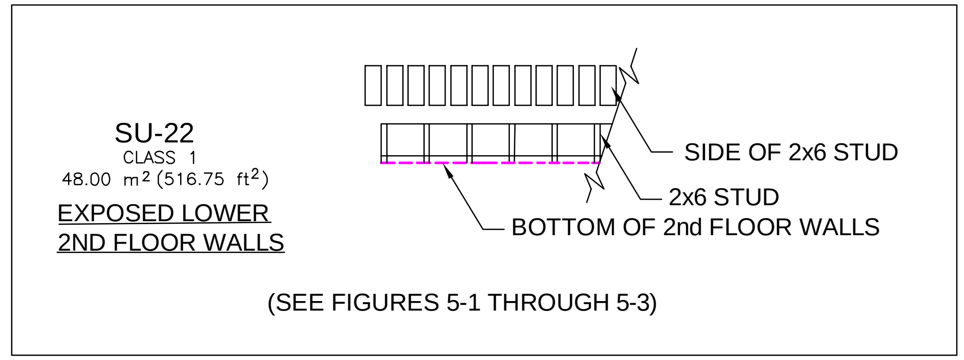
FIGURE 4-2

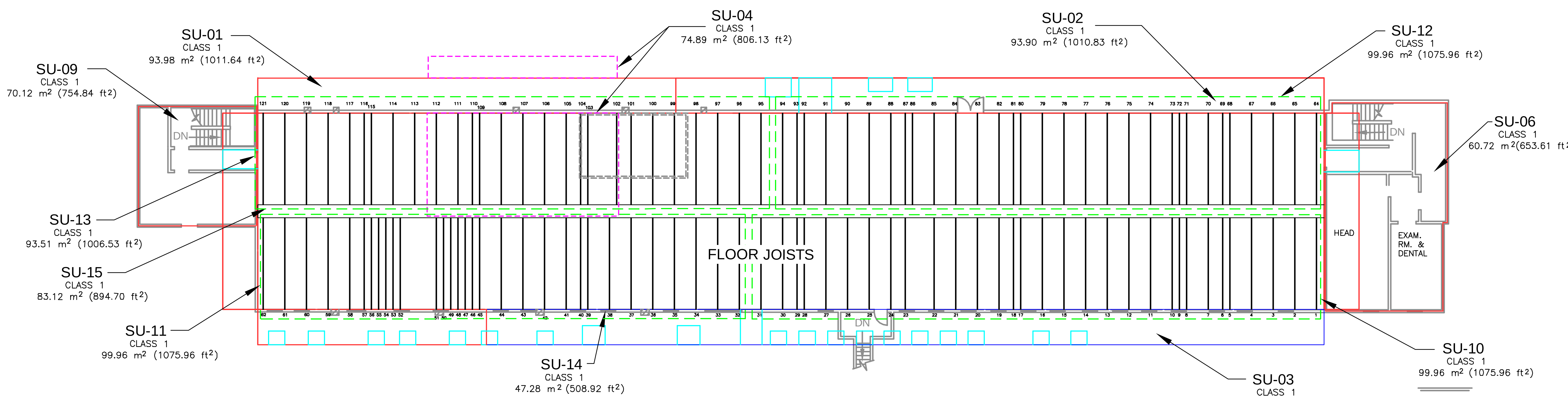
BUILDING 27 CLASS 1 AND 2 SURVEY UNITS- FIRST FLOOR ARRANGEMENT
FORMER NAVAL STATION, PUGET SOUND,SEATTLE,WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

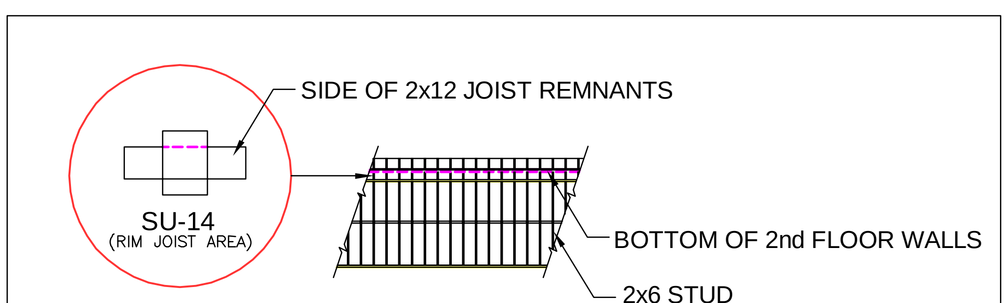
TETRA TECH EC, INC.

Z:\106-40440011 SANDPOINT\CAD\FINAL PROJECT REPORTS\BUILDING 27 FFS FIGURE 4-2_01-05-16.DWG
PLOT/UPDATE: JAN 05 2016 09:27:19





SECOND FLOOR PLAN



DETAIL A

LEGEND:

(red line)	CLASS 1 SURVEY
(cyan box)	WINDOW / DOOR
(vent symbol)	VENT
(black line)	JOIST SURVEYED
SU	SURVEY UNIT
ft^2	SQUARE FEET
m^2	SQUARE METERS

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 4-3

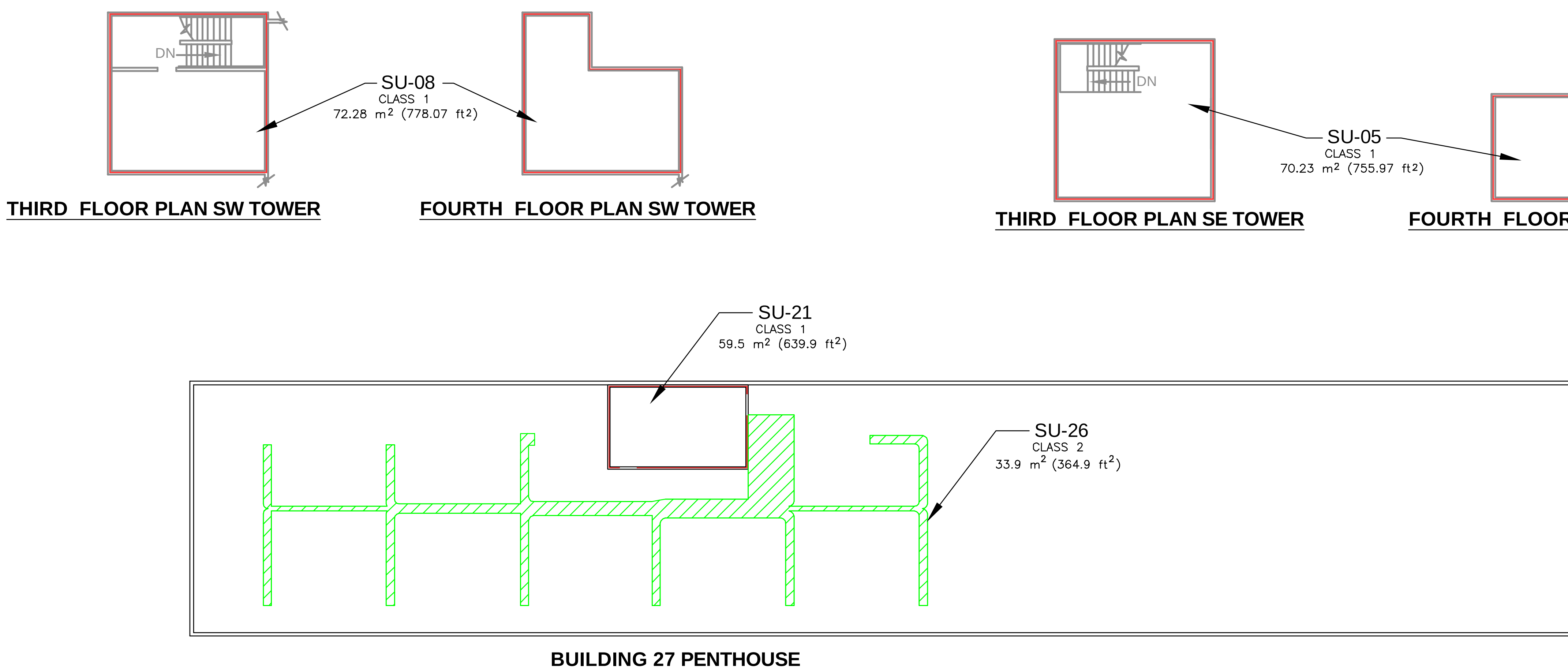
BUILDING 27 CLASS 1 SURVEY UNITS - SECOND FLOOR ARRANGEMENT

FORMER NAVAL STATION, PUGET SOUND, SEATTLE, WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

Z:\106-40440011 SANDPOINT\CAD\FINAL PROJECT REPORTS\BUILDING 27 FFS FIGURE 4-3_01-05-16.DWG
PLOT/UPDATE: JAN 05 2016 09:29:35



LEGEND:

CLASS 1 SURVEY

REMOVED AREA

SU SURVEY UNIT

ft^2 SQUARE FEET

m^2 SQUARE METERS

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION
FIGURE4-4
BUILDING 27 CLASS 1 SURVEY UNITS - THIRD AND FOURTH FLOORS, AND PENTHOUSE ARRANGEMENT, AND CLASS 2 SURVEY UNIT ROOF ARRANGEMENT
FORMER NAVAL STATION, PUGET SOUND, SEATTLE, WA

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

Z:\106-40440011 SANDPOINT\CAD\FINAL PROJECT REPORTS\BUILDING 27 AAR FIGURE 4-4_01-05-16.DWG
PLOT/UPDATE: FEB 25 2016 11:59:07

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

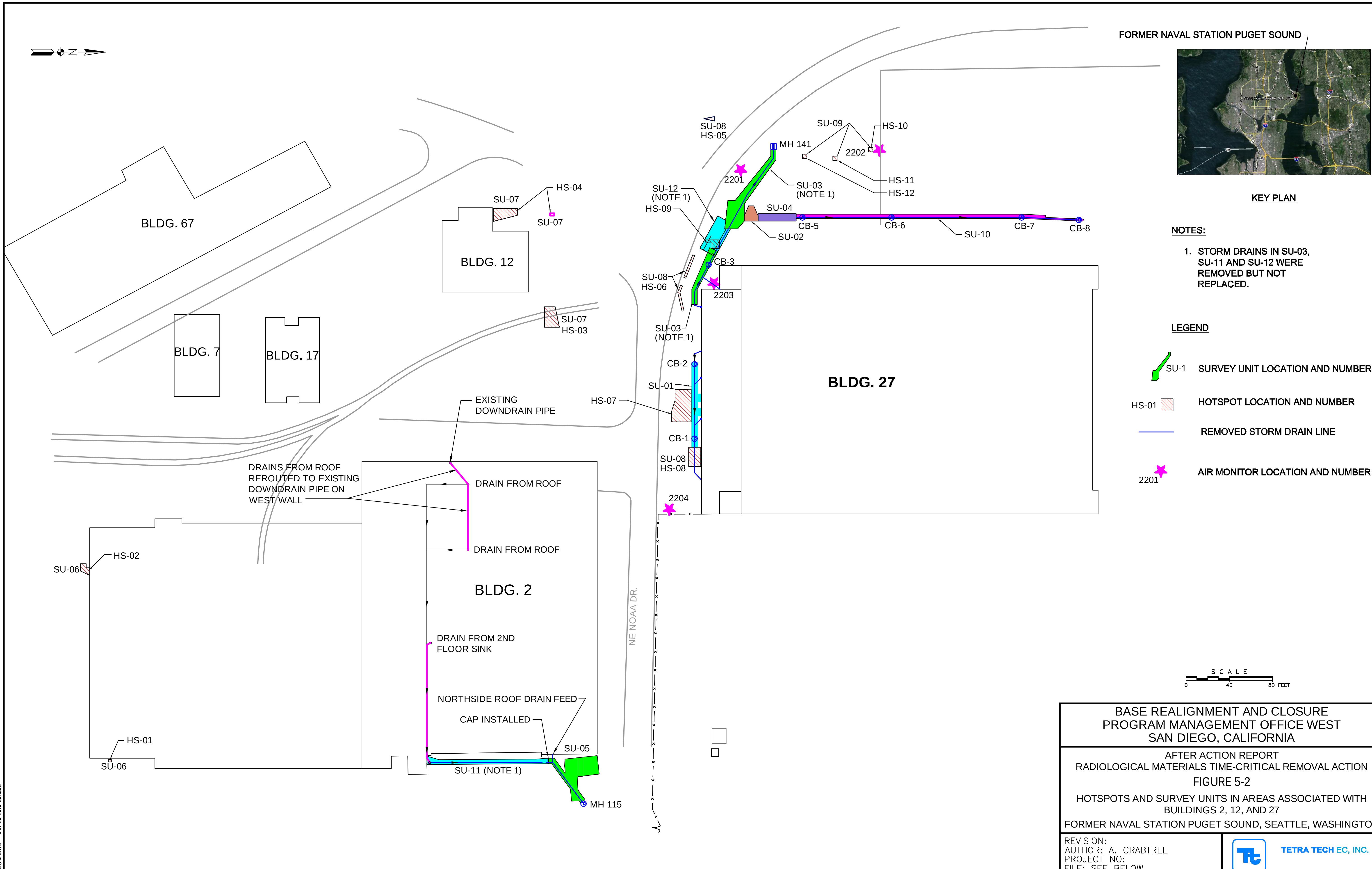
FIGURE 5-1

CHARACTERIZATION NEAR-SURFACE SOIL BORING LOCATIONS

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WA

REVISION: 0
AUTHOR: MS
FILE NUMBER: L7451.mxd

TETRA TECH EC, INC.



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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 5-2

HOTSPOTS AND SURVEY UNITS IN AREAS ASSOCIATED WITH BUILDINGS 2, 12, AND 27

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.

LEGEND

FLOW DIRECTION
STORM DRAIN LINE
CORE LOCATION
MH 250 MANHOLE NUMBER
CATCH BASIN OR MANHOLE
CB CATCH BASIN
MH MANHOLE
EXISTING FENCE
TEMPORARY FENCE
TEMPORARY DISCHARGE HOSE
RAMPS
DEWATERING BOXES
21,000-GALLON WATER HOLDING TANKS WITH CONTAINMENT

N
NOT TO SCALE

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

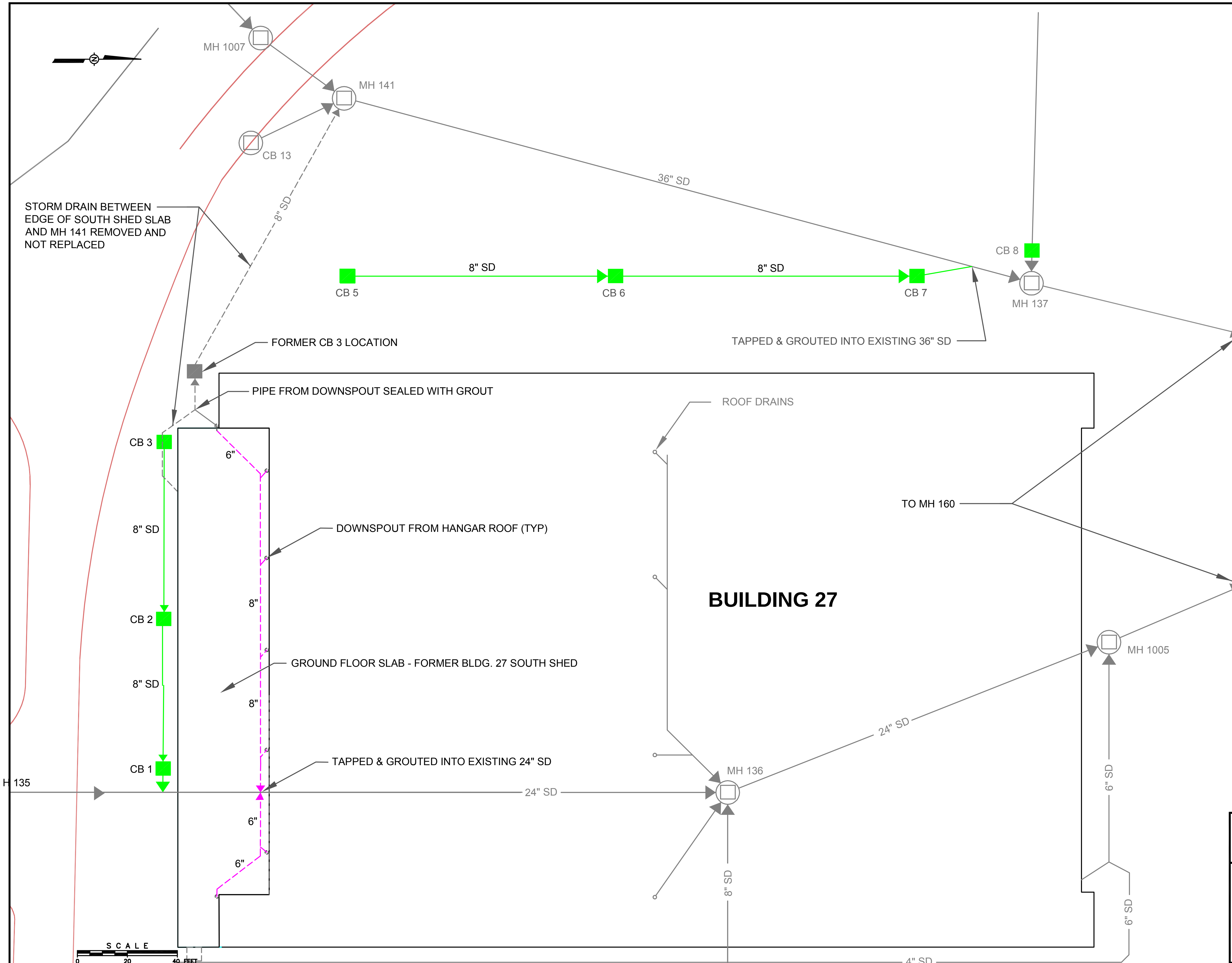
FIGURE 5-3

STORM DRAIN CLEANING, INSPECTION, AND GAMMA SCAN SURVEY LOCATIONS

FORMER NAVAL STATION PUGET SOUND, SEATTLE, WASHINGTON

REVISION:
AUTHOR: A. CRABTREE
PROJECT NO:
FILE: SEE BELOW

TETRA TECH EC, INC.



SOURCE: US NAVAL STATION, SEATTLE WASHINGTON
BUILDING 27 PLAN - 1985 (DRAWING #54151)
1943 (DRAWING #54080)

NOTES:

1. NEW STORM DRAIN PIPE COMPLIES WITH ASTM D3034, SDR 35.
2. NEW CATCH BASINS COMPLY WITH WSDOT STANDARD PLAN B-5.20-01, CATCH BASIN TYPE 1
3. NEW CATCH BASIN FRAMES AND GRATES COMPLY WITH WSDOT STANDARD PLAN B-30.10-01, RECTANGULAR FRAME (REVERSIBLE), AND B-30.50-01, RECTANGULAR HERRINGBONE GRATE.

LEGEND:

SD	NEW STORM DRAIN SYSTEM COMPONENTS
	STORM DRAIN REMOVED AND NOT REPLACED
	NEW U/G ROOF DRAIN COLLECTION PIPING
24"	PIPE DIAMETER
CB	CATCH BASIN
SD	STORM DRAIN
U/G	UNDERGROUND
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
WSDOT	WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

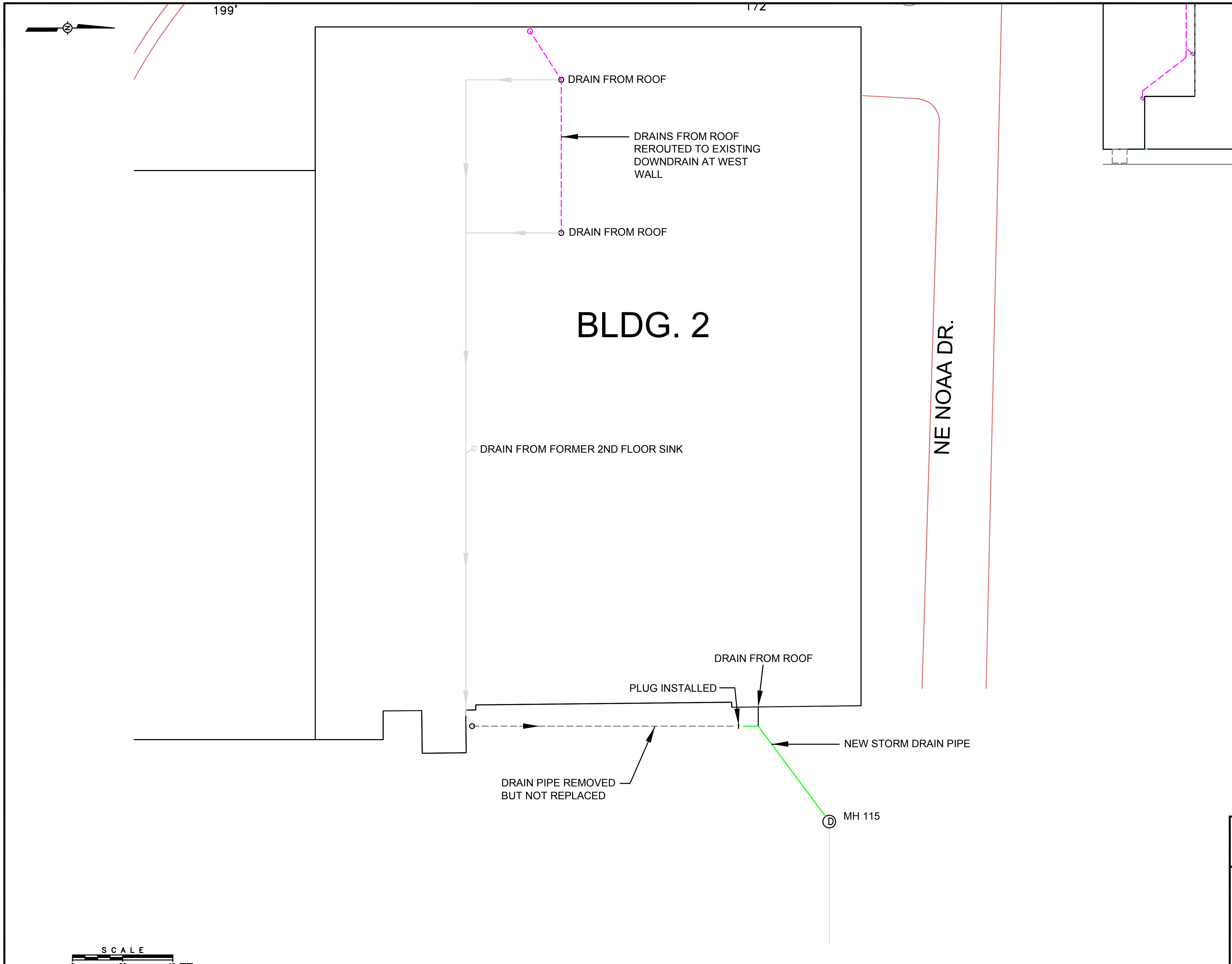
FIGURE 6-1

NEW BUILDING 27 STORM DRAIN AND ROOF DRAIN COLLECTION SYSTEMS
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



NOTES:

1. NEW STORM DRAIN PIPE COMPLIES WITH ASTM D3034, SDR 35.
2. NEW CATCH BASINS COMPLY WITH WSDOT STANDARD PLAN B-5.20-01, CATCH BASIN TYPE 1
3. NEW CATCH BASIN FRAMES AND GRATES COMPLY WITH WSDOT STANDARD PLAN B-30.10-01, RECTANGULAR FRAME (REVERSIBLE), AND B-30.50-01, RECTANGULAR HERRINGBONE GRATE.

LEGEND:

SD	NEW STORM DRAIN SYSTEM COMPONENTS
	STORM DRAIN REMOVED AND NOT REPLACED
	NEW U/G ROOF DRAIN COLLECTION PIPING
24"	PIPE DIAMETER
CB	CATCH BASIN
SD	STORM DRAIN
U/G	UNDERGROUND
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
WSDOT	WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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

AFTER ACTION REPORT
RADIOLOGICAL MATERIALS TIME-CRITICAL REMOVAL ACTION

FIGURE 6-2

NEW BUILDING 2 STORM DRAIN AND ROOF DRAIN COLLECTION SYSTEMS
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

PHOTOGRAPHS

This page intentionally left blank.

Photograph 1-1: Removing ventilation ducting from Building 2 attic space.

Photograph 1-2: Floor remediation in Building 2 former 1941 Instrument Shop area.

Photograph 1-3: Excavation of Building 2 sink drain line.

Photograph 1-4: Backfill/compaction of Building 2 sink drain line trench.

Photograph 1-5: Collecting soil characterization core sample south of Building 27.

Photograph 1-6: Excavation of HS-07 south of Building 27.

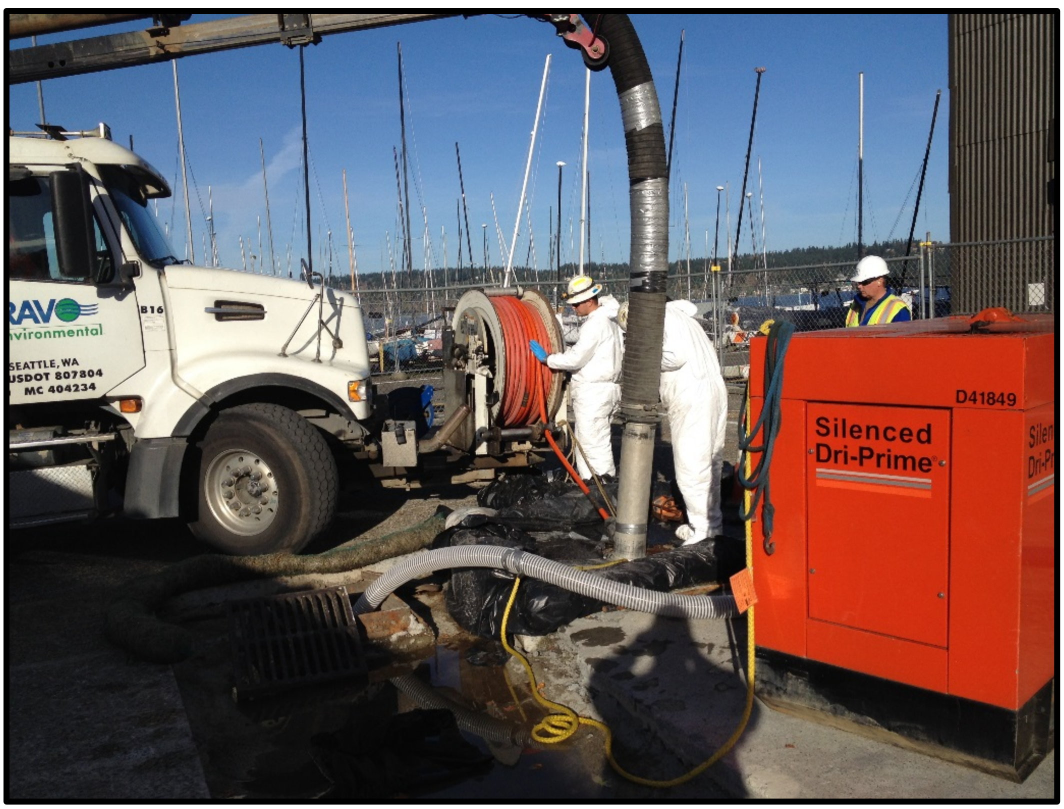
Photograph 1-7: Gamma walkover survey of hotspot excavation west of Building 27.

Photograph 1-8: Removal of storm drain line and soil south of Building 27.

Photograph 1-9: Placement of low-level radioactive soil into a disposal bin.

Photograph 1-10: Storm drain line to MH-141 excavation west of Building 27.

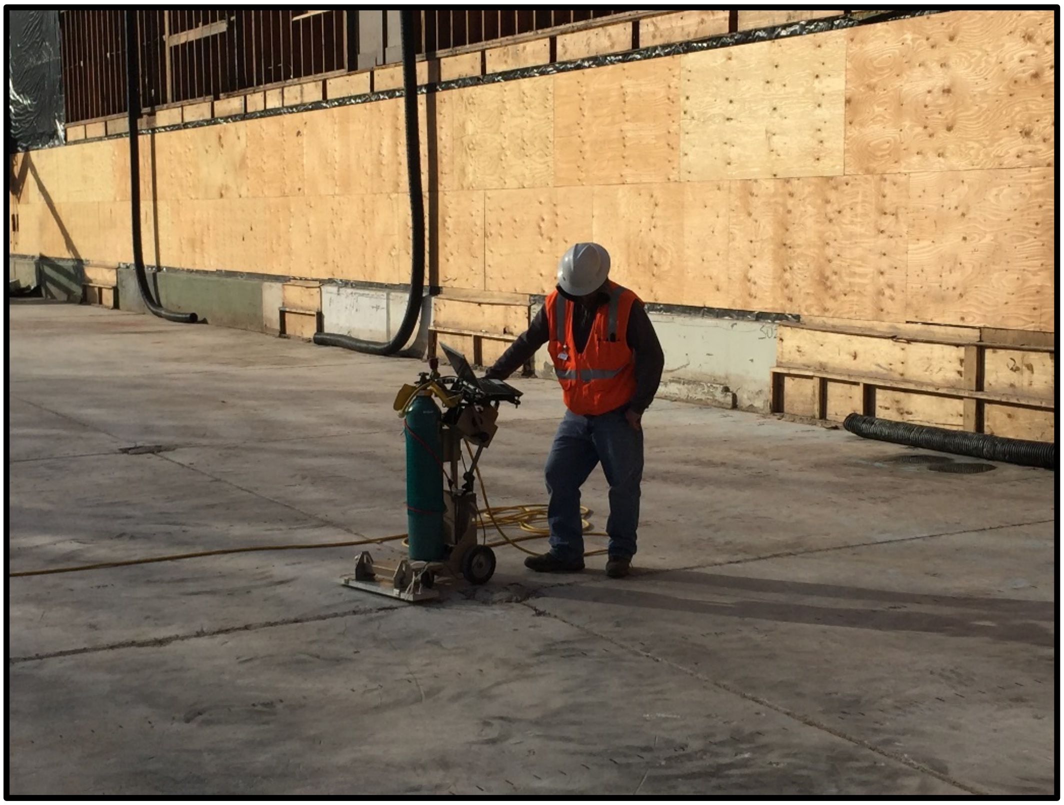
Photograph 1-11: Installation of new storm drain pipe from CB-5 to CB-8.



Photograph 1-12: Storm drain cleaning operation at MH-160.

Photograph 1-13: Installation of plug in storm drain outfall to Lake Washington.

Photograph 1-14: Vapor barrier installation on Building 27 common wall.



Photograph 1-15: Performing alpha/beta scan survey of the former South Shed concrete slab.

Photograph 1-16: Installation of straw matting over reseeded slopes near Building 27.