Final

REMEDIAL ACTION PLAN FOR BORDEAUX DUMP SITE
HALO-KUNTUX LANE
LITTLEROCK, WASHINGTON

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Remedial Action Plan for Bordeaux Dump Site

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
bgs	Below ground surface
CAP	Cleanup Action Plan
COCs	Chemicals of concern
cPAHs	carcinogenic Polycyclic Aromatic Hydrocarbons
DQO	Data quality objective
Ecology	Washington State Department of Ecology
FS	Feasibility Study
GC/MS	Gas Chromatography/Mass Spectrometry
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HASP	Health and safety plan
ug/kg	Micrograms per kilogram
ug/L	Micrograms per liter
mg/L	Milligrams per liter
MDL	Method detection limit
MI	Multi-incremental
MTCA	Model Toxics Control Act
NGVD	National Geodetic Vertical Datum
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PID	Photo ionization detector
PLP	Potentially Liable Party
POC	Point of compliance
QAPP	Quality Assurance Project Plan
QA/QC	Quality assurance/quality control
RAO	Remedial action objective
RI	Remedial Investigation
SAP	Sampling and analysis plan
SOPs	Standard operating procedures
SVOC	Semivolatile organic compound
SWPP	Storm water pollution prevention
TEC	Toxicity equivalent concentration
TEF	Toxicity equivalence factor
TTEC	Total Toxicity Equivalent Concentration
TPH-Dx	Total petroleum hydrocarbons – diesel range
TPH-HCID	Total petroleum hydrocarbons - hydrocarbon identification
UCL	Upper confidence limit
USCS	Unified Soil Classification System
USGS	United States Geological Survey
VOC	Volatile organic compound
WAC	Washington Administrative Code

Remedial Action Plan
for Bordeaux Dump Site

1.0 Introduction

The Bordeaux Dump Site (Site) is located on property in a rural area of Thurston County southwest of Littlerock, Washington. The adjoining property is zoned residential. The Site is accessed via Halo Kuntux Lane, a private gated road connecting to Bordeaux Road on the southern boundary of the property. The Site is shown in Figure 1 and is located within property in the East ½ of the NW ¼ of Section 9, Township 16 North, Range 3 West of the Willamette Meridian.

This remedial action plan for the Site has been prepared to meet the Model Toxics Control Act (MTCA) requirements listed in Washington Administrative Code (WAC) 173-340-400 (and other related sections of WAC 173-340) and the Cleanup Action Plan (CAP , Ecology 2009a). The scope and level of detail required for this remedial design report has been tailored to the site-specific conditions and the nature and complexity of the planned cleanup action (as recognized in WAC 173-340-400).

The bulk of the planned remedial actions (excavation, characterization, waste designation and disposal) is a routine cleanup and therefore this single report (the remedial action plan) has been structured to cover the engineering design requirements (WAC 173-340-400,4,a), construction plans and specifications (WAC 173-340-400,4,b), operation and maintenance (WAC 173-340-400,4,c), and permitting requirements (WAC 173-340-400,5). In addition, this plan describes the compliance monitoring (required under WAC 173-340-410) and identified in the CAP.

1.1 Site History from RI/FS through Cleanup Action Plan

The Washington Department of Ecology (Ecology) issued Agreed Order No. 2888 requiring the Potentially Liable Persons (PLPs) to perform a Remedial Investigation/Feasibility Study (RI/FS) and to prepare a draft CAP for the Hytec-Littlerock property which, at that time, was defined as a 44-acre parcel. The RI/FS was finalized on August 2007 and approved by Ecology in September 2007.

Based on the RI/FS results, Ecology concluded that there are two distinct contaminated sites within the property (the initial 44-acre parcel). These sites are the Fiberglass Debris Landfill area, and the Bordeaux Dump (including an adjacent Rusted Drum area). This remedial action plan is focused on the Bordeaux Dump (including the adjacent Rusted Drum area). An old dump (generally thought to be a historic disposal area from the Town of Bordeaux, circa 1900-1930) is present on the Site. The location and extent of this historical dump was determined using historical photographs, geophysical studies, and characterization studies conducted during the RI. Also during the investigation, a small adjacent area with a single rusted drum (labeled as the “Rusted Drum area”) was identified close to the Bordeaux Dump area. For the purpose of this remedial action plan, the Site is defined as the combination of the Bordeaux Dump and Rusted Drum areas.

In December 2009 Ecology completed a draft a Cleanup Action Plan (CAP) for the Bordeaux Dump (including the Rusted Drum area). The draft CAP was submitted for public comment and a final CAP was issued in August 2010. Following completion of the CAP, the PLPs, Chauncey and Elizabeth Lufkin (Lufkins), signed a consent decree with Ecology regarding implementation of CAP requirements at the Site. The consent decree was entered in Thurston County Superior Court on 20 August 2010.

This remedial action work plan has been prepared to fulfill the work plan requirements listed in the CAP. The planned remedial action for the Fiberglass Debris Landfill area, located north of the Bordeaux Dump area, is covered under a separate CAP (Ecology 2009b) and remedial action plan.

1.2 Organization of this Remedial Action Plan

This Remedial Action Plan is intended to meet the MTCA requirements listed in WAC 173-340 and the CAP. The scope and level of detail required for this remedial design report has been tailored to the site-specific conditions and the nature and complexity of the planned cleanup action as a routine cleanup.

This Remedial Action Plan for the Site has been organized as follows:

Section 1 Introduction, objectives and Site history.
Section 2 Engineering design requirements and sufficient details for construction plans and specifications
Section 3 Monitoring requirements and basis/rationale for sampling.
Section 4 Sampling and analysis plan
Section 5 Reporting
Section 6 References

Appendix A	Waste Designation Procedures and Steps
Appendix B	Quality Assurance Project Plan (including SOPs)
Appendix C	Storm water/Erosion Control Plan
Appendix D	Health and Safety Plan

2.0 Engineering Design

The following sections describe and document engineering concepts and design criteria used in this remedial action plan.

2.1 Remedial Action Goals

The goals of the cleanup action are to:

1. Remove the contaminated fill at the Bordeaux dump area and include the adjacent area with a rusted drum.
2. Restore the soil to meet MTCA B residential soil standards (through excavation and disposal).
3. Collect limited additional groundwater monitoring data to verify that site groundwater is not impacted at levels that exceed MTCA B criteria (use as a potable water supply).

2.2 Site Characteristics

The general characteristics of the site are summarized in the RI/FS (CALIBRE 2007) and the CAP (Ecology 2009). General details for the Bordeaux Dump area are:

- Filled area, roughly circular shape approximately 100 feet in diameter (~ 1/3 acre total), depth of debris/discoloration in soil < 2 feet, samples of fill (mixture of debris and soil) exceed MTCA B standards.
- Soil sampling beneath the fill (> 2 feet deep) indicated all samples below MTCA B standards (VOCs, SVOCs, metals, and PCBs).
- The results of the groundwater sampling are described below.

Visual inspection of the property completed in October 2010 indicated no appreciable change in site conditions since the completion of the RI/FS and CAP. The property where the remedial actions will be implemented is owned by the Lufkins. The remedial action is planned to be implemented by CALIBRE Systems (with appropriate subcontractors) on behalf of the Lufkins. Following completion of the remedial actions the properties will be retained by the Lufkins and may subsequently be sold/transferred. Suitable property access agreements have been requested and received for ingress/egress of the shared common road from the adjacent property owners.

2.2.1 Soil and Groundwater Characteristics

The general characteristics of the soil and the groundwater system at the Site are described in both the RI/FS (CALIBRE 2007) and the CAP (Ecology 2009a). This section presents a brief overview of the Site geology and hydrogeology; more detailed discussions are presented in the final RI/FS report (CALIBRE 2007).

Glacial advance outwash gravel covers the area of the Site and appears to be contiguous with thick gravel deposits found on the Mima Prairie to the east. Typically, the advance outwash deposits are underlain by unconsolidated and undifferentiated deposits of quaternary and tertiary ages. These deposits are of low permeability and generally contain layers of clay and dense silt which is underlain by bedrock.

The conceptual model presented in the RI/FS indicates that groundwater flows predominantly on the surface of a perching layer to the southeast (SE) at a hydraulic gradient of 0.06 feet/feet. The groundwater flow direction experiences a seasonal change from flowing toward the SE during high water levels in April to flowing toward the South-Southeast (SSE) during low water levels in September. The steep hydraulic gradient (0.06 to 0.10 foot/foot) combined with the apparent high permeability soil is indicative of a thin groundwater zone perched on an underlying and steeply dipping low permeability layer (clay/dense silt above bedrock). The steep groundwater gradient is created by the underlying surface slope of the perching low permeability layer.

The two private water-supply wells in the area of the Fiberglass Debris Landfill (Morgan and Spears private wells) are screened in the bedrock. The water-level data indicates a downward vertical gradient from the shallow perched zone to the deeper zones in bedrock. The third water-supply well (Pavlicek well), located northeast of the Bordeaux Dump area, appears to be screened in the glacial outwash gravel.

2.2.2 Groundwater Sampling Results

Several SVOCs were detected in the groundwater sample below the area of the Bordeaux Dump. All of the polycyclic aromatic hydrocarbons (PAHs) detected in the groundwater sample were "J" flagged as estimated by the laboratory. Two of the organic compounds detected (PAHs) are reported at trace levels near or above the MTCA Method A/B criteria; indeno(1,2,3-cd)pyrene reported at 0.15(J) ug/L versus the Method B screening criteria of 1 ug/L and benzo(a)pyrene reported at 0.17(J) ug/L versus the Method A criteria of 0.1 ug/L. The sum of Total Toxicity Equivalent Concentration (TTEC) for carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) was calculated to be 0.25 µg/l which is above the Method A groundwater cleanup level of 0.1 ug/l for benzo(a)pyrene TTEC. This exceedance is based on one sample, which is suspect because:

1) Push probe samples commonly have a high turbidity (i.e., well development does not occur with a temporary probe).
2) None of the soil samples from the Bordeaux dump (in the fill and beneath the fill) identified either of these compounds (indeno(1,2,3-cd)pyrene and benzo(a)pyrene) in any of the soil samples (at levels above the method detection limits, MDLs).
3) A common source of PAHs is from the incomplete combustion of fossil fuels and the probe rig used for sampling was diesel powered.
4) All analytes included in the TTEC calculation are "J" flagged.

The single probe sample beneath the Bordeaux dump was also sampled for conventional landfill leachate parameters[1] (no leachate impacts were identified), metals and VOCs (all metals and VOCs met all MTCA B standards for potable water supply).

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[1] Total Dissolved Solids, Chloride, Nitrogen, Nitrate, Sulfate, Ammonia, Total Organic Carbon

2.3 Characteristics, Quantity, and Location of Materials to be Treated

The general areas planned for remedial action operations (i.e., excavation and stockpiling) are shown in Figure 2. The COCs and applicable cleanup standards are presented in Tables 2-1 and 2-2 (from the CAP). The RI/FS and CAP identified the following chemicals of concern (COCs) in the fill within the Bordeaux Dump area.

Lead, Selenium, Cadmium and Antimony – Human Health
Copper and Zinc – Ecological

The RI/FS also evaluated other analytes including, priority pollutant metals, VOCs, SVOCs, PCBs and fuel related compounds. All samples from the Bordeaux Dump area for these other analytes met all MTCA criteria for unrestricted residential land use (contact with soil, potential leaching impacts to groundwater, and ecological exposure). All samples beneath the fill in the Bordeaux Dump area also met all MTCA criteria for unrestricted residential land use (contact with soil, potential leaching impacts to groundwater, and ecological exposure). The estimated volume of soil requiring excavation at the Site is approximately 900 cubic yards. Actual volumes may be more (or less) based on the conditions encountered and the results of performance sampling.

The RI/FS and CAP identified the following COCs in the adjacent Rusted Drum area.

Cadmium– Human Health
Zinc – Ecological

The RI/FS also evaluated other analytes including, metals, VOCs, SVOCs, PCBs and fuel related compounds. All samples from the Rusted Drum area for these other analytes met all MTCA criteria for unrestricted residential land use (contact with soil, potential leaching impacts to groundwater, and ecological exposure). The estimated volume of soil requiring excavation at the rusted drum area is approximately 5 cubic yards. Actual volumes may be more (or less) based on the conditions encountered and the results of performance sampling.

The cleanup standards for the COCs listed above are based on one of the following:

1. MTCA Method A Soil Cleanup levels for unrestricted land use.
2. Soil-to-groundwater values calculated by equation 747-1 in the MTCA.
3. 90% Natural Background, calculated by WAC 173-340-709.
4. Criteria for unrestricted future use, Table 749-2 of the MTCA.
5. The final cadmium soil cleanup level will be determined before the start of remedial action by one of the MTCA methods described in WAC 173-340-747(3):
    - WAC 173-340-747(3)(b), Variable parameter three-phase partitioning model;
    - WAC 173-340-747(3)(d), Leaching tests;
    - WAC 173-340-747(3)(e) Alternative fate and transport models; or
    - WAC 173-340-747(3)(f) Empirical demonstration.

2.4 Schedule for Design and Construction

The schedule will be determined after Ecology review of this draft remedial action plan (this document), completion of the final remedial action plan and determination of subsequent weather related issues/constraints. The major work elements and anticipated duration are described below:

Work element	Duration and notes
1)Mobilization and clear and grub	1 week
2) Excavation	2 weeks
3) Sampling and evaluation of results	2 weeks, this may trigger added excavation
4) Waste designation sampling and offsite disposal	3 weeks
5) Backfill and Site restoration	1 week
6) Construction documentation	3 months
7) Well installation and 4 quarters of sampling	1 year
8) Site close-out request to Ecology	1 month

2.5 Description of Conceptual Plan and Sequence

The general plan and sequence for the remedial actions is to:

1. Clear and grub the fill area and immediate boundary and an adjacent area for stockpiling the excavated waste material.
2. Excavate the fill with an initial indication based on visual observations of fill(debris)/ discoloration(from prior burning).
3. Stockpile the excavated material and segregate as appropriate.
4. Sample the base of excavation for performance/confirmational sampling and sample the backfill borrow source (to verify it's suitability as clean fill).
5. Evaluate the performance sampling and perform additional excavation and sampling if required.
6. Sample stockpile(s) for waste designation.
7. Complete waste designation steps and dispose in accordance with applicable regulations.
8. Backfill the excavated area and re-vegetate.
9. Prepare construction documentation and as-built diagrams.
10. Install one groundwater monitoring well and sample for PAHs for 4 quarters.
11. Close-out the site and request written notification from Ecology that the requirements of the CAP and Consent Decree have been satisfactorily completed.

2.6 Engineering Justification for Design Parameters

The Site and adjoining property is zoned residential and the cleanup standards are based on residential land use. All wastes generated will be sampled and managed in accordance with WAC 173-303.

Based on the RI/FS and CAP, the COCs have been identified. The lists of COCs and cleanup standards are presented in Tables 2-1 and 2-2 (as identified in the CAP). The estimated volume of contaminated fill to be excavated is approximately 900 cubic yards. The planned stockpile area will cover approximately 1/3 of an acre.

2.7 Design Features for Control of Hazardous Materials Management/Spills

The general design features and considerations for control of potential hazardous materials and accidental discharges include the following:

1. Follow SOPs for drum removal/management (if any are encountered, but are not expected in this area; the rusted drum area is a single trash burning barrel).
2. Include run-on controls (covers) and runoff controls (silt fences) down slope of stockpiles which contain potentially contaminated material.
3. Have contingency plan/measures in place (see SOPs).
4. If precipitation is expected, cover the piles with 6 mil visqueen and weights (sandbags).
5. If the stockpiles are dry enough to become airborne with wind erosion, cover the piles with 6 mil visqueen and weights.
6. Implement appropriate storm water pollution prevention (SWPP) procedures defined in Appendix C (covering both SWPP and soil erosion considerations).

2.8 Design Features to Assure Safety of Workers and Local Residences

The general design features and considerations to assure the safety of workers and local residences include the use of PPE, site monitoring, access restrictions, and emergency response action SOPs. The details are described in the HASP and SOPs. The design features and considerations to assure long-term safety include cleanup to residential standards established under the MTCA.

2.9 Method for Waste Management and Disposal

The waste materials to be generated are expected to be approximately 900 cubic yards. The materials will be excavated and placed in one or more stockpiles. The dump area, planned stockpile locations and ingress/egress routes are shown in Figure 3.

The stockpile area will include two layers of 6 mil visqueen as an under layer. The stockpiles will be covered (as appropriate) if there is a chance of measureable precipitation or wind erosion; additional details are presented in Appendix C. The waste will be sampled and disposed of off-site at a Subtitle D landfill (unless otherwise required based on waste analysis). Transportation and disposal will be in accordance with applicable regulations; additional details are presented in Sections 3, 4 and Appendix A.

2.10 Other Location-Specific Characteristics

The location-specific characteristics that affect design, construction, and implementation of the selected cleanup action include:

1) The area is an undeveloped forested area (a plantation forest).
2) Access roads exist but the must be expanded for trucks/equipment.

3) An access/ work area around the filled area must be cleared.
4) A work area for spoils stockpiles must be cleared.
5) The typical soils type in the area is gravel to cobbles (glacial advance outwash gravel) so surface runoff does not occur.

2.11 Relationship of the Proposed Cleanup Action to Existing Land Use and Neighbors

The existing land use of adjacent properties is residential. The actions will be planned and implemented in a manner to minimize the duration of construction impacts and be implemented in accordance with the access agreements. The remedial action will be completed to meet residential cleanup levels and allow unrestricted use of the property and will be compatible with the uses of adjacent properties.

2.12 Probability of Flooding/Seismic Activity and Consideration of Local Planning and Development Issues

The site topography is nearly flat and the risk of flooding is very small (other than potential complications in excavation and materials management in heavy precipitation). One option for the borrow source (required for backfill of the dump site) is the existing gravel pit adjacent to Bordeaux Road south of the Site. Excavation from this borrow area will be planned and implemented when conditions are sufficiently dry to allow access within the gravel pit. The other option for the borrow source is the area beneath the stockpile/staging area adjacent to the dump site. One, or both, of these borrow areas may be used.

The site work does not include structures so impacts from potential seismic activity (i.e., impacts affecting the shallow excavation process) are expected to be minor.

The property is zoned residential and the cleanup standards in the CAP are residential, therefore any issues with local planning and development agencies should be minor (the project is not a development). The applicable requirements of the State Environmental Policy Act (SEPA, chapter 43.21C RCW) have been met (Ecology 2010).

2.13 Planned Construction Testing for Quality Control

The primary testing planned is associated with the compliance monitoring plan (i.e., chemical testing) which is presented in the following sections. The only other construction testing required may be compaction tests of the backfill. If the backfill source is sand/gravel, no testing will be necessary as the backfill will have sufficient bearing capacity upon placement and one pass with a dozer or trackhoe.

2.14 Compliance Monitoring During Construction

The HASP (and SOPs) provides a description of the construction procedures and monitoring that will be used to assure that the safety and health requirements of WAC 173-340-380 are met. The potential for temperature extremes to impact the work are important (particularly for hot weather). Some of the work could require workers in PPE and potentially include the use of respirators. The HASP includes specific precautions/measures to avoid heat related problems.

2.15 Other Information Related to Applicable Permits and Access

The applicable requirements of the State Environmental Policy Act (SEPA, chapter 43.21C RCW) have been met with the SEPA checklist and Determination of Nonsignificance (DNS) by Ecology (Ecology 2010). The DNS determination was included in the public notice/comment period. Property access is not an issue as the Lufkins own the property of the Site.

The ARARs evaluation in the RI/FS identified one Thurston County permit; a grading permit for moving more than 50 cubic yards (covered under Thurston Co. Building Code Title 14.37 TCC, International Building Code App. J, Grading). Subsequent to the RI/FS, Thurston County has prepared new guidelines for storm water and erosion control which apply to developments (Thurston County 2009). Although this project is not a new development it is an "action", one of the County considerations regarding applicability and standard exemptions is whether the action will clear more than 7,000 square feet (~ 1/6 of an acre). The planned remedial action will exceed this 7,000 square foot threshold, hence the substantive requirements of a grading permit will be met.

This is consistent with WAC 173-340-710 (and Ecology policy 710) which exempt remedial actions from the procedural requirements of specific state environmental permits and local government permits when the remedial action is conducted under an agreed order or consent decree. The intent of the exemption is to expedite cleanup of contaminated sites. The applicable requirements of a grading permit are to prevent storm water pollution and erosion. The details regarding the plans and procedures to meet the substantive requirements of a grading permit are presented in Appendix C.

3.0 Monitoring

The planned cleanup action for the Bordeaux Dump Site includes compliance monitoring to verify the remedial actions implemented meet the MTCA requirements. The compliance monitoring plan was created through a Data Quality Objectives (DQOs) process in order to evaluate and meet the necessary MTCA requirements (see Table 3-1). The DQO process is used to identify the anticipated project scope and decisions and establish the data requirements to support those decisions (i.e., what sampling is required?). The specific MTCA requirements for compliance monitoring of soil and groundwater remedial actions under WAC 173-340-410 are as follows:

> (a) Protection monitoring. Confirm that human health and the environment are adequately protected during construction and the operation and maintenance period of an interim action or cleanup action as described in the safety and health plan;
>
> (b) Performance monitoring. Confirm that the interim action or cleanup action has attained cleanup standards and, if appropriate, remediation levels or other performance standards such as construction quality control measurements or monitoring necessary to demonstrate compliance with a permit or, where a permit exemption applies, the substantive requirements of other laws;
>
> (c) Confirmational monitoring. Confirm the long-term effectiveness of the interim action or cleanup action once cleanup standards and, if appropriate, remediation levels or other performance standards have been attained.

3.1 Sampling for Protection Monitoring

The excavation and off-Site disposal includes protection monitoring during the remedial action (soil excavation) to confirm human health and the environment are adequately protected (during the removal action). Specific elements of the protection monitoring plan are presented in the HASP.

3.2 Sampling for Performance Monitoring

Performance monitoring is required during (and following) excavation to confirm that the remaining soils at the dig face of the excavation and the backfill borrow source meet cleanup levels at the appropriate points of compliance. The analytes for the Bordeaux Dump excavation will include the COCs identified in the CAP (presented in Tables 2-1 and 2-2 of this Remedial Action Plan). All soil samples will be collected and labeled in accordance with the sampling methods described in the SOPs. All samples collected for performance monitoring (from the excavation and the area beneath the spoils stockpile [after removal]) will be discreet samples.

3.2.1 Sampling from Excavation

Based on the RI/FS and CAP, the COCs have been identified. The excavated area will be sampled under a grid pattern (see Figure 4) with approximately 13 sampling locations. Sampling locations will be assigned at the center of each grid by default. After excavation, any remaining visual indication of fill (debris)/discoloration will be noted within each grid and the sampling will be adjusted to these points rather than the default center location. If the removal action creates an excavation area with sidewalls, the sidewalls will be sampled. If the removal action creates an excavation area without sidewalls (i.e., sloped edges up to the existing ground surface) those sloped areas will be sampled. Excavation of the Bordeaux Dump Site and the adjacent Rusted Drum Area will continue until sampling results confirm that the cleanup action has attained cleanup standards.

3.2.3 Sampling from Backfill Borrow Source

There are two potential borrow source that could be used as backfill. One is an existing gravel pit (adjacent to Bordeaux Road, on property owned by the Lufkins, and used in the previous land development of the prior 44-acre parcel). The Site RI/FS included sampling on a grid pattern over the base of the gravel pit and all samples met all applicable MTCA Method B standards for all analytes (metals, SVOCs, VOCs, and fuel related compounds). After the borrow source is excavated to a stockpile (and before transport) one composite sample of the backfill will be collected and analyzed for metals. If during the backfill excavation/stockpiling, there is any indication of staining or smell, additional analytes (SVOCs or fuel related compounds) will be added as appropriate to verify this borrow source meets MTCA Method B requirements.

The other potential borrow source for the backfill is the area beneath the waste spoils stockpile [after removal] adjacent to the Bordeaux Dump site (on property owned by the Lufkins). This area will be sampled as part to the performance monitoring to verify that the excavated stockpiles are fully removed from this work area. This performance monitoring will include six (6) grid points over the stockpile area (collected as discrete samples) and will include the analytes presented in Tables 2-1 and 2-2 (the COCs from the CAP). If during the backfill excavation, there is any indication of staining or smell, additional analytes (SVOCs, VOCs or fuel related compounds) will be added as appropriate to verify this borrow source meets MTCA Method B requirements.

3.2.3 Waste Characterization Sampling

Performance monitoring will include waste characterization sampling to meet requirements of both WAC 173-303 and the acceptance criteria of the disposal facilities. Excavated materials (waste and soil) will be characterized with respect to TCLP data and any other requirements (pretreatment) of a Subtitle C or D facility. Data will be collected for each discrete stockpile of excavated material. Following receipt of the laboratory results for the waste characterization sampling, the waste designation steps presented in Appendix A (from WAC 173-303) will be followed. The sampling procedures (specifically, multi-incremental (MI) composite versus discrete samples) will follow acceptance criteria of the disposal facilities. The typical sampling frequency required (based on the acceptance criteria of the disposal facilities) is 2 samples per stockpile and/or at least 2 samples per 500 cubic yards.

3.3 Sampling for Confirmational Monitoring

In addition to the soil sampling described above, confirmational monitoring of the groundwater for PAHs will be conducted at a monitoring well (to be installed after the excavation). The objective is to collect data on the condition of groundwater after removal of the fill soil and to verify that the trace levels of PAHs detected in the prior groundwater sample do not represent concentrations that exceed MTCA standards. The groundwater sampling will be completed for four quarters following the soil remedial action. All groundwater samples will be collected and labeled in accordance with the sampling methods described in the Sampling and Analysis Plan (SAP, Section 4) and SOPs.

3.4 Summary of Planned Performance Monitoring

As discussed previously, the COCs have been identified based on the RI/FS and CAP. The excavated area will be sampled under a grid pattern (see Figure 4) with approximately 13 sampling locations. Sampling locations will be assigned at the center of each grid by default. After excavation, any remaining visual indication of fill (debris)/discoloration will be noted within each grid and the sampling will be adjusted to these points rather than the default center location. Excavation of the Bordeaux Dump Site and the adjacent Rusted Drum Area will continue until sampling results confirm that the cleanup action has attained cleanup standards. The base of the stockpiles area will also be sampled to verify that all materials are removed. Additional details on the procedures and methods for sample collection and analysis are presented in the SAP in the following section.

4.0 Sampling and Analysis Plan

This section describes methods and procedures that will be used in characterizing soil and groundwater at the Site. This section includes field sampling methods, sample locations and analyses, quality assurance/quality control (QA/QC) requirements, sample handling procedures, laboratory analytical methods, monitoring well installation procedures, and decontamination and waste disposal procedures. A summary of the anticipated sample types, matrix, chemical analyses, and approximate number of each type of sample to be collected is presented in Table 4-1.

4.1 Soil and Groundwater Sampling Methods and Procedures

Sampling is expected to include soil sampling during soil excavation activities, soil samples from stockpiles and groundwater samples collected from monitoring wells. The methods and procedures for collection of each of these types of samples are described below. The laboratory analyses to be conducted on each type of sample are presented in Table 4-1. Standard Operating Procedures (SOPs) for soil, and groundwater sampling are included as an Appendix to the QAPP.

4.1.1 Surface Soil Samples

Surface soil samples will be collected as part of the confirmational sampling (from the base of the excavation). Surface soil samples will be collected using pre-cleaned disposable plastic scoops as described below. A grab sample will be collected from the designated location (center of grid) or from the most contaminated soil based on visual observations and any other field screening. If shallow subsurface soil samples are collected, then a decontaminated shovel will be used to dig to the desired sampling depth and the sample will be collected as described above. All sampling equipment that is non-disposable will be decontaminated and disposable items (sample gloves and plastic scoops) will be cleaned of soil and placed into a waste container for off-site disposal.
All soil samples collected will include the following steps:

- Record the location and depth using an appropriate measure (e.g., a tape measure from two specific reference points, or a hand-held global positioning system (GPS) receiver
- Put on a new pair of sampling gloves
- Remove surface vegetation (if any) using care to minimize mixing of the soil
- Using a disposable plastic scoop; remove soil from the sample location, if this Site is selected for field QC, increase the amount of soil collected
- Fill appropriate number of sample containers depending on analyses required from the location.

4.1.2 Groundwater Samples

Groundwater samples will be collected as part of the confirmational sampling (from a new well to be installed). Groundwater samples will be collected using pre-cleaned dedicated or disposable plastic sampling pump (Watera inertial pump or equivalent).

All sampling equipment that is non-disposable will be decontaminated and disposable items (sample gloves and plastic scoops) will be cleaned of soil and placed into a waste container for off-site disposal. All groundwater samples collected will include the following steps:

- Record the location and depth to water using an appropriate measure (e.g., e-tape or equivalent)
- Purge the well in accordance with the sampling SOPs
- Put on a new pair of sampling gloves
- Fill appropriate number of sample containers depending on analyses required from the location.

4.2 Sample Analyses

Sample analysis will be conducted on the soil and groundwater samples collected, field quality control samples, and decontamination water collected during remedial actions. Sample analytical methods and data quality for samples collected from the Site have been selected based on Site COCs. Laboratory analyses of all performance monitoring samples collected from the excavation will include metals. Additional analytes (e.g., TCLP analysis for lead) will be included in the waste characterization sampling as required by the disposal facilities acceptance criteria. If field observations and/or field screening indicated petroleum products (i.e. gas, diesel, oil), samples will also undergo hydrocarbon identification (NWTPH-HCID). Table 4-2 presents the analytical methods, required sample containers, holding times, and practical quantitation limits for the planned analyses to be conducted. Table 4-2 also presents information for other analytes in the event that changed conditions create the need for other analysis, if necessary.

The analytical QA/QC is presented in the QAPP (Appendix B). The data quality includes confirmation sampling and analysis activities that are conducted using an off-Site laboratory. Documented sampling and analysis procedures and QA/QC requirements will be followed in accordance with this Work Plan and the QAPP.

The overall Quality Assurance/Quality Control (QA/QC) objective for this SAP is to provide data of known and sufficient quality to assure compliance with Ecology requirements and to support the project-specific decisions that are to be made based on the data. All chemical analyses will include a report from the laboratory detailing the results of quality control testing. Analytical methods, QA/QC, and documentation will be equivalent to Tier 2/ Level 3 data quality. The chemical analyses of samples will be conducted by a laboratory that is licensed/accredited for the specific analysis in the State of Washington

4.3 Field and Laboratory Quality Assurance / Quality Control

Quality Control measures will be taken to confirm the integrity of the field and laboratory data generated during the sampling program. These measures will consist of analyzing samples to establish the consistency and validity of sample data. Quality Control samples associated with the samples collected will include (as appropriate) field duplicates, trip blanks, and equipment rinsate samples. Quality Control samples associated with the analytical laboratory will include method blanks, internal standards, surrogate spikes, matrix-spiked duplicates, calibration standards, and measurements of precision, accuracy, and completeness. Field and laboratory QC will include:

- Duplicate Samples - Field duplicate samples will be collected at a frequency of one duplicate for every twenty samples collected. Both soil and water duplicate samples will be submitted to the laboratory. The duplicate samples shall be submitted blind to the analytical laboratory and be noted in the field sampling notebook.
- Trip Blank Samples – When VOC sampling is planned, trip blanks will be prepared by the laboratory to accompany field samples until they are analyzed at the laboratory. Trip blank samples will be analyzed for VOCs at the same time that analyses of the field samples are performed. Trip blank samples will consist of deionized water prepared in 40-milliliter volatile organics analysis (VOA) containers.
- Equipment Rinsate Samples - Equipment rinsate samples will be collected on decontaminated sampling equipment if non-disposable sampling equipment is required. Deionized water will be poured over the equipment and collected in sample containers. The rinsate samples will be analyzed for the same parameters as the associated soil and water samples.
- Laboratory QC Samples - All samples will be analyzed using analytical methods consistent with Ecology approved test methods (e.g., SW-846 Methods or Standard Methods [SM]). Method blanks, internal standards, surrogate spikes, spiked matrix samples, calibration standards, and duplicate samples will be performed according to the laboratory and method-specific procedures. Measurements of precision, accuracy, and completeness will be compiled and calculated by the laboratory and reviewed as specified in the QAPP.

The requisite QC records for sampling and analysis activities are to be generated and controlled as prescribed in the QAPP and specified below. Field documentation for this project will include field logs, Chain-of-Custody Forms, recording of sample IDs, cooler custody seals (if samples are shipped via courier), and Sample Data Sheets (SDS).

A field logbook is to be maintained by the sampling staff for use in documenting details of field sampling and analysis activities. The information in the field logbook is intended to serve as a log and memory aid in documenting field activities and in preparation of the Remedial Action Summary report. Additional activities related to the field and laboratory QA/QC are addressed in the QAPP (Appendix B).

4.4 Sample Handling Procedures

All samples will be collected, handled, and shipped to the analytical laboratory as specified in the following sections and in the QAPP (Appendix B). Analytical methods, sample container requirements, preservation, and holding times specific to this project are presented in Table 4-2.

4.4.1 Sample Containers and Preservation Requirements

All analytical sample containers will be obtained from a source that certifies them to be clean and pre-preserved (as appropriate). Sample labels will be attached to the sample containers. The parameter(s) for which each container is intended will be written on the sample label. Table 4-2 describes the required analyses and methods, containers, volumes, preservation, and holding times for samples collected. Collected samples will be checked to ensure all required data have been recorded on the label and then placed in a ziplock baggie. The baggie will be sealed and placed in a cooler with ice to be maintained at 4^{o} C +/- 2 degrees.

4.4.2 Chain-of-custody, Sample Labeling, and Field Notes

Chain-of-custody procedures will be used to maintain a verifiable record of sample handling during sample collection and analysis. Field notes, sample ID records, chain-of-custody records, and other analytical records will be retained.

Field records will be completed at the time samples are collected. All field records will be initialed by the sampling team and will include the sample identification and the date and time the sample was collected. Field notes will also include sample locations, sample matrix, preservative used, sampler's name, pertinent field data (for example, weather conditions, etc.) and type and size of sample containers. Sample labeling will use unique sample identification numbers that will be used for sample tracking and identification during collection, analysis, review and reporting.

5.0 Remedial Action Reporting

The remedial action reporting will summarize the work completed in accordance with the MTCA requirements (WAC 173-340-840) and the CAP. The construction documentation will include an as-built drawing and a brief summary the construction phases. This will include a summary of construction techniques and materials used and tests/measurements performed.

The remedial action report will include analytical results of the performance/confirmational testing, a summary of the actual waste volumes excavated and disposition along with the manifests. The remedial action report will include a Licensed Engineer's opinion, based on testing results and inspections, as to whether the remedial action has been constructed in substantial compliance with this remedial action plan and related documents.

Groundwater monitoring will commence after the soil removal action and continue for 4 quarters. A total of two groundwater monitoring reports (each covering two quarters) will be submitted.

Bimonthly reporting to Ecology will be prepared for any period in which activities required under the CAP and this remedial action plan have been completed. If a bimonthly period passes when no activities required under the CAP have been completed, Ecology will be notified.

6.0 References

CALIBRE 2007. Remedial Investigation/Feasibility Study Report, Hytec – Littlerock Site, Halo-Kuntux Lane, Littlerock, Washington. August 2007.

Ecology 2009a. Draft Cleanup Action Plan for Bordeaux Dump Site, Halo-Kuntux Lane, Littlerock Washington. Prepared by: Washington State Department of Ecology, Southwest Regional Office, Toxics Cleanup Program. December 2009.

Ecology 2009b. Draft Cleanup Action Plan for Fiberglass Debris Landfill, Hytec-Littlerock Site, Halo-Kuntux Lane, Littlerock Washington. Prepared by: Washington State Department of Ecology, Southwest Regional Office, Toxics Cleanup Program. December 2009

Ecology 2010. SEPA Determination of non-significance (DNS), Washington State Department of Ecology, Southwest Regional Office, 1 June 2010.

Thurston County 2009. Thurston County Drainage Design and Erosion Control Manual, Volume I Minimum Technical Requirements and Site Planning, Prepared by: Thurston County Water Resources Unit, Department of Resource Stewardship. July 2009

Tables

Table 2-1: Soil Cleanup Levels and Chemicals of Concern, Bordeaux Dump Area

Chemicals Of Concern	Highest Concentration Measured, mg/kg	MTCA Soil Cleanup level, mg/kg	90% Natural Background, mg/kg(3)	Ecological Criteria for unrestricted land use mg/kg(4)
Lead	940	250(1)	**-**	**220**
Copper	110	577(2)	**-**	**100**
Selenium	9.5	5.2(2)	**3.2**	0.8
Arsenic	7.7	**20**(1)	**-**	**20**
Cadmium	4.1	**0.69(2)(5)**	-	25
Zinc	1,200	5,970(2)	**-**	**270**
Antimony	6.1	**5.4(2)**	**-**	**-**

Table 2-2: Soil Cleanup Levels and Chemicals of Concern, Rusted Drum Area

Chemicals Of Concern	Highest Concentration Measured, mg/kg	MTCA Soil Cleanup level, mg/kg	90% Natural Background, mg/kg(3)	Ecological Criteria for unrestricted land use mg/kg(4)
Cadmium	3.1	**0.69(2)(5)**	-	25
Zinc	450	5,970(2)	**-**	**270**

The following footnotes apply to both Tables 2-1 and 2-2.
(1) MTCA Method A Soil Cleanup levels for unrestricted land use.
(2) Soil-to-groundwater values calculated by equation 747-1 in the MTCA.
(3) 90% Natural Background, calculated by WAC 173-340-709.
(4) Criteria for unrestricted future use, Table 749-2 of the MTCA.
(5) The final cadmium soil cleanup level will be determined before the start of remedial action by one of the MTCA methods described in WAC 173-340-747(3):

- WAC 173-340-747(3) (b) Variable parameter three-phase partitioning model
- WAC 173-340-747(3) (d) Leaching tests
- WAC 173-340-747(3) (e) Alternative fate and transport models
- WAC 173-340-747(3) (f) Empirical demonstration.

Values presented in **Bold font** are the applicable soil cleanup levels at the Point of Compliance, unless noted otherwise based on footnotes listed above.

Table 3-1 Data Quality Objectives Process Used to Identify Sampling Requirements

DQO process step	**Excavation at Bordeaux Dump**	**Existing Data**	**Additional Data Required to Support Decision**
1) The problem to be resolved at the site	Removal action at the Bordeaux Dump must meet MTCA criteria. Lead, selenium, antimony, cadmium, zinc, and copper are present in solid wastes/soil in excess of MTCA limits.	Site has been sampled and COCs identified. Test pit data indicating boundaries of fill and the nature of fill constituents. Samples beneath the fill (> 2 feet deep) where below MTAC B standards for all analytes	Sampling at the base of excavation that demonstrates compliance. Need to determine precise boundaries of contamination in excess of MTCA standard (to be identified in the excavation and sampling).
2) The boundaries of the study	Bordeaux Dump Site and other surrounding areas above MTCA Residential Standards (including the Rusted drum area)	General mapping of fill has been conducted laterally and vertically	Data are needed (as part of excavation) to verify extent to which contaminants have migrated laterally and vertically.
3) The decisions needed to resolve the problem	1) Has the excavation met cleanup standards?	Site has been sampled and COCs identified. Lead, Antimony, Cadmium, Selenium – Human Health Copper and Zinc – Ecological	Sampling at base of excavation dig face that demonstrates compliance.
	2a) Per the waste acceptance criteria, is the waste acceptable at a Subtitle D (non-hazardous waste) landfill? 2b) Does waste meet Waste Acceptance Criteria for selected repository?	COCs identified. Lead below industrial standards, but exceeds residential standards, the other constituents (listed above) slightly exceed residential or ecological exposure standard.	Excavated materials (waste and soil) must be characterized with respect to TCLP data and any other requirements from the disposal facility. Characterization data is necessary for each discrete stockpile or batch of materials per stockpiling strategy.
	3) If answer to question 2 is no, does the waste require treatment at a Subtitle C (hazardous waste) landfill?	COCs identified. Lead below industrial standards.	Batch failing to meet waste acceptance criteria must be characterized for TCLP data and any other requirements from the disposal facility (pretreatment requirements i.e., stabilization of lead, if required)
	4) Are any other WAC 173-303 requirements applicable which change the above decisions (1 through 3)?	Total PAHs and total Halogenated organic compounds (HOCs) are below MTCA residential criteria and also below 173-303 waste designation criteria for total PAHs and total HOCs	None,

Table 3-1 Data Quality Objectives Process Used to Identify Sampling Requirements			
DQO process step	**Excavation at Bordeaux Dump**	**Existing Data**	**Additional Data Required to Support Decision**
	5) Is the backfill borrow source suitable for backfill at this site?	Backfill is gravel with suitable compressive strength. No further testing. Sampling of gravel pit (grid pattern) has been completed. Existing soil samples demonstrate suitability from the gravel pit. Sampling at base of stockpile area has not been completed (yet) but will be following waste removal/disposal.	Will take composite sample of clean backfill to demonstrate suitability if gravel pit is chosen as the backfill source. If base of stockpile area is used, grid sampling will be completed and a composite sample collected.
	6) Groundwater is not impacted by the removal and backfill?	Single probe sample below landfill. Sampled for conventional landfill leachate, no fill impact. Sampled for metals and VOCs, no fill impact. Trace levels of cPAHs detected but "J" flagged under 1 ppb (with operation of a diesel geoprobe rig). cPAHs identified as the sole COC in groundwater in the CAP	Well to be installed at Bordeaux Dump and sampled quarterly for PAHs.
4) The inputs to the decision	Concentrations of COCs at the base of the excavation, performance/ confirmational sampling for COCs at the base of the excavation.	COCs identified, RI data found clean soil beneath fill (> 2 feet) for all samples and all analytes.	Sampling at the bottom of excavation dig face.
	Characterization of waste soil stockpiles.	COCs identified	Stockpile sampling for COCs, determination of acceptance at appropriate disposal facility.
	Quarterly confirmational groundwater sampling.	cPAHs identified as COCs.	Monitoring well to be installed at site and sampled for COCs.

5) The decision rules	If ../ then… format with quantitative limits: <u>For the excavated spoils stockpiles:</u> If the 95% upper confidence limit (UCL) of mean of performance samples are under MTCA standards, and/or/ No sample is twice the standard No more than 10% of samples are above the standard If dig face of excavation samples exceed MTCA criteria, then excavation will continue in that direction until sample does not exceed criteria. If excavated material does not exceed MTCA residential criteria, then it will be classified as clean fill, or non hazardous solid waste and managed accordingly. If excavated material exceeds MTCA standards, then it will be tested in accordance with waste acceptance criteria for the selected disposal site. If excavated material meets waste acceptance criteria, then it will be transported to disposal site for disposition. If excavated material fails waste acceptance criteria, then it will be treated in accordance with pretreatment requirements and managed accordingly. <u>For the planned borrow source and other sampling:</u> If proposed fill meets MTCA residential criteria, then it will be used to complete the backfilling of the excavation. If proposed fill material fails the backfill criteria, then an alternate backfill source will be used. If groundwater samples exceed MTCA criteria, then results will be reported and corrective actions considered as appropriate.

Table 4-1
Sample Types, Media, and Analyses

Sample Types	**Media**	**Analyses**	**Approximate Number of Samples**
Soil Samples from base of excavation	Soil	Metals	15-25 (potentially one or more grab samples collected per grid if contamination evident)
Monitoring Well Samples	Water	PAHs	4 quarters
Waste characterization Waste (excavated soil, decon water, soil cuttings, well development water)	Soil	Metals, and TCLP as required by off-site disposal facility, other analytes (VOCs, SVOCs) to be determined by disposal facility waste acceptance criteria (following their review of RI characterization data & summary)	10-15 samples The sampling procedures (specifically, multi-incremental (MI) composite versus discrete samples) will follow acceptance criteria of the disposal facilities. The typical sampling frequency required (based on the acceptance criteria of the disposal facilities) is 2 samples per stockpile and/or at least 2 samples per 250 cubic yards.

All sample numbers listed above are approximate and do not include additional QA samples (trip blanks and field duplicates/splits).

Table 4-2

Sample Analytical Methods, Containers, Preservatives, and Holding Times

Analysis/ Methods	Matrix	Sampling Container	Holding Time	Preservation	Practical Quantitation Limit
VOCs EPA 8260C	Water	3-40 ml vials	14 days to extraction, 14 days to analysis	Cool to 4^o C, HCl to pH <2	0.5 – 2.0 ug/L
SVOCs EPA 8270D	Water	2 1-Liter Amber Glass	14 days to extraction, 40 days to analysis	Cool to 4^o C,	0.2 – 15 ug/L
Priority Pollutant Metals EPA 6020/7000	Water	1-1Liter poly	6 months to analysis	Filter, and then HNO_3 to pH <2 Cool to 4^o C	0.0002 – 0.001 mg/L
NWTPH-HCID	Water	2-1Liter amber glass bottles	7 days to extraction analyze within 40 days	Cool to 4^o C, HCl to pH <2	0.1 - 0.5 mg/L qualitative
TSS EPA 160.2	Water	1-1 Liter poly	7 days to analysis	Cool to 4^o C,	10 mg/L
VOCs EPA 8260C/5035A	Soil	Encore or Methanol preserved 40 ml. vials	24 hours to preservation, 14 days to analysis	Encore or Methanol Cool to 4^o C,	1.0 – 5.0 ug/kg (Encore), 8 – 200 ug/kg (lab or field preserved with methanol)
SVOCs EPA 8270D	Soil	1-8 oz. CWM	14 days to extraction, 40 days to analysis	Cool to 4^o C,	20-500 ug/kg
Priority Pollutant Metals EPA 6010/7000	Soil	1-8 oz. CWM	30 days to extraction, 6 months to analysis	Cool to 4^o C,	0.02 – 5 mg/kg
NWTPH-HCID	Soil	1-8 oz. CWM	7 days to extraction, Analyze within 14 days	Cool to 4^o C,	20 mg/kg qualitative
Grain Size ASTM D422	Soil	1-16 oz. poly	none	none	N/A
TCLP EPA 1311	Soil / Water	As per analysis conducted (see above)	Extraction within holding time of analysis above	Cool to 4^o C,	As per analysis conducted above

Note: pH, Dissolved Oxygen, ORP, Turbidity, and Specific Conductance will be measured in the field during collection of groundwater samples from monitoring wells.

CWM = Clear Wide Mouth glass container
VOCs = Volatile organic compounds
SVOCs = Semi-volatile organics

Figures

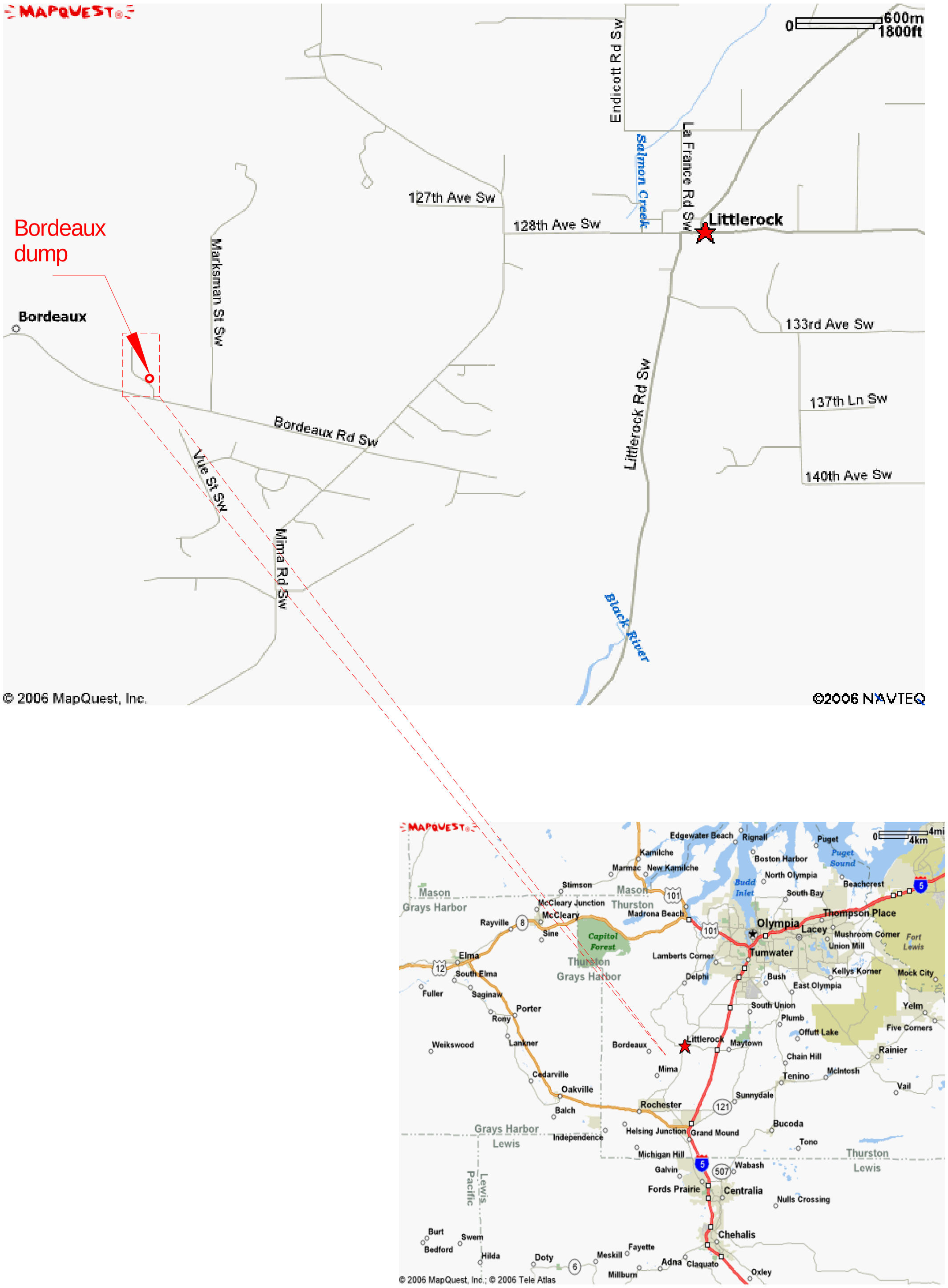


Figure 1. Site Vicinity and Location, Bordeaux Dump

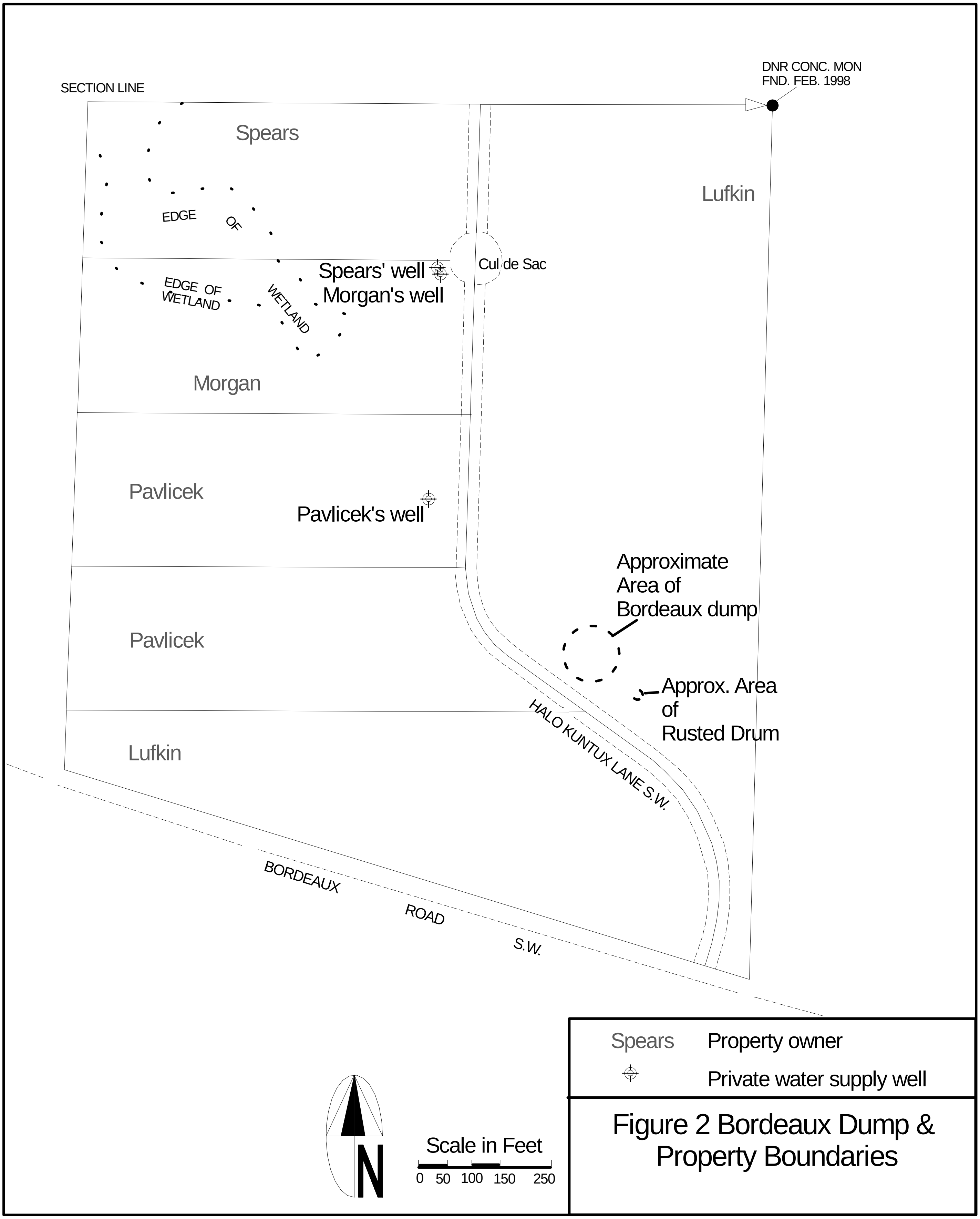
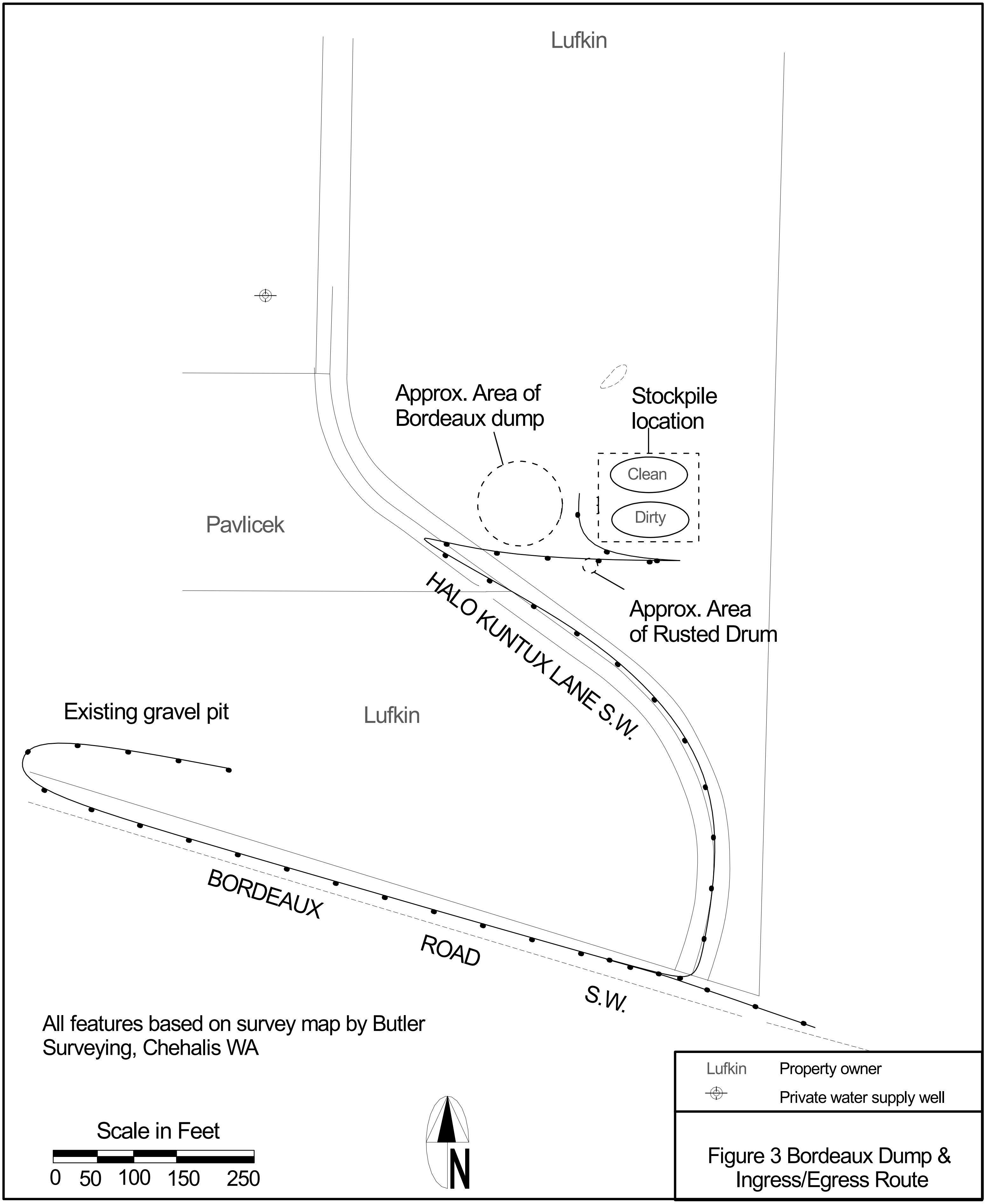


Figure 2 Bordeaux Dump & Property Boundaries



All features based on survey map by Butler Surveying, Chehalis WA

Figure 3 Bordeaux Dump & Ingress/Egress Route

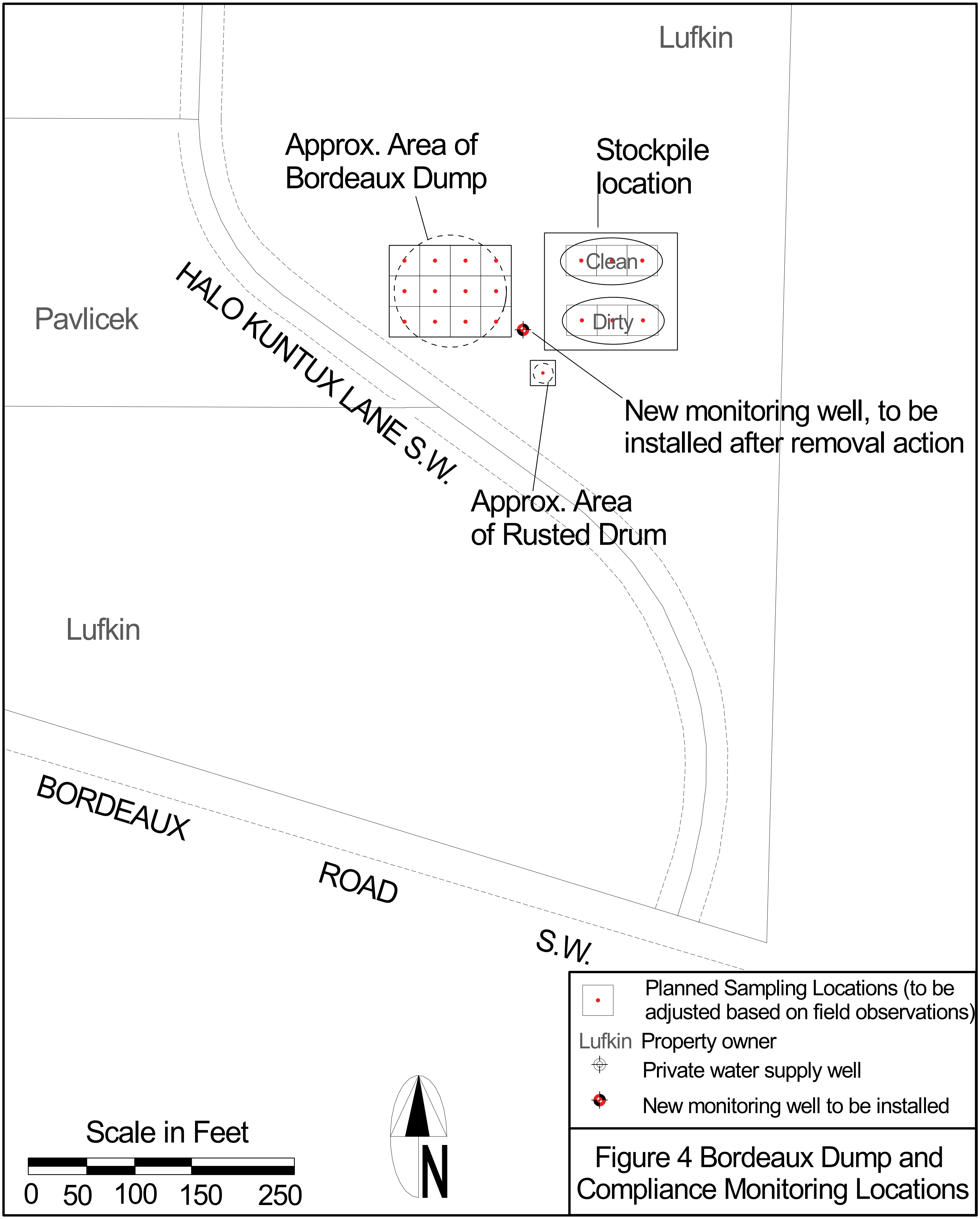


Figure 4 Bordeaux Dump and Compliance Monitoring Locations

Appendix A
Designation of Solid Waste Following Washington Dangerous Waste Regulations

1.0 Introduction

This Appendix has been prepared to summarize the waste designation steps for the excavated material at the Bordeaux Dump Site (Site). The evaluation steps follow the requirements set forth in the Washington State Dangerous Waste Regulations (Washington Administrative Code [WAC] 173-303). Soil sampling of the fill material has been completed as part of the site-characterization phase of the Remedial Investigation. Existing site-characterization sampling of the fill material at the site has included multiple test pits located throughout the filled area and the COCs have been identified. The objective of this Appendix is to delineate the process that will be used in anticipated waste designation based on the existing data and stockpile characterization. The waste designation process described in this appendix is from WAC 173-303.

2.0 Waste Sampling and Analysis

The prior site-characterization samples were analyzed in accordance with analytical procedures defined in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication SW-846*. None of the site-characterization samples were analyzed via *Method 1311 Toxicity Characteristic Leaching Procedure* (TCLP) for evaluating designation as a characteristic waste. Initial review of the data indicates that designation as a TCLP characteristic waste seems unlikely since the primary chemical constituents detected at higher concentrations are not on the TCLP characteristic waste list, however the TCLP testing for lead still needs to be conducted.

The other characteristic waste criteria, ignitability, corrosivity, and reactivity, have not been tested as part of the existing site-characterization sampling. However, visual observations of the bulk fill material (typically soil mixed with debris) would indicate that designation as a characteristic waste from these criteria seems highly unlikely. Additional sampling/analysis for TCLP and other characteristic waste criteria will be completed as appropriate and necessary.

The anticipated waste designation described herein is intended to apply generally to the bulk fill material present at the site (the sampling used as the basis of this evaluation is considered representative of the bulk fill). If containers are encountered which contain materials that are different than the bulk fill material, then the waste designation of that material may also be different depending on the constituents present in any containers found.

3.0 Waste Designation

The general waste designation steps required under WAC 173-303 are presented in Table 1 along with brief descriptions regarding applicability.

Following the initial evaluation summarized in Table 1, the procedures described in WAC 173-303-100 will be completed to determine the applicable waste designations. The following sections describe the evaluation to determine the waste designation for the fill material at the site.

3.1 Toxicity Criteria

The book designation procedure will be used to determine the Toxicity Criteria waste designation (for waste with U-listed constituents). The toxicity criteria procedure basic steps are as follows:

a) Determine toxic category for each toxic constituent present in waste (see Table 2 for selected examples);
b) Calculate the concentration of each constituent present on a percentage basis;
c) Calculate the Equivalent Concentration (EC) per the following equation (from WAC 173-303):

$$\text{Equivalent Concentration (\%)} = \sum X\% + \sum A\%/10 + \sum B\%/100 + \sum C\%/1{,}000 + \sum D\%/10{,}000$$

where ∑ (X, A, B, C, or D)% is the sum of all concentration percentages for a each Toxic Category (from Table 2).

d) Determine waste designation (EC < .001% then not a dangerous waste, EC > .001%<.1% then a dangerous waste and EC > .1% then a extremely hazardous waste).

Table 3 presents a summary of the identified Non-Human Toxicity Values for selected constituents along with the corresponding Toxic Category ranking/classification as specified in WAC 173-303-100. The toxicological data for each known chemical constituent (VOCs, SVOC and metals) were identified from two primary resources that are maintained by the National Institutes of Health (NIH):
http://toxnet.nlm.nih.gov/ and
http://chem.sis.nlm.nih.gov/chemidplus/chemidheavy.jsp.

For this initial evaluation of data from the site, the highest concentration of each chemical constituent (from all of the test pits) was used to determine a worst-case waste designation. This approach represents a worst-case analysis because the highest constituent concentrations detected are from different samples. The worst-case EC for the waste was calculated at 0.00006%. Since this is less than 0.001% the fill is not designated as a dangerous waste following the toxicity criteria defined in WAC 173-303-100 (based on the RI data collected).

3.2 Persistence Criteria

The waste designation procedure for the persistence criteria set forth in WAC 173-303-100 (6) is described based on the total concentration level (of all constituents present) of either the halogenated organic compounds (HOC) or the polycyclic aromatic hydrocarbons (PAH) on a percentage basis. These compounds are simply summed on a % weight basis (PAHs and sum HOCs separately) and compared with the WAC 173-303 criteria (greater than 0.01% for sum HOCs for D,W and/or greater than 1% for sum HOCs or sum PAHs for EHW). Based on the existing RI data, waste is not expected to designate when compared to either of these criteria.

Tables
for this Appendix

Table 1 WAC 173-303 Waste Designation Steps and Applicability to Bordeaux Dump Site

WAC Designation Step	**WAC Waste Designation/Evaluation Criteria**	**Applicability to fill at Site**
1	Solid Wastes	Materials present are solid waste that are not a usable product
2	Exemptions and Exclusions	None apply to preclude designation
3	Listed Discarded Chemical Products (P and U Waste Numbers)	Chemicals detected may include U-list constituents (but not discarded chemical products)
4	Listed Sources (F, K and W001 Waste Numbers)	The known source of the fill material is unknown, no listed sources apply
Characteristic Wastes (D Waste Numbers)		
5	Ignitable Characteristic (D001 Waste Number)	Data have not been collected regarding ignitability, present indication seems unlikely to be applicable
6	Corrosive Characteristic (D002 and WSC2 Waste Numbers)	Data have not been collected regarding corrosivity, present indication seems unlikely to be applicable
7	Reactive Characteristic (D003 Waste Number)	Data have not been collected regarding reactivity, present indication seems unlikely to be applicable
8	Toxic Characteristic (TCLP) (D004-D043 Waste Numbers)	Data have not been collected regarding TCLP, present indication seems unlikely to be exceeded, but needs to be tested
Additional Washington State Only Designation		
9	Washington State Toxic Criteria	Characterization data indicates U-list constituents are present, evaluation following WAC 173-303-100 (book designation) procedures required
10	Washington State Persistent Criteria (WP01, WP02 and WP03 Waste Numbers)	Characterization data indicates Halogenated and Polycyclic Aromatic Hydrocarbons compounds detected, evaluation following WAC 173-303-100 procedures required

Table 2 Toxic Category Table (from WAC 173-303-100)

Toxic Category	**Fish** LC_{50}(mg/L)*	**Oral (Rat)** LD_{50}(mg/kg)	**Inhalation (Rat)** LC_{50}(mg/L)	**Dermal (Rabbit)** LD_{50}(mg/kg)
X	<0.01	<.5	<.02	< 2
A	0.01 - <0.1	.5 - <5	.02 - <.2	2 - <20
B	0.1 - <1	5 - <50	.2 - <2	20 - <200
C	1 - <10	50 - <500	2 - <20	200 - <2,000
D	10 – 100	500 – 5,000	20 – 200	2,000 - 20,000

* The LC_{50} data must be from an exposure period greater than or equal to twenty-four hours. LC_{50} data from any species is acceptable; however, if salmonid LC_{50} data is available it will supersede all other fish data. If salmonid data is unavailable but fathead minnow data is available, it will supersede all other fish species data.

Note: "Inhalation LC_{50}" means a concentration in milligrams of substance per liter of air which, when administered to the respiratory tract for four hours or less, kills within fourteen days half of a group of ten rats each weighing between 200 and 300 grams.

Table 3 Non-Human Toxicity Values and Toxic Category of Chemical Compounds

Toxic Category		Fish	Oral (Rat)	Inhalation (Rat)	Dermal (Rabbit)
	Chemical Compound Potentially Found at Site	**LC$_{50}$ (mg/L)**	**LD$_{50}$ (mg/Kg)**	**LC$_{50}$ (mg/L)**	**LD$_{50}$ (mg/Kg)**
D	Arsenic		763		
C	Cadmium		225	25	
	Chromium		NA		
	Lead		NA		
	Mercury		NA		
	Barium		NA		
	1,2,4-Trimethylbenzene		NA		
D	1,2-Dichlorobenzene		500	821	10,000
D	1,2-Dichloroethane	116	670	1,000	3,400
D	1,3,5-Trimethylbenzene			19,512	
D	1,4-Dichlorobenzene	7.4	500		
D	4-Isopropyltoluene		4,750		
D	Benzene		3,306	10,000	
D	Carbon tetrachloride		2,800		
D	Chlorobenzene	10	2,290		
D	Chlorobenzene		2,290		
D	Chloromethane		1,800	5,285	
D	Ethylbenzene		3,500		17,800
D	Isopropylbenzene	,	1,400	8,000	
D	m-Xylene & p-Xylene		4,300		
C	Naphthalene		490		
D	N-Propylbenzene		6,040		
D	o-Xylene		4,300		
D	sec-Butylbenzene		2,240		
D	Styrene		1,000	2,770	
D	tert-Butylbenzene		3,045		
D	Tetrachloroethene		2,400	4,100	
D	Toluene		2,600	8,000	
D	Trichlorofluoromethane		3,725	100,000	
D	Trichlorofluoromethane		3,725	100,000	
D	1,2-Dichlorobenzene		500	821	10,000
C	1,4-Dichlorobenzene	7.4	500		
D	1-Methylnaphthalene		1,840		
D	2,4,5-Trichlorophenol		820		
D	2-Methylnaphthalene		1,630		
	Acenaphthene		NA		
	Anthracene		NA		
	Benzo[a]anthracene		NA		
	Benzo[a]pyrene		NA		

Toxic Category	Chemical Compound Potentially Found at Site	Fish	Oral (Rat)	Inhalation (Rat)	Dermal (Rabbit)
		LC_{50} (mg/L)	LD_{50} (mg/Kg)	LC_{50} (mg/L)	LD_{50} (mg/Kg)
	Benzo[g,h,i]perylene		NA		
	Benzofluoranthene	NA	NA		
D	Benzoic acid	180	1,700	>0.026	> 5,000
C	Bis(2-chloroethyl)ether	600	75	700	
D	Bis(2-ethylhexyl) phthalate		>25,000		25
D	Butyl benzyl phthalate		13,500		
B	Chrysene	0.999	NA		
D	Diethyl phthalate		9,500		
D	Dimethyl phthalate		2,400		10
D	Di-n-butyl phthalate		8,000		
D	Fluoranthene				2,350
	Indeno[1,2,3-cd]pyrene		NA		
C	Naphthalene		490		>2,000
A	Pentachlorophenol	0.068	146		
	Phenanthrene		NA		
C	Phenol		317		850
D	Pyrene		2,700	138	

NA =	Not Available
Source	http://toxnet.nlm.nih.gov/
	http://chem.sis.nlm.nih.gov/chemidplus/chemidheavy.jsp

Appendix B

QUALITY ASSURANCE PLAN FOR REMEDIAL ACTIONS AND ENVIRONMENTAL SAMPLING AT BORDEAUX DUMP SITE, LITTLEROCK, WA

Prepared by:

CALIBRE SYSTEMS, INC.

November 8, 2010

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Quality Assurance Plan for Environmental Sampling at Bordeaux Dump Site, Littlerock, WA

1.0 Introduction and Objectives

This Quality Assurance Project Plan (QAPP) describes activities that will be implemented to assure integration of applicable Quality Assurance/Quality Control (QA/QC) requirements into sampling activities conducted in support of field investigations and if applicable, remediation efforts. The objective of this QAPP is to present procedures, organization, objectives, functional activities, and specific QA/QC activities to assure that data collected during field activities are of known and sufficient quality to meet project objectives.

2.0 Measurements

Measurements will be made to collect both screening data and definitive data needed to meet project objectives. In general, screening data will be collected using field analytical methods and definitive data using laboratory analytical methods. Examples of measurements commonly performed and associated data quality levels are summarized in Table 2-1.

Table 2-1 Examples of Measurements

Measurement Type	Data Collected	Data Quality Level[1]
Laboratory Analytical Measurements	Concentrations of VOCs in groundwater samples.	II or III
	Concentrations of semi-volatile organics in groundwater samples.	II or III
	Concentrations of metals in groundwater samples.	II or III
	Concentrations of VOCs in soil samples.	II or III
	Concentrations of semi-volatiles in soil samples.	II or III
	Concentrations of metals in soil samples.	II or III
Field Analytical Measurements	Concentration of dissolved oxygen (DO) in groundwater samples.	I
	Hydrogen ion activity (pH) of groundwater samples.	I
	Oxidation-reduction potential (ORP) of groundwater samples.	I
	Specific conductance of groundwater samples.	I
	Temperature of groundwater samples.	I
Field Physical Measurements	Instantaneous pumping rate of groundwater.	N/A
	Piezometric head in monitoring wells.	N/A

[1] The Data Quality Levels referenced above follow definitions from U.S. EPA, "Data Quality Objectives for Remedial Response Activities". Examples include the following;
Level 1—data from calibrated field instruments such as a water quality meter for DO, pH, temperature, or PID for organic vapors;
Level 2—data from calibrated analytical instrument for contaminant delineation such as field GC, portable XRF, or PID analysis for vapors to include added QA such as calibration curves, field duplicates, custody documentation (field sample tracking sheets) and a representative sample (typically 10%) submitted for laboratory verification;
Level 3—data from samples analyzed by a certified laboratory with QA/QC documentation following standard methods such as U.S. EPA -846.
Level 4—data from samples analyzed by a certified laboratory with QA/QC documentation following special or modified methods such as the EPA Contract Lab Program (CLP), typically includes additional QA/QC documentation.

3.0 Quality Assurance Organization and Key Personnel

The Field Operations Manager (FOM) will regularly communicate with the CALIBRE Project Manager (PM). Both the CALIBRE PM and the FOM have direct contact with the Customer PM (and other stakeholders). The FOM is fully responsible for the technical quality of the work, as well as project budget and schedule. He will direct, coordinate, and monitor the efforts of the Site Team members to assure the technical quality of the work and accurate reporting to management. Specific responsibilities related to QA/QC include:

- Assure availability of technical standard operating procedures (SOPs) and training of staff to SOPs;
- Assist the PM in preparing the project work plan (WP);
- Assure project activities are conducted according to SOPs/QAPP;
- Review and evaluate data and verify data quality;
- Implement corrective actions resulting from QA audits;
- Report QA problems to client's PM; and
- Supervise preparation of project deliverables.

The FOM reports quality issues to the Quality Assurance Manager (QAM) and technical issues to the Corporate Principle Engineer at CALIBRE.

The QAM is responsible for developing and implementing the project QA program. The QAM will communicate QA responsibilities to all project staff and provide guidance for implementation of the QAPP. The QAM has authority to terminate the project activities if the quality of data is jeopardized. Specific responsibilities of the QAM related to QA /QC include:

- Serve as point-of-contact for all matters involving QA;
- Provide guidance and technical information concerning QA issues to project staff;
- Review project activities for proper implementation of the WP and SOP;
- Plan and conduct QA audits; and
- Identify QA deficiencies to FOM and assist in identification of corrective actions.

The QAM reports to the corporate QAM at CALIBRE.

The Field Supervisor (FES) will provide day-to-day supervision of all field sampling and analysis activities. Specific responsibilities of the FES related to QA/QC include:

- Supervise all field sampling and analysis activities to assure proper implementation of the SOP;
- Supervise sample collection, logging, and documentation of field activities and test results;
- Assure all field activities identified in work plan are implemented, required environmental and QC samples are collected, and required field measurements are taken;
- Coordinate with analytical laboratory(ies) for scheduling of analyses and receipt of samples;
- Supervise subcontractor staff involved with field activities; and
- Coordinate transfer of field data and records to FOM for data reduction and validation.

The FES reports to the FOM. If the FES cannot be present during certain field activities, the FOM will designate an alternate FES for those activities. The alternate FES will have all responsibilities identified above. If required, field technicians (FTs), will report to and perform field sampling and analysis activities under the supervision of the FES. Responsibilities of the FT related to QA/QC include:

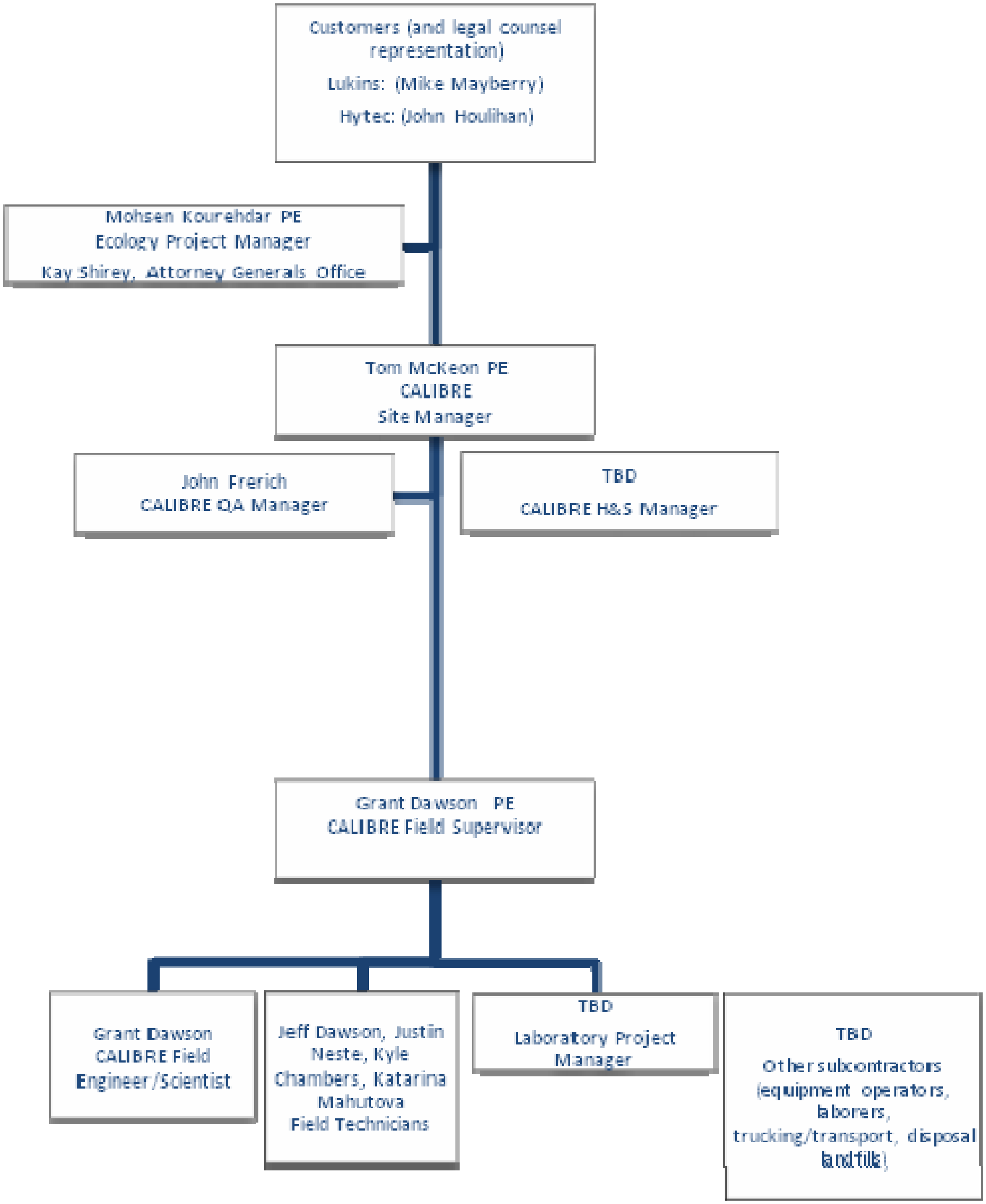
- Perform field tasks according to the work plan and applicable SOPs; and
- Prepare and maintain records of field activities.
- Coordinate activities with FOM to assure integration of field operations; and
- Generate and maintain documentation of field activities and test results.

Table 3-1 and the organization chart shows key personnel in the CALIBRE QA/QC organization for this project.

Table 3-1. QA/QC Organization and Project Personnel

Name	Organization	Title	Contact Information
Tom McKeon, PE	CALIBRE	Site Manager & CALIBRE Project Manager	425/643-4634
John Frerich	CALIBRE	QA Manager	425/226-6435
Grant Dawson, PE	CALIBRE	Field Supervisor	253/277-0739
Jeff Dawson Justin Neste	CALIBRE	Field Technicians	509/430-4649 360/981-5606
Grant Dawson, PE	CALIBRE	Field Engineer/Scientist	253/277-0739
	TBD	Project Manager (Lab)	
Mike Mayberry		Customer Project Coordinator	(360)943-8320
John Houlihan		Customer Project Coordinator	(206) 547-5052
Mohsen Kourehdar PE	WA Dept of Ecology	Ecology Project Manager	(360) 407-6256

Project Organization Chart



4.0 Data Quality Objectives

Data quality objectives (DQOs) describe the quality of data needed to meet project objectives. The DQOs depend on how the data will be used. Analytical data will generally be used to identify the areal extent and types and concentrations of contaminants. Additionally, laboratory leaching experiments may be conducted to determine the maximum concentration of a contaminant that may leach to groundwater without exceeding groundwater criteria. Important parameters associated with the laboratory/site characterization data quality are quantitation limit, precision, accuracy, representativeness, comparability, and completeness. These are discussed below.

4.1 Quantitation Limit

The sensitivity of an analytical method is expressed as the quantitation limit. In order for analytical data to be of sufficient quality, the quantitation limit of the analytical method used must be less than the quantitation limit required to meet project objectives. The former depends on site-specific matrix effects and is commonly expressed as the estimated quantitation limit (EQL). Examples of EQLs for the methods and matrices specified for this project are summarized in Table 4-1. The required quantitation limit is related to the use of the data.

Table 4-1. Examples of Laboratory Analytical Methods, Performance, and Quality Goals

Analytical Laboratory Methods				**Precision**		**Accuracy**	
Analyte	**Matrix**	**Method**	**EQL**	**LCS/LCSDRPD**	**MS/MSD RPD**	**LCS % Recovery**	**MS % Recovery**
Volatiles	Water	EPA 8260C	1-5 ug/L	<55	<27	50 - 150	50 - 125
Semi-volatiles	Water	EPA 8270D	0.2-15 ug/L	<50	<25	50-150	50 - 125
Metals, in general	Water	EPA 6010	0.2-1 mg/l	<20	<20	75-125	75 - 125
Total Petroleum Hydrocarbons	Water	NWTPH-HCID	0.1-0.5 ug/L	<55	<28	50 - 150	50 - 125
Metals, in general	Soil	EPA 6010/ 3050	0.02-5 mg/kg	<30	N/A[(a)]	75 - 125	N/A[(a)]
Volatiles	Soil	EPA 8260C	10-200 ug/kg	<30	N/A[(a)]	75 - 125	N/A[(a)]
Semi-volatiles	Soil	EPA 8270D	20-500 ug/kg	<30	N/A[(a)]	76 - 110	N/A[(a)]
Total Petroleum Hydrocarbons	Soil	NWTPH-HCID	20-100 mg/kg	<30	N/A[(a)]	76 - 110	N/A[(a)]

Soil Property/Geotechnical Tests	
Physical Property	**Test Method**
USCS soil classification	ASTM D2487
Density	ASTM D698
Organic carbon content	Walkee Black Method
Moisture content	ASTM D2216
Grain size distribution	ASTM D422
Porosity	ASTM D4645

Acronyms and Notes:

LCS/LCSD	Laboratory control sample/laboratory control sample duplicate
MS/MSD	Matrix spike/matrix spike duplicate
RPD	Relative percent difference
(a)	Matrix spikes will not be performed.

4.2 Precision

Analytical precision is calculated by expressing, as a percentage, the difference between the results of analysis of duplicate samples relative to the average of those results for a given analyte. Precision is expressed as the relative percent difference (RPD). Examples of the required RPD for each method and matrix are presented in Table 4-1.

4.3 Accuracy

Analytical accuracy is calculated by expressing, as a percent, the recovery of a standard reference material or an analyte that has been added to the sample (or standard matrix) at a known concentration before analysis. Examples of the required recovery are specified in Table 4-1`. The spiked (fortified) concentration used will be specified by laboratory quality control requirements as detailed in the analytical method. Samples for matrix spikes will be collected at the frequency specified in the project objectives.

4.4 Representativeness, Completeness, and Comparability

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Data representativeness will be attained through the proper design of the sampling program.

Completeness is a measure of the relative number of analytical data points that meet all the acceptance criteria for accuracy, precision, and any other criterion required by the specific analytical methods used. Data completeness is affected by laboratory accidents, insufficient sample volume, or sample breakage during shipment, etc. The quality assurance objective for analytical data completeness is 95%. To help assure completeness, chain-of-custody (COC) forms will be used to document and trace possession of samples from the time of collection through delivery to the analytical laboratory.

Comparability expresses the confidence with which one data set can be compared to another. Data comparability will be achieved through the use of standard sampling and analytical techniques. Data results will be reported in appropriate units consistent with existing site data and applicable regulatory levels.

5.0 Analytical Procedures and Calibration

The following sections describe analytical and calibration procedures to be followed.

5.1 Laboratory Procedures

Groundwater and soil samples collected will be analyzed according to standard methods such as EPA Method 8260C and other analytical methods specified in Table 4-1. Any changes and modifications to procedures will be documented thoroughly in the narrative summary for the data package. All parameters specified by the analytical methods will be determined. Compounds may be added to subsequent analyses if they are identified and judged to be of concern.

5.2 Laboratory Equipment Calibration

Before any instrument is used as a measuring device, the instrument response to known reference materials must be determined. The manner in which various instruments are calibrated is dependent on the particular type of instrument and its intended use. All sample measurements will be made within the calibrated range of the instrument.

Routine calibration standards will be used in the analytical laboratory(ies) to demonstrate that the performance of an instrument does not cause unnecessary error in the analysis. This calibration will indicate instrument stability and sensitivity. The methods for verification and documentation of instrument conditions prior to and during testing will be described by the analytical laboratory(ies) in specific laboratory procedures.

Laboratory instrument calibrations typically consist of two types, initial calibration and continuing calibration. Initial and continuing calibration criteria must meet the method acceptance criteria before sample analysis can begin. Initial calibration procedures establish the calibration range of the instrument and determine instrument response over that range. Typically, three to five analyte concentrations are used to establish instrument response over a concentration range. The instrument response over that range is expressed as a correlation coefficient (e.g. for atomic absorption, inductively coupled plasma, UV-visible/infrared spectrophotometry, ion chromatography) or by a response factor, amount/response (e.g., for gas chromatography, gas chromatography/mass spectrometry, high performance liquid chromatography).

Continuing calibration usually includes measurement of the instrument response to one or more calibration standards and requires instrument response to compare within certain limits (e.g., ±10%) of the initial measured instrument response. Continuing calibration is performed at least once per operating shift for all analyses.

Specific instrument calibration procedures for various analytical instruments are described in detail in analytical procedures.

5.3 Field Analytical Procedures

Field analytical procedures will be employed to determine DO concentration, ORP, pH, specific conductance, and temperature of groundwater samples. Such analyses will be performed using procedures contained in EPA's Methods for Chemical Analysis of Water and Wastewater and the latest edition of Standard Methods for the Examination of Water and Wastewater.

5.4 Field Equipment Calibration

All instruments and equipment used to perform field measurements will be operated, calibrated, and maintained according to manufacturer's guidelines and recommendations. Operation, calibration, and maintenance will be performed by personnel who have been properly trained in these procedures.

6.0 Data Reduction, Validation, and Reporting

The following sections describe required data reduction, data validation, and data reporting.

6.1 Data Reduction

Data reduction consists of those activities involving conversion of raw data to reportable units, transfer of data between recording media, and computation of summary statistics, standard errors, confidence intervals, tests of hypotheses relative to the parameters, and model validation. Statistically-acceptable data analysis procedures will be implemented for all data reduction steps.

6.1.1 Laboratory Data Reduction

Laboratory data reduction will be performed according to requirements established by CALIBRE and the client.

6.1.2 Field Technical Data Reduction

Field technical data (i.e., non-laboratory generated) can generally be characterized as either objective or subjective data. Objective data include all direct measurements such as field analyses and water level measurements. Subjective data include descriptions and observations. Some activities, for example, test boring and well logs, include both types of data in that the data recorded in the field are descriptive but can be reduced using the standardized lithologic coding system.

All field data necessary to meet project objectives will be recorded by field personnel. As appropriate, field data will be recorded on forms included with SOP. At the completion of a task, copies of all field records will be checked and the data reduced to tabular form wherever possible by entering the data into database files. Subjective data will be filed as hard copies for incorporation into technical reports as appropriate.

The project work plan describes how the data collected during the project will be analyzed to meet specific project objectives. All calculations will be performed on standard calculation sheets that will include the name of the person performing the calculations and the date of the calculations. All calculations will be checked by a second person. This person's name and the date that the calculations were checked will be entered on each calculation sheet. All calculation sheets will be retained in the project file.

6.2 Data Validation

Data validation, an after-the-fact review of data, is the process whereby data are determined to be of acceptable or unacceptable quality based on a set of predefined criteria. These criteria depend upon the type(s) of data involved and the purpose for which data are collected.

6.2.1 Laboratory Data Validation

Laboratory data review will be performed as described in the data review preview procedures stipulated in CALIBRE's QAPP.

6.2.2 Field Data Validation

Validation of objective field and technical data will be performed at two different levels. On the first level, data will be validated at the time of collection by following standard procedures and quality control checks. At the second level, data will be validated by the FOM or his designee who will review the data to ensure that the correct codes and units have been included. After data reduction into tables or arrays, the FOM will review data sets for anomalous values. Any inconsistencies or anomalies discovered by the FOM will be resolved immediately, if possible, by seeking clarification from the field personnel responsible for collecting the data.

Subjective field and technical data will be validated by the FOM, who will review field reports for reasonableness and completeness. In addition, random checks of sampling and field conditions will be made to confirm the recorded observations. Whenever possible, peer review will also be incorporated into the data validation process, particularly for subjective data, to maximize consistency among field personnel. For example, during drilling activities, the FOM may schedule periodic reviews of archived lithologic samples to ensure that the appropriate lithologic descriptions and codes are being consistently applied by all field personnel. In addition, for field analyses and tests, an independent review of the applicable items described previously for laboratory data validation will be conducted (e.g., calibration methods, control limits, instrument checks, etc.). A record of field data validation will be made using the data validation/review form contained in CALIBRE's QAPP.

6.3 Data Reporting

Laboratory analyses will be analytical level II or III (see Table 2-1). As a result, Contract Laboratory Program (CLP) data packages are not required. The standard analytical laboratory data reports for organic and inorganic analyses will consist of a transmittal letter and the following, as appropriate for the analyses performed:

- Cover page describing data qualifiers, sample collection, sample receipt, extraction and analysis dates, and a description of any technical problems encountered with the analyses;
- Copies of the chain-of-custody forms;
- Copies of the analytical forms;
- Spreadsheet sample analytical results and quality control summaries;
- Calculated recoveries for all quality control samples, method duplicate or duplicate spike and method blank results;
- All laboratory quality control data including method blank, method blank spike, matrix spike, laboratory duplicate or spike duplicate, and surrogate recovery data;
- Method quantitation limits for all parameters and dilutions; and
- Five-peak library search report for GC/MS volatiles and semi-volatiles.

Analytical results will be reported in ug/L for aqueous samples, mg/kg for soil samples, and ppbv (or ug/m^3) for gas samples.

Non-analytical data will consist of results of physical measurements or tests (e.g., aquifer tests). The results of these tests will be reported in the formats and units indicated in the specific procedure used.

7.0 Internal Quality Control Checks

Internal quality control checks will allow evaluation of the consistency and validity of generated data.

7.1 Laboratory Analytical Activities

Internal quality control of laboratory analyses will conform to EPA requirements for the analytical methods used.

7.2 Field Sampling Quality Control Activities

Quality control activities for field sampling provides a means of evaluating the integrity of a sample from the time of collection through analysis at an approved laboratory. Field sampling quality control activities involve maintenance of chain-of-custody, documentation of activities, use of appropriate sample containers and preservatives, submission of samples to laboratories in a timely manner, use of a consistent sample numbering system, and collection of appropriate quality control samples. These activities are discussed in more detail below.

Chain-of-custody involves documenting the possession and handling of a sample from the time of collection through analysis. This documentation will be made through use of the chain-of-custody forms. In addition to the chain-of-custody forms, a master sample logbook will be maintained for all samples collected during the project.

Standard operating procedures (SOPs) specify requirements for collection of field data. Forms for collecting most field data are contained in the SOPs. SOPs for pertinent field sampling activities are presented in Appendix A. Any additional data collected will be recorded in personal or field team logbooks. Field team members will keep accurate, written records of sample collection activities and other field data collection activities. All data entries will be legible and will be written in waterproof ink. All entries will be dated and initialed. Errors will not be erased but will be crossed out with a single line and the change initialed and dated.

Sample containers, preservatives, storage requirements, and holding times are summarized in Table 7-1. Samples from nonpermanent locations (e.g., soil borings) will be identified using the following 10-character identification scheme:

Table 7-1 Summary of Sample Handling, Preservation, and Storage Requirements

Analysis	**Matrix**	**Container**	**Preservative**	**Storage Requirements**	**Holding Time**
Volatiles, EPA 8260C	Water	3 40-mL glass vials	pH < 2 with HCl	4°C	14 days to extraction and analysis
Semi volatiles, EPA 8270D	Water	2 1-L amber-glass bottles	None	4°C	14 days to extraction, 40 days thereafter
Metals, Priority Pollutant (Dissolved), EPA 6010/7000	Water	1 1-L polyethylene bottle	Filter, pH < 2 with HNO_3,	4°C	6 months to analysis
NWTPH-HCID	Water	2 1-L amber-glass bottles	pH < 2 with HCl	4°C	7 days to extraction, analyze within 40 days
Volatiles, EPA 8260C/5035A	Soil	40 ml. VOA vial	Encore or MeOH preserved	4°C	24 hours to preservation, 14 days to analysis
Semi volatiles, EPA 8270/3510	Soil	1 8 ounce. CWM	None	4°C	14 days to extraction, 40 days thereafter
Metals, Priority Pollutant, EPA 6010/7000	Soil	8 ounce CWM	None	4°C	30 days to extraction, 6 months thereafter
NWTPH-HCID	Soil	8 ounce CWM	None	4°C	7 days to extraction, analyze within 14 days

Note: pH, Dissolved oxygen, ORP, turbidity, and specific conductance will be measured in the field during collection of groundwater samples.

CWM = Clear Wide Mouth glass container
VOC = Volatile organic compounds
SVOC = Semi-volatile organics
NWTPH = Northwest Total Petroleum Hydrocarbon
HCID = Hydrocarbon Identification

B NNN NNN XXX
where:
B designates samples from the Bordeaux site;
NNN NNN are six numeric characters identifying the sample location; and
XXX are three numeric characters identifying other sample information (such as depth).

Samples from monitoring wells will be identified using the permanent location designation assigned by the client point of contact. The quality control samples that will be collected are summarized in Table 7-2 and described below.

Field replicate soil and groundwater samples will be given a unique alphanumeric identifier and submitted to the laboratory blind, (i.e., without indicating the location). These samples will serve as blind field splits and will be used to evaluate laboratory reproducibility and field reproducibility.

Equipment (rinsate) blanks will be included as part of the field QA/QC program for groundwater sampling activities. These samples will serve as a check on the sampling device cleanliness.

Ambient blanks and trip blanks will be included for analysis of groundwater samples for VOCs. Ambient blanks are collected by pouring organic-free water into a sample container in the field at the time and location of sampling. These blanks are used to assess the potential for contamination of samples by ambient sources. Trip blanks are prepared in the laboratory and consist of organic-free water that is placed in the same type of sample container as the groundwater samples. The trip blanks are transported to the field and handled and packaged in the same manner as the groundwater samples. Trip blanks serve as a check on sample contamination originating from sample transport, shipping, and/or site conditions.

Additional sample volume will be required to perform matrix spikes and matrix spike duplicates (MS/MSD) for samples. Samples for MS/MSD will consist of three times the normal sample volume specified in Table 7-1. Samples for MS/MSD will be collected at a frequency of one per 20 samples or one per analytical batch, whichever is more frequent.

7.3 Design / Deliverable Quality Control

The Project Manager will determine requirements for project-specific design control and deliverable quality control procedures. QA Level III projects are required to have formal design control procedures in place within two weeks of project initiation. QA Level I and II projects should disseminate a deliverable checking and validation process to each member of the project team as soon as possible after initiation of a project.

Each staff member is responsible for the style and content of documents they prepare. Documents and other deliverables are to meet CALIBRE standards, be responsive to clients' needs and requirements, conform to applicable industry standards and practices, and fulfill contractual obligations. Technical reviewers are to ensure that the content of documents, which they review, is accurate and relevant for the subject document and that their review is limited to the subject area of their expertise. Project Managers are responsible for ensuring that appropriate review procedures are in place and used by the project staff.

The following sections describe required procedures for design control of QA Level III projects. All engineering and design work should be performed according to the requirements and specifications of the state in which the design will be implemented.

Table 7-2 Summary of Field Quality Control Samples

QC Sample Type	Sample Matrix	Applicable Analysis	Frequency	Purpose	Acceptance Criteria	Corrective Action
Field Duplicate	Groundwater	EPA 8260C	One per 20 samples or sample batch See note (a)	Monitor sample variability	<50% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.
		EPA 8270D	One per 20 samples or sample batch See note (a)	Monitor sample variability	<50% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.
		NWTPH-HCID	One per 20 samples or sample batch See note (a)	Monitor sample variability	<50% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.
		EPA 6010/7000	One per 20 samples or sample batch See note (a)	Monitor sample variability	<30% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.
	Soil	EPA 8260C	One per 20 samples or sample batch See note (a)	Monitor sample variability	<100% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.

QC Sample Type	Sample Matrix	Applicable Analysis	Frequency	Purpose	Acceptance Criteria	Corrective Action
Field Duplicate	Soil	EPA 8270D	One per 20 samples or sample batch See note (a)	Monitor sample variability	<100% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.
		NWTPH-HCID	One per 20 samples or sample batch See note (a)	Monitor sample variability	<100% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.
		EPA 6010/7000	One per 20 samples or sample batch See note (a)	Monitor sample variability	<100% RPD	Evaluate source of variability. Evaluate whether sampling frequency needs to be increased.
Ambient Blank	Water	EPA 8260C	One per 20 samples, or as specified in SAP	Monitor potential for contamination from ambient sources	See note (b)	Evaluate source of contamination and determine procedure change, if needed.

Table 7-2 Summary of Field Quality Control Samples (Continued)

QC Sample Type	Sample Matrix	Applicable Analysis	Frequency	Purpose	Acceptance Criteria	Corrective Action
Equipment Rinsate Blank (c)	Groundwater	EPA 8260C	One per 20 samples	Monitor decontamination effectiveness and sample cross contamination	See note (b)	Evaluate source of contamination and determine procedure changes, if needed.
		EPA 8270D	One per 20 samples	Monitor decontamination effectiveness and sample cross contamination	See note (b)	Evaluate source of contamination and determine procedure changes, if needed.
		NWTPH-HCID	One per 20 samples	Monitor decontamination effectiveness and sample cross contamination	See note (b)	Evaluate source of contamination and determine procedure changes, if needed.
		EPA 6010/7000	One per 20 samples	Monitor decontamination effectiveness and sample cross contamination	See note (b)	Evaluate source of contamination and determine procedure changes, if needed.
Trip Blank	Groundwater	EPA 8260C	One per sample shipment containing samples for VOC analysis	Monitor contamination from sample handling and shipment	See note (b)	Evaluate source of contamination and determine procedure changes, if needed.

Notes:

(a) If the number of samples collected and submitted to a laboratory on 1 day (a sample batch) is less than 20 samples, a field duplicate will be included in the batch.

(b) Sample must exhibit contaminant at a level equal to or greater than 5 times the quantitation limit to be considered detectable.

(c) If groundwater sampling procedures include the use of multiple purging pumps, an equipment rinsate blank will be collected from each pump.

7.3.1 Design Input

The Project Manager will develop design input requirements, including technical, regulatory, and process requirements. The Project Manager will seek and obtain peer review of these requirements and document final specifications.

7.3.2 Design Review

At appropriate stages of the design process (as defined by the Project Manager), formal documented reviews of the design will be conducted for CALIBRE activities. Project Technical Reviews will be performed to assess validity of the technical basis for a given technology prior to acquisition, optimal design parameters for individual technologies, optimal configuration for specific installations, and strategic recommendations to clients. CALIBRE staff with expertise in areas that are critical to the design, and who can provide an objective evaluation of the particular activity, will perform these reviews. It is the responsibility of the Project Manager to determine the specific review requirements and to ensure that personnel certified in the relevant state, as appropriate, perform the reviews.

Documents prepared for submittal to clients are subject to a formal, controlled, and traceable review process. Authors will identify reviewers at the beginning of the document preparation process and establish a schedule for document delivery and review. Authors will identify appropriate individual(s) to serve as Technical Reviewer(s) for a document; some documents may require review by more than one individual, based on the breadth of issues discussed in the document. Reviewers shall be knowledgeable and qualified to review the document's subject area by virtue of education and/or work experience.

7.3.3 Design Verification

The Project Manager will ensure that design verification measures are incorporated into project activities to ensure that design output meets input requirements. These measures will be applied to the process at critical stages of design, as determined by each Project Manager. Design verification may include, but is not limited to, such activities as comparison of design with a similar proven design, performance of alternative calculations, tests and demonstrations, and peer review. The Project Manager or designated Quality Officer will maintain records of design verification measures. A copy will be sent to the Quality Manager to be included in the project QAfile.

7.3.4 Design Changes

Design changes and modifications that are of a permanent nature will be identified, documented, reviewed, and approved by Project Managers and appropriate technical staff before they are implemented. Where appropriate, technical personnel will prepare a technical memorandum detailing changes and distribute the memorandum to appropriate CALIBRE staff. Design changes of a site-specific nature will be noted on the design materials, initialed, and dated.

8.0 Performance and System Audits

The requirement for systems audits for the field activities associated with project will be satisfied, in part, by approval of this QAPP and all procedures referenced therein. In addition, field activities will be monitored by the project QAM to ensure compliance with the requirements of this QAPP.

An on-site audit of project-specific monitoring activities will be conducted at least once per project by a CALIBRE staff member not otherwise involved in the activities being audited. The focus of the audit will be on actual QC activities of data collection, and will use the QAPP as a reference. The sampling systems audit checklists contained in the QAPP will be used as appropriate to the activities being audited. The following specific activities will be reviewed in the audit:

- Sample collection and analytical activities;
- Equipment calibration techniques and records;
- Decontamination and equipment cleaning;
- Equipment suitability and maintenance/repair;
- Background and training of personnel;
- QC samples; and
- Sample containers, preservation techniques, and chain-of-custody.

The requirements for performance audits will be satisfied by taking measures to ensure measurement accuracies are being achieved and maintained. These measures primarily include the provisions identified in Section 7.0 of this QAPP including the submission of blanks and duplicate samples for analysis. The performance of these activities will be performed or witnessed, as appropriate, by the QAM.

9.0 Corrective Action Plan

Corrective action is initiated when the following situations arise:

- Specific requirements of the analysis method or sampling/analysis procedure are not met;
- Data quality objectives for precision, accuracy, and completeness are not achieved; and/or
- Laboratory or field data review indicates that data are incomplete or that improper calculation, methodology, or technique was employed, or that an instrument malfunction has occurred.

When deficiencies are found, the QAM and FOM will determine if the data in question are essential to the project and what corrective action will be taken. Corrective action may include one or more of the following:

- Additional information or recalculations are supplied.
- Instrument operation and calibration are checked. Calibration standards are checked and new standards are obtained, if necessary. Instrument malfunctions are corrected.
- Personnel repeat the task using the same procedure.
- A different individual repeats the task using the same procedure.
- Samples are re-analyzed (if holding time permits).
- Sampling and/or analytical procedures are evaluated and amended.
- Personnel repeat the task using a validated new or modified procedure.
- If practical, a new sample is collected and analyzed.

If the anomaly is not resolved after the above steps are taken, the data are reported with qualifying statements. In some cases, depending on the nature and degree of deviation, no data may be reported.

9.1 Laboratory Corrective Action

The initial responsibility for monitoring the quality of an analytical system lies with the analyst. The analyst will verify that all quality control procedures are followed and that the results of analysis of quality samples are within acceptance criteria. This requires that the analyst assess the correctness of all the following items, as appropriate:

- Sample preparation procedures,
- Initial calibration,
- Calibration verification,
- Method blank result, and
- Laboratory control standard.

If the assessment by the analyst reveals that any of the quality control acceptance criteria, as defined by the most recent edition and updates of the analytical method are not met, the analyst must immediately assess the analytical system to correct the deficiency. The analyst must notify his/her supervisor and the laboratory quality assurance coordinator of the deficiency and, if possible, identify potential causes and corrective action. Analytical data quality concerns that may require corrective action will be identified using the analytical request form described in the QAPP.

The nature of the corrective action obviously depends on the nature of the deficiency. For example, if a continuing calibration verification is determined to be out of control, the corrective action may require recalibration of the analytical system and re-analysis of all samples since the last acceptable continuing calibration standard.

Quality control samples (e.g., matrix spikes and matrix spike duplicates) provide an indication of matrix affects on analyses. Failure to achieve method specific performance on quality control samples will trigger corrective action or additional re-analysis, as appropriate.

When the appropriate corrective action measures have been defined and the analytical system is determined to be in control, the analyst will document the problem, the corrective action, and the data demonstrating that the analytical system is in control. Copies of this documentation will be provided to the laboratory supervisor and the laboratory quality assurance coordinator.

9.2 Field Corrective Action

The initial responsibility for monitoring the quality of field measurements and observations lies with the field personnel. The FS is responsible for verifying that all quality control procedures are followed. This requires that the FS assess the correctness of field methods and the ability to meet quality assurance objectives. If a deficiency occurs that might jeopardize the integrity of the project or cause some specific quality assurance objective not to be met, it is the responsibility of all field project staff to report it.

10.0 Analytical Laboratory Requirements

The analytical laboratory(ies) will be responsible for performing all analyses exactly as specified in the appropriate analytical methods. The analytical methods to be performed are summarized in Table 4-1. In addition, the analytical laboratory(ies) must comply with applicable requirements of this QAPP, including the following:

- Equipment Calibration (Section 5.2)
- Data Reduction (Section 6.1)
- Data Validation (Section 6.2)
- Data Reporting (Section 6.3)
- Internal Quality Control Checks (Section 7.1)
- Corrective Action (Section 9.1)

11.0 Personnel Qualifications and Training

The Project Manager is responsible for determining appropriate personnel categories for a project and for ensuring that qualified individuals fill those positions.

CALIBRE is committed to assigning only qualified personnel to project tasks. Part of the qualification process is training. Training requirements are separated into three general categories:

1. Training dictated by good business practices to promote safe and cost-effective work practices and minimize any potential losses to the company and customer;

2. Training required by specific tasks or the use of specific specialized equipment, tools, or materials; and

3. Training/certification/licensing mandated by legal and regulatory requirements.

It is the responsibility of the Project Manager to ensure that project personnel maintain the proper level of training to meet quality requirements for projects under their management. The Project Manager will identify any staff training requirements during initial project planning. It is the responsibility of the CALIBRE Health and Safety Officer to ensure that all CALIBRE personnel meet the required training requirements for work performed. Training certifications for all CALIBRE personnel will be maintained in the CALIBRE Personnel files; copies will be maintained in the project files, as appropriate. Figure 11-1 shows the Personnel Qualifications and Training form.

Figure 11-1 Personnel Qualifications and Training Form

CALIBRE
PERSONNEL QUALIFICATIONS AND TRAINING

PROJECT NAME: Bordeaux-Littlerock

CONTRACT NO. K0308000-004

PROJECT MANAGER: Tom McKeon

DATE: 10/28/10

Identify any project-specific qualification requirements and work functions requiring special skills, special educational backgrounds, security clearances, licenses, certifications, and/or registrations. Project managers are responsible for determining the nature and extent of personnel qualifications required for each project. Complete a work function and qualifications description for each key work element or key personnel required to complete the contract requirements; do not include qualifications that are not necessary for this project. Qualifications of proposed personnel should be demonstrable qualifications.

WORK FUNCTION:	Engineer of record
QUALIFICATIONS REQUIRED:	WA PE
PROPOSED PERSONNEL/ SUBCONTRACTOR:	Tom McKeon
QUALIFICATIONS OF PROPOSED PERSONNEL:	WA PE
WORK FUNCTION:	Drilling & Well Construction Contractor
QUALIFICATIONS REQUIRED:	WA Licensed
PROPOSED PERSONNEL/ SUBCONTRACTOR:	To be determined
QUALIFICATIONS OF PROPOSED PERSONNEL:	WA Licensed

Original ☐ Project Files ☐ Central Files ☐

WORK FUNCTION:	Field team for intrusive work
QUALIFICATIONS REQUIRED:	OSHA training, meet the HASP requirements, physically fit for work in cold/heat
PROPOSED PERSONNEL/ SUBCONTRACTOR:	Tom McKeon, Jeff Dawson, John Frerich, Grant Dawson, Justin Neste, Kyle Chambers
QUALIFICATIONS OF PROPOSED PERSONNEL:	40-hours OSHA training, current 8-hour refresher course, meets HASP requirements, and physically fit for work.
WORK FUNCTION:	Excavation contractor
QUALIFICATIONS REQUIRED:	Licensed and bonded in WA, 40 hour OSHA training and current 8-hour refresher.
PROPOSED PERSONNEL/ SUBCONTRACTOR:	To be determined
QUALIFICATIONS OF PROPOSED PERSONNEL	
WORK FUNCTION:	Transport contractor (trucking)
QUALIFICATIONS REQUIRED:	Licensed and bonded in WA, appropriate OSHA training as required (40 hr training is not expected to be a requirement for transport contractor)
PROPOSED PERSONNEL/ SUBCONTRACTOR:	To be determined
QUALIFICATIONS OF PROPOSED PERSONNEL	

Original ☐ Project Files ☐ Central Files ☐

Attachment 1 (to QAPP)
CALIBRE Standard Operating Procedures (SOPs)

Contingency Plan and Emergency Procedures
Utility Clearance Required Prior to Intrusive Investigation or Remediation Activities
Photoionization Detector (PID) Calibration and Use
Soil Sampling
Groundwater Sampling
Decontamination of Sampling Equipment
Low-Flow Groundwater Sample Collection
Direct-Push and Monitoring Well Groundwater Sampling
Sample Packaging and Shipment
Well Construction and Development
Well Drilling, Construction, and Sampling In Roadways
Drum Handling and Management
Data Validation
Heavy Equipment Operation

CONTINGENCY PLAN AND EMERGENCY PROCEDURES
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in conducting field work on job sites will abide by the procedures outlined in this document. These emergency procedures are designed to meet or exceed applicable the Occupational Safety and Health Administration (OSHA) standards for safe work practices.

2.0 PURPOSE

The purpose of this contingency plan is to lessen the potential impact on the public health and the environment in the event of an emergency circumstance, including a fire, explosion, or unplanned release of dangerous waste or dangerous waste constituents to air, soil, surface water, or ground water. This contingency plan has been developed to eliminate or minimize potential impacts of such emergency circumstances, and the elements of this plan are to be implemented immediately in emergency circumstances.

3.0 RESPONSE ACTIONS

The key response actions to be taken in an emergency situation include the following:

1) In the event of a fire, worker will immediately notify the local fire department. If this person has been trained in the proper use of fire extinguishers, he or she may then attempt to extinguish the fire if this can be done safely, but only after first notifying the local fire department.

2) In the event of a small spill, the worker will immediately act to contain the spill using the on-site spill response materials. After the spill has been contained, the worker will arrange cleanup of the spill residuals and notify the client contact. For any larger spills, the worker will contact local Fire and Security.

3) In the event of a fire, explosion, or other release that could threaten human health outside the facility or that has reached waters of the state, the worker must notify Boeing Fire and Security. Note the following:

    - The date, time, and type of incident;
    - The quantity and type of dangerous waste involved in the incident;
    - The extent of injuries, if any; and
    - The estimated quantity and disposition of recovered materials, if any.

All employees performing operation and maintenance activities at the site will understand proper waste handling and emergency procedures relative to their job responsibilities. As noted above, because of the limited number of employees working on the site, all employees will be responsible for reviewing and understanding the required procedures for management of process waste streams before they are allowed to work on site.

1) Description of Actions Which O&M Workers Must Take in Case of Emergency

Actions to be taken if any event occurs during operation of the project that is an emergency circumstance, including a fire, explosion, or unplanned release of waste or waste constituents to air, soil, surface water, or ground water will include:

- The equipment is to be shutdown immediately.
- If a fire exists, notify the fire department, use the on-site fire extinguisher.
- If a discharge exists, take immediate actions stop the discharge (shut off valve or other mechanism), call 911, use spill containment equipment to contain and cleanup any materials spilled.
- Notify client contacts and other project contacts (Attachment A).

2) Local Emergency Facilities

The Project Heath and Safety Plan (present on site) describes the route to a hospital.

3) Emergency Equipment at the Facility

The emergency equipment located on site includes:

- fire extinguisher
- spill control equipment (storm drain cover, absorbent pads and bulk media, shop-vac and extension cord, brooms, storage drum, decontamination equipment).

This list will be updated as appropriate.

4) Copies of Contingency Plan

A copy of this contingency plan and all revisions to the plan will be maintained at the facility and submitted to all local emergency response teams that may be called upon to provide emergency services.

5) Amendments

The owner/operator will review and amend the contingency plan, if necessary, whenever any of the following occur:

- Applicable regulations or the facility permit are revised
- The plan fails in an emergency
- The facility changes (in its design, construction, operation, maintenance, or other circumstances) in a way that materially increases the potential for fires, explosions, or releases of dangerous waste or dangerous waste constituents, or in a way that changes the response necessary in an emergency
- The list of emergency coordinators changes
- The list of emergency equipment changes

Review and Signature

The following operations staff have reviewed this contingency plan (and the primary O&M Manual) and hereby certify that they understand the objectives and requirements of this plan.

Name	Date

DATA VALIDATION
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual or contractor conducting data validation will abide by the procedures outlined in this document. These procedures are designed to meet or exceed the National Functional Guidelines for Data Review.

2.0 PURPOSE

The purpose of this document is to specify the procedures to be used to evaluate the quality of various data acquired from chemical analysis of samples. These procedures promote uniformity of data review, to help clarify and augment the review guidance of the National Functional Guidelines, and to give guidance for areas of data review that require considerable professional judgment.

3.0 SCOPE

The procedures required by this document are generally applicable to chemical analytical data. The extent of evaluation and the criteria against that data are evaluated is dependent upon intended data use.

4.0 REQUIREMENTS

Chemical analytical data shall be assessed, verified, and qualified according to intended use as described in the Data Quality Objectives of the project plan. This evaluation shall be performed by qualified individuals not involved in the data acquisition. Any limitations on data use shall be expressed and documented in any reporting of the data.

5.0 PROCEDURE

Chemical analytical data are obtained from different analytical methods. The evaluation procedure used for analytical data is dependent on the method by that the data were obtained.

The identity of all data shall be verified. Sampling records, logbooks, chains-of-custody records, and/or shipping records shall be examined to verify that the reported data are associated with the proper samples and have not been misidentified.

For analytical data acquired from laboratory chemical analyses and requiring formal validation, the data shall be validated following the *National Functional Guidelines for Data Review* (organic (EPA 1999) and inorganic (EPA 2004)). These documents explicitly describe the procedure for validating analytical. During data validation project specific DQOs and criteria identified in the project QAPP shall take precedence over criteria in individual methods and in *National Functional Guidelines for Data Review.*

For data acquired from documented analytical methods other than those described in the National Functional Guidelines (i.e., non-Contract Laboratory Program, CLP, methods such as SW-846, ASTM, Standard Methods, EPA Series, WA Department of Ecology Methods, and others), the evaluation procedure for that analytical method shall be used to validate the data. Where no documented evaluation procedure exists or where the documented procedure is incomplete, the data shall be evaluated generally following the procedure described in the *National Functional Guidelines for Data Review*. In this case, any evaluation criteria or procedures applicable to the respective analytical method shall be used, when available and appropriate, in place of the criteria or procedures described in the National Functional Guidelines. For example, a method might not specify a validation procedure for data obtained from the analysis, but might specify that the relative percent difference between matrix spike and matrix spike duplicate results be no greater than 50 percent. In this case, the data would be validated following the *National Functional Guidelines for Data Review*, but the validation criterion for the relative percent difference between matrix spike and matrix spike duplicate would be 50 percent instead of the criterion specified in the *National Functional Guidelines for Data Review*. Additionally, different data quality levels will be used for different projects based on the project objectives, decisions to be made based on the data to be collected, and availability of existing data. Where applicable, some projects will request and utilize a Level II data package from the laboratory. The Level II data package does not contain (intentionally) the same lab reporting requirements equivalent to a Level IV or CLP type data package. In this case, the data shall be evaluated generally following intent of the procedures described in the *National Functional Guidelines for Data Review* but adapted (or truncated) to the specific data included within the laboratory reporting package (and case narrative).

For data acquired from non-standard, non-routine, or undocumented analytical procedures, an evaluation procedure shall be developed, and documented, and performed by a qualified and knowledgeable individual and the evaluation shall be documented.

Regardless of the analytical method used, once the data have been validated an assessment of the impact of field quality control samples (trip blanks, field blanks, equipment blanks, etc.) on the analytical results shall be made.

The results of the validation and field quality control sample result impact assessment shall be used to evaluate the quality of the data relative to their intended use. Results of this evaluation shall be documented.

6.0 REFERENCES:

EPA, 1999, *National Functional Guidelines for Organic Data Review*: Contract Laboratory Program, EPA 540/R-99-008 (PB99-963506), October 1999.

EPA, 2004, *National Functional Guidelines for Inorganic Data Review*: Contract Laboratory Program, EPA 540-R-04-004, October 2004.

DECONTAMINATION OF SAMPLING EQUIPMENT
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in field work requiring the decontamination of field equipment or instruments will abide by the procedures outlined in this document. These procedures are designed to meet or exceed applicable Occupational Safety and Health Administration (OSHA) standards for safe work practices.

2.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide the methods and procedures for decontamination of sampling or field equipment used in the collection of environmental samples and/or used for field activities at known or potentially contaminated sites.

3.0 SCOPE AND APPLICATION

This SOP should be used for decontaminating all disposable and non-disposable equipment used during field work. Items requiring decontamination may include personal protective equipment, sample equipment (shovels, trowels, pumps, tubing, depth to water probe, etc.) and heavy equipment (backhoes, direct-push probes, and drill rig augers). Upon completion of decontamination procedure, record that the decontamination activities have occurred in the field logbook and/or sample data record sheet.

4.0 EQUIPMENT

1. Potable water supply.
2. Liquinox or other specified cleaning agent.
3. Deionized (DI) water.
4. Buckets/tubs for wash and rinse.
5. Other decontamination liquids/solvents specified in site-specific plans.
6. Drums (55-gallon) or other containers for containerizing decontamination fluids.
7. Pressure washer and containment pad for heavy equipment.
8. Sample containers for sampling decontamination fluids (if required).

5.0 DECONTAMINATION PROCEDURES

5.1 Decontamination Procedures for Water Level Meters and the Water Quality Field Parameter Sensors

The electronic water level indicator probe/steel tape and the water-quality field parameter sensors will be decontaminated by the following procedures:

- The water level meter will be hand washed with phosphate free detergent and a scrubber, then thoroughly rinsed with distilled water.
- Water quality field parameter sensors and flow-through cell will be rinsed with distilled water between sampling locations. No other decontamination procedures are necessary or recommended for these probes since they are sensitive. After the sampling event, the flow cell and sensors must be cleaned and maintained per the manufacturer’s requirements.

- Containerize, label, and sample (if required) all decontamination fluids for appropriate disposal.

5.2 Decontamination Procedure for Sampling Pumps

Upon completion of the groundwater sample collection the sampling pump must be properly decontaminated between monitoring wells. The pump and discharge line including support cable and electrical wires which were in contact with the groundwater in the well casing must be decontaminated by the following procedure:

- If a hydrophobic contaminant is present (such as separate phase, high levels of PCB’s, etc.), an additional decontamination step, or steps, may be added. For example, an organic solvent, such as reagent-grade isopropanol alcohol may be added as a first spraying/bucket prior to the soapy water rinse/bucket. Acid washes are not typically used as they can corrode the sampling pumps.
- The outside of the pump, tubing, support cable and electrical wires must be pressured sprayed with soapy water, tap water and distilled water. Spray inside and outside of tubing and pump until water is flowing off of tubing after each rinse. Use bristle brush to help remove visible dirt and contaminants.
- Place the sampling pump in a bucket or in a short PVC casing (4-in. diameter) with one end capped. The pump placed in this device must be completely submerged in the water. A small amount of phosphate free detergent must be added to the potable water (tap water).
- Remove the pump from the bucket or 4-in. casing and scrub the outside of the pump housing and cable.
- Place pump and discharge line back in the 4-in. casing or bucket, start pump and re-circulate this soapy water for 2 minutes (wash).
- Re-direct discharge line to a 55-gallon drum; continue to add 5 gallons of potable water (tap water) or until soapy water is no longer visible.
- Turn pump off and place pump into a second bucket or 4-in. casing which contains tap water, continue to add 5-gallons of tap water (rinse).
- Turn pump off and place pump into a third bucket or 4-in. casing which contains distilled/deionized water, continue to add three to five gallons of distilled/deionized water (final rinse).
- Containerize, label, and sample (if required) all decontamination fluids for appropriate disposal.
- In the case of sampling equipment coming into contact with LNAPL or DNAPL the equipment must be decontaminated using solvent as a first cleaning step. Whenever possible it is important to inspect historical well data to prevent unexpected exposure to NAPLs.

5.3 Decontamination Procedures for General Field Sampling Equipment and PPE

Field sampling tools such as shovels, trowels, and PPE will be cleaned using the following procedures:

- Spray/rinse off excess dirt, mud, or other residue with potable water.
- Scrub sampling equipment and soiled PPE in potable water and Liquinox or other non-phosphate detergent.
- Rinse with potable water.
- Rinse reusable sampling equipment with deionized water, air dry, and store in aluminum foil.

- Rinse with methanol, hexane, isopropanol, nitric acid, or other cleaning agents if specified in QAPP or SAP.
- Dispose of all cleaned equipment/PPE appropriately.
- Containerize, label, and sample (if required) all decontamination fluids for appropriate disposal.

5.4 Decontamination Procedures for Heavy Equipment

Heavy equipment requiring decontamination may include drill rigs, drill augers, direct-push rods and samplers, backhoes, and other equipment that has contacted potentially contaminated media. The procedures include the following:

- Construct a lined containment pad for collection of all soil, residue, and decontamination fluids.
- Pressure wash equipment with potable water until clean.
- Rinse sampling equipment (such as direct-push split spoon or sampler) in DI water, air dry, and store in clean container (such as aluminum foil). Use other cleaning agents if specified in QAPP or SAP.
- Containerize all sediments/soils and decontamination fluids in 55-gallon drums. Separate media (soil, water) if possible and sample for appropriate disposal. Label all containers with contents, date, location, and contact information.
- Decontaminate containment pad or pad liner. Dispose of all non-reusable items appropriately after thoroughly decontaminated.
- Containerize, label, and sample (if required) all decontamination fluids for appropriate disposal.

6.0 HEALTH AND SAFETY CONSIDERATIONS

Follow all requirements of the project Health and Safety Plan (HASP). Ensure all field equipment has been decontaminated in accordance with the site-specific HASP and this SOP.

DIRECT-PUSH AND MONITORING WELL GROUNDWATER SAMPLING
CALIBRE STANDARD OPERATING PROCEDURES

1.0 PURPOSE

This Standard Operating Procedure (SOP) provides instructions that are to be followed in collecting direct-push groundwater samples.

2.0 GROUNDWATER SAMPLING

The following sections describe sampling procedure to be used in the collection of direct-push groundwater samples from direct-push boreholes and monitoring wells.

2.1 Direct Push Groundwater Sampling

When the desired depth interval is reached, a push-rod is inserted into the center of the drill-string. Sections are added until the push-rod contacts the Direct-push point. After threading the rod on to the end cone and releasing it from the drill-string, the drill-string is retracted while holding the push-rod in place exposing the screen. The push-rod is withdrawn and new (unused) tubing with a foot valve on the end is lowered to a point where it is centered in the screen. A groundwater sample is extracted either with the use of a peristaltic pump or by applying a quick up and down motion to the tube until water comes out of the end of the tube. Teflon tubing or Teflon lined tubing should be used when sampling for organic chemicals near trace levels.

2.2 Monitoring Well Groundwater Sampling

Groundwater may be sampled in monitoring wells by use of Waterra pumps, peristaltic pumps, submersible pumps, or bailers. Regardless of the system employed, the point of collection (i.e. pump or foot valve) is placed at the mid-screen interval. Groundwater is withdrawn from the well until three well casing volumes have been removed and groundwater parameters (pH, temperature, conductivity, etc.) have stabilized. At that point, sample containers may be filled in accordance with project specific Field Sampling Plan procedures. Whenever feasible the methods described in the low-flow groundwater sampling SOP shall be used especially whenever trace amounts of chemicals are anticipated. For trace level VOC sampling, positive displacement sampling techniques should be used in lieu of peristaltic pumps or bailers.

2.3 Sample Handling

When the sample water appears, use the following the sequence of steps described below:

(1) Label all bottles with required tags and labels. Fill out all information except the actual date and time. Sort bottles, one set per sampling location with additional sets as needed for QA/QC samples.

(2) Note depth and bore location of the sample in the field logbook or sample data sheet.

(3) At the time of individual sample collection, record date and time on all sample containers and in the field logbook. Cover all container labels with wide, transparent, waterproof tape to ensure label integrity.

(4) Hold bottle so that water pours into it without the lip of the bottle touching the tube.

(5) If the samples are being analyzed for volatile organic compounds (VOCs), collect the VOC fraction first. VOC vials should be filled to the top with a meniscus above the lip of the vial, leaving no airspace in the bottle when the lid is screwed on.

(6) Fill the remaining bottles up to the shoulder of the bottle and seal with the cap.

(7) Wipe off the outside of the bottle/vial and place it in a bubble baggie. Place the bagged bottle in a cooler, with ice if the sample plan calls for ice.

(8) Decontaminate the sampling equipment for the next sample if sampling equipment is not dedicated or disposable.

2.4 Waste

Insure that all purge water and decontamination water, which may be contaminated, are handled and disposed of properly.

GROUNDWATER SAMPLING
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in collection of groundwater samples at job sites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed guidelines set forth by the Environmental Protection Agency (EPA) for the collection of groundwater samples at Superfund or Resource Conservation and Recovery Act (RCRA) sites.

2.0 PURPOSE

This Standard Operating Procedure (SOP) provides instructions that are to be followed in collecting groundwater samples.

2.0 GROUNDWATER SAMPLING

The following sections describe sampling procedures to be used in the collection of groundwater samples from direct-push boreholes and monitoring wells. Whenever feasible the methods described in the low-flow groundwater sampling SOP shall be used especially whenever trace amounts of chemicals are anticipated.

2.1 Direct-Push Groundwater Sampling

When the desired depth interval is reached, a push-rod is inserted into the center of the drill-string. Sections are added until the push-rod contacts the direct-push point. After threading the rod on to the end cone and releasing it from the drill-string, the drill-string is retracted while holding the push-rod in place exposing the screen. The push-rod is withdrawn and fresh (unused) tygon tubing with a foot valve on the end is lowered to a point where it is centered in the screen. A groundwater sample is extracted either with the use of a peristaltic pump or by applying a quick up and down motion to the tube until water comes out of the end of the tube. Teflon tubing or Teflon lined tubing should be used when sampling for organic chemicals near trace levels.

2.2 Monitoring Well Groundwater Sampling

Groundwater may be sampled in monitoring wells by use of Waterra pumps, peristaltic pumps, submersible pumps, or bailers. Regardless of the system employed, the point of collection (i.e. pump or foot valve) is placed at the mid-screen interval. Groundwater is withdrawn from the well until three well casing volumes have been removed and groundwater parameters (pH, temperature, conductivity, etc.) have stabilized. At that point, sample containers may be filled in accordance with project specific Field Sampling Plan procedures. When sampling wells with trace levels of VOCs a positive displacement pump is preferred to the use of bailers or peristaltic pumps for groundwater extraction.

Prior to sampling historical data should be inspected to determine the likelihood of the presence of LNAPL or DNAPL. If NAPL is likely, use of a Waterra style pump may be preferred as the equipment can be readily decontaminated and disposed.

2.3 Sample Handling

When the sample water appears, use the sequence of steps described in the following list:

1) Label all bottles with required tags and labels. Fill out all information except the actual date and time. Sort bottles, one set per sampling location with additional sets as needed for QA/QC samples.

2) Note depth and bore location of the sample in the field logbook or sample data sheet.

3) At the time of individual sample collection, record date and time on all sample containers and in the field logbook. Cover all container labels with wide, transparent, waterproof tape to ensure label integrity.

4) Hold bottle so that water pours into it without the lip of the bottle touching the tube.

5) If the samples are being analyzed for volatile organic compounds (VOCs), collect the VOC fraction first. VOC vials should be filled to the top with a meniscus above the lip of the vial, leaving no airspace in the bottle when the lid is screwed on.

6) Fill the remaining bottles up to the shoulder of the bottle and seal with the cap.

7) Wipe off the outside of the bottle/vial and place it in a bubble baggie. Place the bagged bottle in a cooler, with ice if the sample plan calls for ice.

8) If sampling equipment is not dedicated or disposable, then decontaminate the sampling equipment for the next sample.

2.4 Waste

Insure that all purge water and decontamination water, which may be contaminated, are handled and disposed of properly.

HEAVY EQUIPMENT OPERATION
CALIBRE STANDARD OPERATING PROCEDURES

1.0

It is the policy of CALIBRE that any individual engaging in the use of heavy equipment on jobsites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed applicable Occupational Safety and Health Administration (OSHA) standards for safe work practices.

2.0 PURPOSE

This standard operating procedure (SOP) provides instructions that are to be followed in the operation of heavy equipment and other equipment deemed to be outside of the scope of small hand tools. The activities and requirements listed in this SOP are designed to ensure that work is accomplished in a safe manner that minimizes the risk of injury or death to operators or nearby personnel and damage to equipment and property.

3.0 COVERED EQUIPMENT

This SOP applies to, but is not limited to, the following list of equipment:

- Tractors
- Loaders
- Backhoes
- Excavators
- Dozers
- ATVs
- Forklifts
- Trailer mounted equipment (i.e. generators, pumps)
- Chainsaws
- Any equipment too large to be lifted or moved by a single individual

This SOP does not apply to licensed road vehicles.

4.0 GENERAL CONSIDERATIONS

Only experienced and authorized operators shall be permitted to operate a designated piece of equipment. Operator trainees will be permitted to operate equipment under the direct supervision of an experienced operator as approved by the Field Operations Manager. An operator trainee will be designated an experienced operator for any given piece of equipment when they are deemed proficient by both the Equipment Operation Trainer and the Field Operations Manager.

Personal protective equipment (PPE) is mandatory and may include the following:

- Safety toe boots
- Long substantial pants
- Hearing protection
- Eye/face protection

- Hard hat
- Gloves

Refer to the specific project Health and Safety Plan for detailed PPE requirements.

Prior to starting any piece of equipment, perform a pre-start/walk-around inspection:

- Check for loose or worn parts and have repaired or replaced immediately.
- Check all fluid/coolant levels. **Caution! Open radiator cap only when engine is cooled.**
- Inspect hydraulic line connectors and hoses for leaks before applying pressure to the system. Use paper or cardboard, not your hands, to search for leaks. **Caution! Hydraulic fluid escaping under pressure can penetrate skin and cause serious bodily harm.**
- Check tires for cuts, bulges, irregularities, abnormal wear, and proper inflation.
- A fire extinguisher and first aid kit shall be readily available at the location of equipment operation.
- Clean windshield, mirrors, and lights when applicable.

Perform the following work site precautions:

- In the event that the equipment does intrusive groundwork, insure that a thorough utility locate has been performed.
- Thoroughly inspect all work area clearances such as overhead utilities, holes or drop offs, and partially hidden obstacles or facilities.
- Maintain constant awareness of other nearby activities or personnel that might end up in harms way.
- Follow all equipment specific safety and operating manuals.
- Maintain a 3-point contact with steps and hand rails while getting on/into a piece of equipment; do not use the controls or steering wheel as a handhold. **Caution! Do not get on or off a machine that is in motion.**
- Do not operate a piece of equipment with wet, greasy, or muddy hands or shoes.
- Fasten seat belt and adjust seat prior to starting.
- Controls should be in neutral and parking brake set before starting engine.
- Start engine only from operator’s seat.
- Check all gauges, lights, instruments, and warning devices to assure that they are functioning properly and the readings are within normal range.
- Test steering and brakes.
- Familiarize yourself with all controls and ensure all implement controls are operating properly.
- Park on level ground and lower all hydraulic equipment before shutting down machine.
- Smoking is prohibited at all times.

5.0 OPERATING REQUIREMENTS

Following are the operating requirements for specific types of equipment.

Tractor

- Tractors are one person machines and no other person is allowed in or on the machine while it is operating.
- Drive at speeds compatible with weather and ground conditions. Watch for row ends, ditches, and trees.
- Keep the tractor in gear at all times, especially on a steep grade, in order to have full control of the tractors speed.
- Insure that power take off (PTO) has shield. Wear snug clothing when operating equipment with a PTO or rotating parts.

Loader

- Loaders are one person machines and no other person is allowed in or on the machine while it is operating.
- Loader operations should be performed with two people; the operator and a spotter on the ground directing the operator.
- Operate at a speed consistent with working conditions, visibility, and terrain.
- When crossing exposed railroad tracks, ditches, ridges, or curbs, reduce speed and cross at an angle.
- Stay in gear when traveling downhill to control speed.
- Never move or swing a load over the heads of other workmen.
- When backfilling, use extreme caution; weight of the load plus the weight of the machine could cause new construction to collapse.
- Keep work area level; avoid developing ruts by occasionally back dragging the bucket to smooth the surface.

Backhoe

- Backhoes are one person machines and no other person is allowed in or on the machine while it is operating.
- Before operating the backhoe, lower stabilizers so that the rear wheels are just off the ground and machine is level.
- Clear everyone from the bucket swing area. Do not swing bucket over truck cabs.
- Operate backhoe only from the seated position.
- Do not dig under the backhoe stabilizers.
- When operating on a slope, swing to the uphill side.
- Before dismounting, be sure the backhoe is in its transport mode and the bucket is lowered to the ground. Never leave a load hanging.
- Lift excessively heavy objects to the rear of the backhoe to prevent tipping; ensure they are properly balanced to prevent tipping or swaying.

Excavator

- Excavators are one person machines and no other person is allowed in or on the machine while it is operating.
- Clear everyone from the bucket swing area. Do not swing bucket over truck cabs.
- Operate excavator only from the seated position.

- When operating on a slope, swing to the uphill side.
- Before dismounting, be sure the excavator is in its transport mode and the bucket is lowered to the ground. Never leave a load hanging.
- Ensure the dead stick is disengaged before dismounting.

Dozer

- Dozers are one person machines and no other person is allowed in or on the machine while it is operating.
- Always secure seatbelt before operating dozer.
- Lower blade before dismounting.

ATV

- Operate at a speed consistent with working conditions, visibility, and terrain.
- Never travel cross-slope on slopes greater than 30°.

Forklift

- Forklifts are one person machines and no other person is allowed in or on the machine while it is operating.
- No person shall be allowed to stand or pass under an elevated part of a forklift whether loaded or empty.
- Operate forklift only on level surfaces.
- If operator is $\geq$ 25 ft. from forklift or out of sight of forklift, load must be lowered, controls neutralized, and brakes set.
- Come to a complete stop before reversing directions.
- Travel in reverse when load obstructs the operators view.
- Slow down when approaching intersections, blind corners, and when traveling on wet or slippery surfaces.
- Use horn when visibility is limited and at intersections.
- Only stable or safely arranged loads shall be handled.
- Be aware of overhead clearances.

Trailer Mounted Equipment

- Never place fingers under hitch when hooking up to vehicle.
- Use extreme caution when backing vehicle with trailer attached.
- Ensure that brake lights, turn signals, tail lights, and clearance lights on the trailer are working before traveling.

Chainsaw

- Wear gloves, chaps, hardhat, steel-toed boots, and safety glasses during use.
- Use caution that loose clothing does not get near saw chain where it might get caught and draw body parts into harms way of the equipment.
- Never operate a chainsaw with fingers or other body parts placed in the direction/pathway of the cut.

- After a cut, wait until the chain has stopped moving before moving the saw to a new location.
- Allow chainsaw to cool before refueling.
- Do not make overhead cuts with a chainsaw.
- Always operate chainsaw with both hands on the chainsaw handles.

6.0 EQUIPMENT USAGE FORM

Figure 1 is the form that is to be filled out each time heavy equipment is rented by CALIBRE.

Figure 1. Equipment Usage Form

Project Name and Code ____

Equipment Rented:

____
____
____
____
____

Rental Company ____

Value of Equipment Stated by Rental Company ______________________________

Rental Start Date ____________________ End Date __________________________

CALIBRE Operator(s) ____

Field Operations Manager ____

DRUM EXCAVATION AND MANAGEMENT
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual or contractor handling, removing, or managing excavated drums will abide by the procedures outlined in this document. These procedures are designed to ensure the safe handling, excavation, and transport of excavated drums with unknown contents that may or may not contain potentially hazardous compounds.

2.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to specify the procedures which will be used to manage the handling and removal of excavated drums on a work site. These procedures have been developed to promote safety and awareness while working on a site where drums are being excavated.

3.0 SCOPE

The procedures required by this document are generally applicable, and limited to, drum excavation/handling on a site where drums filled hazardous substances (as liquids) are not expected to be present based on prior site characterization data. If drums containing hazardous substances are encountered but they may be handled without danger to personnel (solid or cured substances, Level C Personal Protective Equipment (PPE) is acceptable they may also be removed following the protocols set forth in this document. This SOP has been developed for, and is limited to, projects where Level D or C (use of respirators) PPE is appropriate. In the case of drum excavation where higher potential exposure to hazardous substances is anticipated (or measured through on-site monitoring) indicating that level B PPE is required, the contingency plan is to halt excavation until appropriate measures can be taken to ensure the safety of site workers and reduce the chance of releasing any hazardous substance.

4.0 PROCEDURE

When a buried drum is uncovered during excavation, the first action taken is to attempt to identify its contents based on the labeling on the exterior of the drum and the material that the drum is made of. This preliminary inspection can determine what hazards the drum might present and the appropriate response necessary in handling the drum. As an initial caution, soil will be carefully removed from around the drum and a dry chemical fire extinguisher will be on hand as a contingency to control small fires. For shallow drum burial (i.e., less than 6 feet) workers will initialize this process by digging a trench with equipment near the drum, so a worker can get next to the drum for inspection. The trench must have appropriate sloping and or bracing to allow safe access. Caution will be taken when digging the trench to verify no additional drums are impacted during the trenching. Once a trench has been completed allowing personnel access near the drum, the remainder of the drum may be excavated using equipment and/or hand shovels to ensure the drum is not punctured.

Visual inspection of the drum is the next step before removal. The exterior of the drum may be labeled with symbols suggesting the hazard level of its contents. Signs of deterioration, such as corrosion or significant rust indicate a risk for leaking. A drum whose walls bulge outwards indicates a drum under pressure. If the drum is lined with polyethylene or PVC, the drum may contain strong acid or base; and if the drum is an exotic metal such as stainless steel or aluminum, it may contain extremely hazardous materials. A drum may contain a reactive or explosive substance if it shows fittings for both product filling and injection of an inert gas, such as single walled drums used as pressure vessels. Laboratory packs used for disposing expired chemicals and process samples from laboratories, universities, and hospitals, may contain incompatible materials, radioisotopes, shock-sensitive, highly volatile, highly corrosive, or very toxic exotic chemicals, and should be treated with extreme caution. If the drum appears to have contained a non-hazardous substance and is empty of its contents (i.e., drum has been punctured or is crushed), it will be removed with operating equipment and disposed of as scrap metal. If the drum appears to contain a non-hazardous substance, or a potentially hazardous substance that is not of a volatile nature (solids, cured substance) and can be safely removed in Level C PPE, the drum procedures for removal from the excavation pit will be enacted.

Prior to drum removal, the drum will be thoroughly inspected for signs of significant corrosion that may indicate the drum will shear or split if removed with equipment. If the drum appears structurally sound, a drum grappler may be attached to the excavator or like equipment and the drum lifted from the excavation to a staging area where it can be loaded for proper disposal. If the drum appears to have a high level of corrosion and structural damage, an overpack may be place over the drum while it is still within the excavation pit. After the drum is contained within the overpack it can be removed from the excavation and placed in a staging area for proper disposal.

Continuous monitoring of the environment while excavating drums is important in ensuring worker safety. A photo-ionizing detector (PID) and a lower-explosive-limit (LEL) detector (or suitable 4-gas meter) will be present at all times in the vicinity of excavating drums. Suitable Level C Air Purifying Respirators (APRs), with organic vapor filters, will also be present at all times in the event that hazardous levels of organic vapors are detected in the air. Where potentially leaky drums may result in minor spills, an adequate volume of absorbent will be kept for cleanup. Where leaky drums may result in a larger spill, a containment berm adequate to contain the entire spill will be constructed, prior to drum handling. If a drum is heavily rusted but not punctured, an overpack will be placed on the drum to ensure containment of any potential leaks.

Drums may require handling by personnel on site for sampling purposes to identify substances within drums for disposal characterization. When and if sampling of drums is required, continuous monitoring of the work space will be conducted (using a PID and LEL) and practices for safe procedures of drum opening and sample collection be followed, see specific examples in EPA 1992 (“Standard Operating Safety Guides” see Chapter 10)

In most cases, movement and transport of drums will be most safely conducted using equipment. This includes bulk excavation of overlaying soil above buried drums, lifting drums free from the ground, and loading onto transport vehicles which can remove drums from site. To maximize the safety of equipment operators, only vehicles with sufficient rated load capacity to handle anticipated loads will be used. Air conditioned cabs with heavy slash guard shields can help protect operators from inhaling or coming into contact with hazardous substances. Use of extreme caution is important when moving drums that are not intact or tightly sealed. Equipment operators need a clear line of sight for driving, and when this is impaired, workers will be available to direct the operator’s motion.

If any drums containing hazardous material are identified which may result in work place exposure where Level B PPE is required, operations will cease and personnel will evacuate the immediate work area until appropriate PPE and personnel trained and qualified in Level B operations are present for further action.

5.0 REFERENCES

Occupational Safety and Health Administration (OSHA) Standards. Title 29, Code of Federal Regulations, Parts 1910 and 1926 (29 CFR 1910 and 1926).

US EPA, Standard Operating Safety Guides, United States Environmental Protection Agency, Office of Emergency and .Remedial Response, Publication 9285.1-03, June 1992

LOW-FLOW GROUNDWATER SAMPLE COLLECTION
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in collection of low-flow groundwater samples at job sites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed guidelines set forth by the Environmental Protection Agency (EPA) for the collection of low-flow groundwater samples at Superfund or Resource Conservation and Recovery Act (RCRA) sites.

2.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide a method that minimizes the impact the purging process has on the groundwater chemistry during sample collection and minimizes the volume of water that is being purged and disposed. The flow rate at which the pump will be operating will depend on both hydraulic conductivity of the aquifer and the drawdown, with the goal of minimizing the drawdown within the monitoring well. The flow rate from the pump during purging and sampling is targeted at a rate that will not compromise the integrity of the analyte that is being sampled. The operating flow of groundwater to the pump will depend on the hydraulic conductivity of the aquifer within the screen interval. In order to minimize the drawdown in the monitoring well, a low-flow rate must be utilized. Low-flow refers to the velocity with which water enters the pump intake from the surrounding formation in the immediate vicinity of the well screen. This SOP was developed to be consistent with guidelines from the Superfund/ RCRA Groundwater Forum and draws directly from a USEPA Groundwater Issue Paper, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers (Yeskis and Zavala, 2002).

3.0 SCOPE AND APPLICATION

This SOP should be used primarily at monitoring wells which have a screen or an open interval with a length of ten feet (typically) or less and can accept a sampling device that minimizes the disturbance to the aquifer or the water column in the well casing. The groundwater samples that are collected using this procedure are acceptable for the analyses of groundwater contaminants that may be found at typical groundwater contamination sites (CERCLA, RCRA and other sites). The analytes may be volatile organic compounds, semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic compounds. The screened interval should be located within the contaminant plume(s) and the pump intake should be placed at or near the known source of the contamination within the screened interval. It is critical to place the pump intake in the same exact location or depth for each sampling event (indicating an obvious preference for permanently installed sampling devices where possible). If dedicated sampling pump is not possible, then the placement of the pump intake should be positioned with a pre-measured sampling pump hose. The pump intake should not be placed near the bottom of the screened interval to avoid disturbing any sediment that typically accumulates on the bottom of the well.

Water-quality indicator parameters (and water levels if feasible) must be measured during purging, prior to sample collection. Stabilization of the water quality parameters as well as monitoring water levels are prerequisites to sample collection. The water-quality indicator parameters that are recommended include: specific conductance, dissolved oxygen, oxidation-reduction potential, pH, and temperature. Turbidity may be useful but is not a required parameter. Also, when samples are collected for metals, semi-volatile organic compounds, and pesticides, every effort must be made to reduce turbidity to 10 NTUs or less (not just the stabilization of turbidity) prior to the collection of the water sample. In addition to the measurement of the above parameters, depth to water should be measured (if feasible) during purging. However, recognizing that many groundwater monitoring wells are two-inch diameter, the pump assembly may not allow access for a depth to water probe.

Proper well construction, development, and maintenance are essential for any groundwater sampling procedure. Prior to conducting the field work, information on the construction of the well and well development should be obtained and that information factored into the site-specific sampling procedure. The attached Pre-Sampling Checklist is an example of the general type of information that is useful.

Stabilization of the water-quality indicator parameters is the criterion for sample collection. But if stabilization is not occurring and the procedure has been followed, then sample collection can take place once three (minimum) to six (maximum) casing volumes of groundwater have been removed from the well. The specific information on what took place during purging must be recorded in the field notebook or in the Well Sampling Data Sheet. This SOP is not to be used where non-aqueous phase liquids (immiscible fluids) are present in the monitoring well.

4.0 EQUIPMENT

1) Depth-to-water measuring device - An electronic water-level indicator (E-tape) or steel tape and chalk, with marked intervals of 0.01 foot. Interface probe for determination of non-aqueous phase liquids (NAPL) (if needed).
2) Steel tape and weight - Used for measuring total depth of well. Lead weight should not be used. If the wells are less than 75 feet deep, the E-tape may suffice for this total depth measurement, deeper wells may need steel tape and weight.
3) Sampling pump - Submersible or bladder pumps with adjustable rate controls are preferred. Pumps are to be constructed of inert materials, such as stainless steel and Teflon. Pump types that are acceptable include gear and helical driven, centrifugal (low-flow type) and air-activated piston.
4) Adjustable rate, peristaltic pump can be used when the depth to water is 20 feet or less.
5) Tubing - Teflon or Teflon lined polyethylene tubing is preferred when sampling for organic compounds. Polyethylene tubing can be used when sampling inorganics.
6) Power Source - If a combustion type (gasoline or diesel driven) generator is used, it must be placed downwind of the sampling area.
7) Flow measurement supplies - flow meter, graduated cylinder and a stop watch.
8) Multi-parameter meter with flow-through-cell. This can be one instrument or more contained in a flow-through cell. The water-quality indicator parameters which must be monitored are pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), specific conductance, and temperature. The inlet of the flow cell must be located near the bottom of the flow cell and the outlet near the top. The size of the flow cell should be kept to a minimum and a closed cell is preferred. The flow cell must not contain any air or gas bubbles when monitoring for the water-quality indicator parameters.
9) Calibration fluids for all instruments. There needs to be sufficient volume of calibration solution for daily calibration throughout the sampling event.
10) Decontamination Supplies - Including a reliable and documented source of deionized (DI) or distilled water and any solvents (if used). Pressure sprayers, buckets, or decontamination tubs for pumps, brushes, and non-phosphate soap will also be needed.

11) Sample bottles, sample preservation supplies, sample tags or labels, and chain of custody forms.
12) Field Sampling and Quality Assurance Project Plan.
13) Well construction data, field and water quality data and water levels from the previous sampling event.
14) Well keys, tools to open well head monuments, and map of well locations.
15) Field notebook, Well Sampling Data Sheets/forms (attached), and calculator.
16) Filtration equipment (if needed for dissolved metals analyses). An in-line disposable filter is recommended.
17) Polyethylene sheeting which will be placed on ground around the well head.
18) Personal protective equipment specified in the site Health and Safety Plan, including any air monitoring equipment specified in the site Health and Safety Plan.
19) Tool box - All tools required for access to wells and for all site equipment used.
20) A 55-gallon drum or other appropriate container to contain the purged water.

Construction materials of the sampling equipment (bladders, pumps, tubing, and other equipment that comes in contact with the sample) should be limited to inert materials (such as stainless steel, Teflon, or other inert materials). This will reduce the chance of the sampling materials altering the groundwater where concentrations of the site contaminants are expected to be near the detection limits. The sample tubing diameter thickness should be maximized and the tubing length should be minimized so that the loss of contaminants into and through the tubing walls may be reduced and the rate of stabilization of groundwater parameters is maximized. The tendency of low level organics to sorb into and out of material makes the appropriate selection of sample tubing material critical for trace analyses.

5.0 CALIBRATION OF WATER QUALITY INSTRUMENTS

All water quality instruments to be used need to be calibrated (daily) following procedures in the instrument specific user manual.

6.0 DEPTH TO WATER AND PRE-SAMPLING ACTIVITIES (Non-dedicated and dedicated system)

1) Sampling events must begin at the monitoring well with the least contamination, generally up-gradient or farthest from the site or suspected source. Then proceed systematically to the monitoring wells with the most contaminated groundwater. Depth to water measurements should be collected in the same order.
2) Check and record the condition of the monitoring well for damage or evidence of tampering. If the ground surface indicates a potential for contamination (dirt, mud, debris or other), prepare the ground surface near the well to avoid contamination with clean plastic sheeting near/around the well to minimize the likelihood of contamination of sampling/purging equipment from surface soil contamination. Place monitoring, purging, and sampling equipment on the sheeting.
3) Unlock well head. Record location, time, date, and appropriate information in a field logbook or on the Well Sampling Data Sheet (See attached Well Sampling Data Sheet).
4) Remove well casing cap and observe any apparent pressure changes within the casing, if the cap is under vacuum or pressure allow the well time to equilibrate before measuring water levels .

5) As appropriate, monitor the headspace of the monitoring well at the rim of the casing for volatile organic compounds (VOC) with a photoionization detector (PID) or flame ionization detector (FID), and record in the logbook. If the existing monitoring well has a history of positive readings of the headspace, then the sampling must be conducted in accordance with the Health and Safety (H&S) Plan. This step may be skipped if prior data indicate that the specific well has not posed H&S issues in prior sampling.
6) Measure the depth to water (water level must be measured to nearest 0.01 feet) relative to a reference measuring point on the well casing with an E-tape or steel tape and record in logbook or Well Sampling Data Sheet. If no reference point is found, measure relative to the top of the inner casing, then mark that reference point and note that location in the field logbook. Record information on depth to groundwater in the field logbook or Well Sampling Data Sheet.
7) Measure the depth to water a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.
8) Check the available well information or field information for the total depth of the monitoring well. Use the information from the depth of water in step 6 and the total depth of the monitoring well to calculate the volume of the water in the monitoring well or the volume of one casing. Record information in field logbook or Well Sampling Data Sheet.

7.0 PURGING AND SAMPLING PROCEDURES

The following describes the purging and sampling procedures for the Low Flow method for the collection of groundwater samples. These procedures also describe steps for dedicated and non-dedicated systems.

7.1 Purging and Sampling Activities

Non-dedicated system - Place the pump and support equipment at the wellhead and slowly lower the pump and tubing down into the monitoring well until the location of the pump intake is set at a pre-determined location within the screen interval. The placement of the pump intake should be positioned with a calibrated sampling pump hose, sounded with a weighted-tape, or using a pre-measured discharge tubing. Refer to the available monitoring well information to determine the depth and length of the screen interval. Measure the depth of the pump intake while lowering the pump into location. Record pump location in field logbook or Well Sampling Data Sheet.

Dedicated system - Pump has already been installed, refer to the available monitoring well information and record the depth of the pump intake in the field logbook or Well Sampling Data Sheet.

Non-dedicated system and dedicated system
Measure the water level (water level must be measured to nearest 0.01 feet) and record information on the Well Sampling Data Sheet, leave water level indicator probe in the monitoring well (if sufficient space in casing).

Connect the discharge line from the pump to a flow-through cell. The discharge line from the flow-through cell must be directed to a container to contain the purge water during the purging and sampling of the monitoring well.

Start pumping the well at a low flow rate (0.2 to 0.5 liters per minute) and slowly increase the pumping rate. Check the water level if feasible: Note if the groundwater monitoring well is two-inch diameter, the pump assembly (pump, support cable, discharge hose, electrical supply, and pump booster stages in some cases) may fill the entire well casing access and a depth-to-water probe may not fit within the well casing. Field personnel need to exercise extreme care and good judgment when adding a probe to the tight space within a well. Equipment jammed or locked deep in a well casing may be lost/destroyed and future sampling access eliminated.

Maintain a steady flow rate while maintaining a drawdown of less than 0.33 feet (USEPA 2002). If drawdown is greater than 0.33 feet, lower the flow rate. The maximum drawdown of 0.33 feet is a <u>goal</u> to help guide with the flow rate adjustment. It should be noted that this goal may not be feasible under a number hydrogeologic conditions (relatively thin aquifers and/or low permeability soils). If this goal is not feasible, the sampling approach will require adjustment based on site-specific conditions and personal experience.

Measure the discharge rate of the pump with a graduated cylinder and a stop watch. Also, measure the water level, if feasible, and record both flow rate and water level on the Well Sampling Data Sheet. Continue purging, monitor and record water level and pump rate every three to five minutes during purging. Pumping rates should be kept at minimal flow to ensure minimal drawdown in the monitoring well.

During the purging, a minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the water-quality indicator parameters. Then monitor and record the water-quality indicator parameters every three to five minutes.

The water-quality indicator field parameters are pH, specific electrical conductance, ORP, dissolved oxygen, temperature, and turbidity. The ORP may not always be an appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions. The stabilization criterion is based on three successive readings of the water quality field parameters; the following are the criteria to be used :

Table 1. Parameter Stabilization Criteria Reference

pH	Conductance	ORP	DO	Temperature	Turbidity
+/- 0.1 pH unit	+/- 5% mS/cm	+/- 10 millivolts	+/- 0.3 mg/L	+/- 5% degrees Centigrade	+/- 10% NTUs (when greater than 10 NTUs)

Once the criteria have been successfully met indicating that the water quality indicator parameters have stabilized, then sample collection can take place. If a stabilized drawdown in the well can't be maintained at 0.33 feet and the water level is approaching the top of the screened interval, reduce the flow rate or turn the pump off (for 15 minutes) and allow for recovery to 90% of the height of the original water column. It should be noted whether or not the pump has a check valve. A check valve is required if the pump is shut off. Under no circumstances should the well be pumped dry. Begin pumping at a lower flow rate, if the water draws-down to the top of the screened interval again turn pump off and allow for recovery. If two tubing volumes (including the volume of water in the pump and flow cell) have been removed during purging then sampling can proceed the next time the pump is turned on. This information should be noted in the field notebook or Well Sampling Data Sheet with a recommendation for a different purging and sampling procedure.

Maintain the same pumping rate or reduce slightly for sampling (0.2 to 0.5 liter per minute) in order to minimize disturbance of the water column. Samples should be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. Disconnect the pump's tubing from the flow-through-cell so that the samples are collected directly from the pump's discharge tubing.

For samples collected for dissolved gases or Volatile Organic Compound (VOC) analyses, the pump's tubing needs to be completely full of groundwater to prevent the groundwater from being aerated as the groundwater flows through the tubing. The sequence of the samples is immaterial unless filtered (dissolved) samples are collected and they must be collected last. All sample containers should be filled with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container. When filling the VOC samples a meniscus must be formed over the mouth of the vial to eliminate the formation of air bubbles and head space prior to capping. In the event that the groundwater is turbid (greater then 10 NTUs), samples for metals should include a filtered metal (dissolved) sample.

If filtered metal sample is to be collected, then an in-line filter is fitted at the end of the discharge tubing and the sample is collected after the filter. The in-line filter must be pre-rinsed with groundwater following manufacturer's recommendations and if there are no recommendations for rinsing, a minimum of 0.5 to 1 liter of groundwater from the monitoring well must pass through the filter prior to sampling.

Non-dedicated system
Remove the pump from the monitoring well. Decontaminate the pump and tubing and dispose of non-dedicated tubing.

Dedicated system
Disconnect the tubing that extends from the discharge cap at the wellhead (or cap) and decontaminate and dispose of any non-dedicated discharge tubing.

Non-dedicated and dedicated system - Close and lock the well.

8.0 DECONTAMINATION PROCEDURES

Follow decontamination procedures from appropriate SOP. Sensors in the field water quality instruments are sensitive and rinsing with distilled water between sampling locations is the only decontamination recommended.

9.0 FIELD QUALITY CONTROL

Quality control (QC) samples must be collected to verify that sample collection and handling procedures were performed adequately and that sampling procedures have not compromised the quality of the groundwater samples. Follow all requirements of the site-specific Quality Assurance Project Plan (QAPP), typically to include some version of the following:

- Field duplicates (1 per 20 samples)
- Matrix spike/spike duplicate (extra volume at 1 per 20 samples or sample delivery group)

- Equipment blank (depends on sampling equipment use)
- Trip blank (for VOCs, 1 per sample cooler)
- Temperature blank (1 per sample cooler)
- Field Blank (as required in QAPP or 1 per sampling event)

10.0 HEALTH AND SAFETY CONSIDERATIONS

Follow all requirements of the project Health and Safety Plan. Ensure all field equipment has been decontaminated and stored appropriately.

11.0 POST-SAMPLING ACTIVITIES

Several activities need to be completed and documented once ground-water sampling has been completed. These activities include, but are not limited to:

1) If any equipment problems are noted, notify the CALIBRE Equipment Pool Manager before the item is returned to storage. Determine where the equipment item should be shipped.
2) Ensure that all field equipment has been decontaminated and returned to proper storage location. Once the individual field equipment item has been decontaminated, tag it with date of cleaning, site name, and name of individual responsible.
3) All field data should be complied for site records.
4) All sample paperwork should be processed, including copies provided to the project manager, project files and any other project required sample handling and tracking facility.
5) All analytical data when processed by the analytical laboratory, should be verified against field sheets to ensure all planned data collection has been received from the laboratory.

12.0 REFERENCES

USEPA 2002. D. Yeskis and B. Zavala, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency. EPA 542.S-02-001. May 2002.

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal

PRE-SAMPLING CHECKLIST

Well Identification:
Map of Site Included: Y or N
Wells Clearly Identified w/ Roads: Y or N
Well Construction Diagram Attached: Y or N
Well Construction:
Details of well monument/cap security; specific keys/tools to open: Any traffic or pedestrian control requirements (if needed):
Diameter of Borehole: Diameter of Casing:
Casing Material: Screen Material:
Screen Length: Total Depth:
Approximate Depth to Water: and prior date:
Maximum Well Development Pumping Rate:
Date of Last Well Development:
Previous Sampling Information:
Was the Well Sampled Previously: Y or N
(If Sampled, Fill Out Table Below)
Table of Previous Sampling Information
Parameters Previously Sampled:
Number of Times Sampled:
Maximum Concentrations:
Notes (include previous purge rates):

Well Sampling Data Sheet

Date		Site Location	
Samplers		Well ID	
Casing Material		Constructed Depth	
Casing Diameter		Condition of Well	

Field Measurements:

Time		Depth Measured From:	
Depth to Water			Top of access port
			Mark on PVC casing
			Mark of protective casing
			Other

Purging Information:

Pump:		Dedicated		Non-dedicated		
Bailer:		PVC		Stainless Steel		Other:
Purge Start Time		Purge End Time				
Approximate Gallons Purged						

Water Monitoring Conditions:

Time							
pH							
Conductivity							
Turbidity							
D.O.							
Temperature							
ORP							
Purge Rate							
Gallons Purged							

Sampling Data:

Time		Sample ID	
pH		Duplicates	
Conductivity		QA/QC Volumes	
Turbidity			
D.O.			
Temperature			
ORP			

Sampling Device:

PVC Bailer		SS Bailer		Dedicated Pump		Teflon Bailer	

Analyses to be Performed:

Volatile Organics		VOCs 8260B	SVOCs by 8270C		Sulfate 375.2	
Total Metals		RCRA 8 or Priority Pollutants	SVOCs by 8270C/SIM		RSK-175 (methane, ethane, ethene)	
Dissolved Metals			Total Organic Carbon 415.1		Other	

Sampling Notes:

Well Diameter	Well Volume (Gal/ft)
1 inch	0.041
2 inch	0.163
4 inch	0.653
6 inch	1.469

Or:(total depth(ft) - DTW(ft)) x Well Dia^2 x 0.0408 = 1 Well Volume

PASSIVE DIFFUSION BAG SAMPLERS
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in groundwater sampling using passive diffusion bag samples will abide by the procedures outlined in this document. These procedures are designed to meet or exceed applicable regulatory procedures for sampling volatile organic compounds (VOCs) in groundwater using passive diffusion bag (PDB) samplers.

2.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide the methods and procedures for sampling groundwater for VOCs using PDB sampler.

3.0 SCOPE AND APPLICATION

Diffusion sampling is a relatively new technology designed to utilize passive sampling techniques without the need for well purging. Specifically, a diffusive membrane capsule is filled with deionized/distilled water, sealed, suspended in a well installation device, and lowered to a specified depth in a monitoring well. Over time (normally a minimum of 14 days), the volatile organic compounds (VOCs) in the groundwater diffuse across the membrane and reach equilibrium with the water inside the sampler. The sampler is subsequently removed from the well, and the water within the diffusion sampler is transferred to a sample container and submitted for laboratory analysis. Some benefits of using PDB samplers include reduced sampling costs and reduced generation of investigation-derived waste (IDW). The PDBs' ability to reflect dissolved VOC concentrations in the adjacent aquifer allows determination of stratification and vertical concentration gradients of VOC contaminants.

The PDB samplers were developed in the late 1990's and they become a widely accepted technique for determining concentrations of VOCs in groundwater monitoring wells. PDB samplers are commercially available and several brand names are available. The procedures for installing and retrieving PDB samplers may vary someone depending on the type of sampler that is being used. This SOP provides general methods and procedures for passive or polyethylene diffusion bag samplers; however, the specific procedures for each type of PDB you are using should be review to ensure the procedures you follow are in accordance with the manufacturer's procedure specific to the sampler being used.

PDB samplers are made of low density polyethylene (typically 4mils thick) film which serves as a semi-permeable membrane. The membrane is formed into the shape of a tube to create a sample chamber which is filled with de-ionized water and sealed. Various configurations are commercially available either pre-filled and sealed at both ends at the factory, or with a fill port and plug for filling at the factory, in the field, or at the user's lab. PDB samplers are typically 18 to 24 inches long and 1.25 to 1.75 inches in diameter to fit into a 2-inch diameter and larger monitoring wells. These dimensions provide 200 to 350 ml of sample for multiple VOA samples and duplicates. Other diameters and lengths are available to fit smaller diameter wells or to provide specific sample volumes. PDBs are available with an exterior polyethylene mesh that protects against abrasion.

Advantages of PDB samplers include:

- do not purge water
- only sample for VOC compounds
- effective in low yield wells
- allow for rapid installation and sample collection
- easy to use
- inexpensive to purchase and use
- samples discrete interval or can integrate sample over longer vertical interval
- multiple, stacked samplers provide vertical contaminant profile
- collect samples from discrete intervals in surface water bodies and tank

4.0 EQUIPMENT

1. PDB Sampling Forms.
2. Depth to water probe.
3. Rope or string to hold samplers.
4. Plastic sheeting.
5. Stainless steel weights.
6. Nylon zip-ties.
7. Scissors or device for opening samplers.
8. Decontamination supplies.
9. Drums (55-gallon) or other containers for containerizing excess groundwater or decontamination fluids.

5.0 SAMPLING PROCEDURES

New and clean nitrile gloves should be worn by any sampling personnel who will be in direct contact with any material that will, or that has the potential to, contact the groundwater.

5.1 Installing Passive Diffusion Bag Samplers

1. Measure the water elevation in the monitoring well in accordance with applicable site-specific SOPs. This will be used to determine how much of the well screen is in the saturated zone (i.e., saturated well-screen length). Note this depth on the Sampling Form.

2. Measure the total well depth and compare the measured depth with the depth to the reported bottom of the well screen on the PDB Sampling Form. This will provide information on whether sediment has accumulated in the bottom of the well or whether there is a blank section of pipe (sump) below the well screen.

3. Determine if the well screen is completely saturated. If not, determine the length of well screen that is saturated.

4. One sampler will be installed in each well unless specified differently by the project manager.

5. The PDB sampler should be placed in the center of the saturated screen interval and should be completely submerged throughout the equilibration period. If anticipated water elevation changes (based on historical data) may expose the top of the sampler to air, the diffusion sampler should be placed deeper.

6. If assembly work is conducted on the ground, prepare the ground surface near the well for assembly of the diffusion sampler string, place clean plastic sheeting near the well and sample string construction will be performed on the plastic sheeting. If assembly is completed in vehicle, verify work area is clean.

7. Attach the stainless steel weight to the sampling assembly/line (a weight and weight hanger slides over the bag and the top of the bag is snapped on the suspension line, which is 60# braided fishing line, or other assembly procedure depending on the PDB bag and model).

8. Lower the PDB and assembly into the well to the target interval (typically to the bottom of the well then raised back up 5 ft, or other procedure/interval defined in the work plan).

9. Use a total of two zip-ties per PDB sampler. Finally, place a knot or a zip-tie at the location on the rope that corresponds to the top of the well casing.

10. Record in the field logbook and the PDB Sampling Form the depth at which each sampler is to be installed.

11. Attach the top and bottom of the diffusion sampler to the rope using the zipties that were inserted into the rope in Step 9 above. If no obvious hook exists on the sampler to which to attach the sampler to the rope using the zip-tie, attach the sampler to the rope by weaving the zip-tie through the mesh tubing of the diffusion sampler. The zip-ties should be threaded through the mesh tubing in a way that prevents the polyethylene diffusion bag from sliding out of the mesh and in a way that prevents slack from developing in the rope between the bottom and top of the sampler.

12. Samples that will be collected in duplicate for quality control (QC) purposes may require additional sample volume to fill the required sample containers. In these instances, utilize either oversized, longer samplers (for 2-inch diameter wells) or attach two regular samplers to the same depth interval on the rope (for wells with a casing diameter larger than 2-inches). Check the volume of the sampler and laboratory volume requirements to determine if an additional sampler is required.

13. Using decontaminated scissors (see Decontamination SOP), trim the excess from the zip-ties before placing the sampling string down the well.

14. Gently lower the diffusion sampling string into the well (weight first) until the weight rests on the bottom and the upper knot or zip-tie (indicating the top of the well casing) is even with the top of the well casing. The diffusion sampler should now be positioned at the correct depths.

15. Secure the rope or string at the wellhead in this position. A suggested method is to attach the rope to a hook (if one exists) on the inside of the well cap or the cap can be fitted over the rope to hold the rope at the desired depth.

16. If the well cap cannot be installed over the rope, install a temporary cover over the well casing to prevent debris from entering the well.

17. Close and lock the well protective covering.

18. Leave the sampling string in place for at least 14 days (or as specified in the Work Plans).

5.2 Diffusion Sampler Recovery and Sample Collection

This section describes the procedures for retrieving PDB samplers from groundwater monitoring wells. Following the equilibration period, the diffusion sampling string will be retrieved and samples will be collected for field screening and laboratory analysis using the following procedures.

1. Measure the water level in the monitoring well in accordance with applicable site-specific SOPs. Note this depth on the sample collection form and verify that the top of the PDB sampler is completely submerged below the water level.

2. Gently but quickly reel up (or pull) the sampler on the string.

3. Cut the cable ties and remove the diffusion sampler from the rope. Examine the surface of the diffusion sampler for evidence of algae or a film that could affect the performance of the diffusion membrane. Note any observations in the sampling field book and on the PDB Sampling Form.

5. Cut open the diffusion sampler using a properly decontaminated pair of scissors and gently pour the water into three (3) 40-mL VOA vials (or as specified in the Work Plans). As an alternative to using scissors, a fill kit may be provided by the PDB supplier for transferring water from the PDB to the sample container. Regardless of the method of transference, the water should be carefully poured down the inner walls of the sample bottle to minimize aeration of the sample. WATER NEEDS TO BE TRANSFERRED FROM THE DIFFUSION SAMPLERS TO THE VOA VIALS AS QUICKLY AS POSSIBLE TO MINIMIZE CONTAMINANT VOLATILIZATION.

6. Once filled to the brim, sample bottles will be sealed in a manner such that there is no headspace (i.e., no air bubbles).

7. Sample bottle preservation, labeling, and shipment will be performed according to the procedures detailed in the Sample Packaging and Shipment SOP.

8. Excess water from the diffusion samplers will be collected in sealable plastic buckets or steel drums for containment until it is disposed of. All investigation derived waste (IDW), including excess sample water, spent diffusion samplers, disposable sampling equipment, and personal protective equipment will be managed according to the criteria specified in the IDW plan specified in the site Work Plan.

6.0 HEALTH AND SAFETY CONSIDERATIONS

Follow all requirements of the project Health and Safety Plan (HASP). Ensure all field equipment has been decontaminated in accordance with the site-specific HASP and the decontamination SOP.

7.0 Selected References

ITRC, 2004. Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater.

Parsons 2004. Final Comprehensive Results Report for the Passive Diffusion Bag Sampler Demonstration.

ITRC— Technical Overview of Passive Sampler Technologies March 2006

Vroblesky, D. A. 2001. User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compounds Concentrations in Wells, Part 1 and 2.

US Geological Survey Water Resources Investigation Reports 01-4060 and 01-4061.
ITRC, Diffusion Sampler Information Center (DSIC),
http://diffusionsampler.itrcweb.org/common/default.asp

NJDEP, August 2005, Field Sampling Procedures Manual, Chapters 5 and 6.
http://www.state.nj.us/dep/srp/guidance/fspm/

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PHOTOIONIZATION DETECTOR (PID) CALIBRATION AND USE
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in the use of a photoionization detector (PID) on jobsites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed applicable OSHA standards for safe work practices.

2.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the procedures for using a photoionization detector (PID).

3.0 SCOPE AND APPLICATION

The PID is a portable, nonspecific, vapor/gas detector employing the principle of photoionization to detect a variety of chemical compounds, both organic and inorganic, in air. This procedure is applicable to the PIDs used for air monitoring. These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and reported.

4.0 METHOD SUMMARY

The PID is a useful general survey instrument at hazardous waste sites. A PID is capable of detecting and measuring real-time concentrations of many organic and inorganic vapors in air. A PID is similar to a flame ionization detector (FID) in application; however, the PID has somewhat broader capabilities in that it can detect certain inorganic vapors. Conversely, the PID is unable to respond to certain low molecular weight hydrocarbons, such as methane and ethane that are readily detected by FID instruments.

The PID employs the principle of photoionization. The analyzer will respond to most vapors that have an ionization potential less than or equal to that supplied by the ionization source, which is an ultraviolet (UV) lamp. Photoionization occurs when an atom or molecule absorbs a photon of sufficient energy to release an electron and form a positive ion. This will occur when the ionization potential of the molecule in electron volts (eV) is less than the energy of the photon. The sensor is housed in a probe and consists of a sealed ultraviolet light source that emits photons with an energy level high enough to ionize many trace organics, but not enough to ionize the major components of air (e.g., nitrogen, oxygen, carbon dioxide). The ionization chamber exposed to the light source contains a pair of electrodes, one a bias electrode, and the second the collector electrode. When a positive potential is applied to the bias electrode, an electro-magnetic field is created in the chamber. Ions formed by the adsorption of photons are driven to the collector electrode. The current produced is then measured and the corresponding concentration displayed on a meter, directly, in units above background. Several probes are available for the PID, each having a different eV lamp and a different ionization potential. The selection of the appropriate probe is essential in obtaining useful field results. Though it can be calibrated to a particular compound, the instrument cannot distinguish between detectable compounds in a mixture of gases and, therefore, indicates an integrated response to the mixture.

Three probes, each containing a different UV light source, are available for many PIDs. Energies are 9.5, 10.2, and 11.7 eV. All three detect many aromatic and large molecular hydrocarbons. The 10.2 eV and 11.7 eV probes, in addition, detect some smaller organic molecules and some halogenated hydrocarbons. The 10.2 eV probe is the most useful for environmental response work, as it is more durable than the 11.7 eV probe and detects more compounds than the 9.5 eV probe.

Gases with ionization potentials near to or less than that of the lamp will be ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials higher than that of the lamp will not be detected. Ionization potentials for various atoms, molecules, and compounds are given in standard references (see attached in Appendix A).

5.0 INTERFERENCES AND POTENTIAL PROBLEMS

5.1 PID Instrument Limitations

1) The PID is a nonspecific total vapor detector. It cannot be used to identify unknown substances; it can only roughly quantify them.
2) The PID must be calibrated to a specific compound (or including a conversion factor for equivalent response such as isobutylene)
3) The PID does not respond to certain low molecular weight hydrocarbons, such as methane and ethane. In addition, the PID does not detect a compound if the probe has a lower energy than the compound's ionization potential.
4) Certain toxic gases and vapors, such as carbon tetrachloride and hydrogen cyanide, have high ionization potentials and cannot be detected with a PID.
5) Certain models of PID instruments are not designed for use in potentially flammable or combustible atmospheres.
6) The lamp window must be periodically cleaned to ensure ionization of the new compounds by the probe (i.e., new air contaminants).
7) The PID measures concentrations are not linear over this entire range. For example, if calibrated to benzene, the response is linear from about 0-600 units above background. This means the PID reads a true concentration of benzene only between 0 and 600.
8) This instrument is not to be exposed to precipitation (rain). The units are not designed for this service. Significant humidity may impair the accuracy of the PID.
9) Do not use this instrument for head space analysis where liquids can inadvertently be drawn into the probe.

5.2 Regulatory Limitations

Transport of calibration gas cylinders by passenger and cargo aircraft must comply with International Air Transport Association (IATA) Dangerous Goods Regulations or the U.S. Code of Federal Regulations, 49 CFR Parts 100-177. A typical calibration gas included with a PID is isobutylene. It is classified as a non-flammable gas, UN #1556 and the proper shipping name is Compressed Gas. It must be shipped by cargo aircraft only.

6.0 EQUIPMENT/APPARATUS

The following equipment is required for PID operation:

1) PID
2) Operating manual
3) Probes: 9.5 eV, 10.2 eV, or 11.7 eV
4) Battery charger for PID
5) Spare batteries
6) Jeweler's screwdriver for adjustments
7) Tygon tubing
8) NBS traceable calibration gas (isobutylene) or other gas when calibrating to specific compound
9) "T" valve for calibration
10) Field Data Sheets/Site Logbook
11) Intake assembly extension
12) Strap for carrying PID
13) Teflon tubing for downhole measurements
14) Plastic bags for protecting the PID from moisture and dirt
15) Mild soap solution for cleaning unit surfaces, Methanol for cleaning ionization chamber (GC grade), and Light source cleaning compound (if applicable)

Note: Battery charge status - This instrument may be kept on continuous charge without battery damage.

The PID is calibrated in accordance with the operations manual using isobutylene as the calibration standard. The operations manual may also be referred to for alternate calibration to a specific compound.

7.0 PROCEDURES

7.1 Preparation

Check out and ensure the proper operation of the PID, as appropriate, using the equipment checklist provided in Sections 6.0 and the steps listed below.

7.2 Start-Up Procedures

1) Allow the temperature of the unit to equilibrate to its surrounding. This should take about five minutes.
2) Attach the probe to the unit.
3) Turn the instrument to ON.
4) Zero the instrument per the operations manual
5) Check the SPAN with calibration gas
6) Set the PID to the desired range (i.e., 0-20, 0-200, 0-2000, if applicable based on unit).
7) Listen for the vacuum pump operation to verify function.
8) Check instrument with a point calibration gas, and other source, such as a magic marker, prior to survey to verify instrument function.
9) Routinely during the day, verify the unit calibration and recalibrate the instrument if necessary

7.3 Field Calibration and Operation

7.3.1 Field Calibration

Follow the start-up procedure in Section 7.2. Set the FUNCTION switch to the range setting which includes the concentration of the calibration gas. Calibrate as follows:

1. Attach a regulator to a disposable cylinder of calibration gas. Connect the regulator to the probe of the PID with a piece of clean tygon tubing. Open the valve on the regulator.
2. After 15 seconds, the meter reading should equal the response value as indicated on the calibration gas cylinder used. If the reading is within ±15% of the response value, then the instrument can be field calibrated to the response value using the external SPAN ADJUSTMENT control. The SPAN ADJUSTMENT control should be adjusted to a lower setting until the correct reading has been obtained. The lower the number on the SPAN ADJUSTMENT control, the greater the instrument sensitivity. If the SPAN ADJUSTMENT control has to be adjusted below a setting of 4.00, the unit should be red-tagged and returned for repairs.
3. If the meter reading is greater than ±15% of the response value of the calibration gas used, then the instrument should be red-tagged and returned for repair.
4. Record the calibration of instrument in the instrument calibration log and field logbook including: instrument model and ID number, date, time, initial and final span settings, and concentration and type of calibration gas.
5. In some field applications, with the exception of the probe's inlet and exhaust, the PID should be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation.

7.3.2 Operation

1. All readings are to be recorded in the site logbook. Readings should be recorded as "units above background," not ppm.
2. As with any field instrument, accurate results depend on the operator being completely familiar with the operator's manual. The instructions in the operating manual should be followed explicitly in order to obtain accurate results.
3. Position the probe assembly close to the area to be monitored because the low sampling rate allows for only very localized readings. Under no circumstances should the probe tip assembly be immersed in fluid.
4. While taking care to prevent the PID from being exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the site Health and Safety Plan. The PID survey should be conducted at a slow to moderate rate of speed and the intake assembly (the probe) slowly swept from side to side. There is a three to five second delay in the read-out depending upon the instruments sensitivity to the contaminant.
5. During drilling activities, PID monitoring is to be performed at regular intervals downhole and in the breathing zone. When opening monitoring wells readings should be taken at the wellhead and in the breathing zone. Always follow the air monitoring requirements specified in the site-specific Health and Safety Plan.

7.4 Post Operation

1. Turn FUNCTION Switch to OFF.

2. Return the PID to a secure area and check the calibration (Section 7.3.1.) before charging. Connect the instrument to charger and plug in the charger. The probe must be connected to the readout unit to charge the HNU type PID.
3. Complete logbook entries, verifying the accuracy of entries, and sign/initial all pages.

8.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:
1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

9.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and site-specific Health and Safety practices.

TN-106 TECHNICAL NOTE

CORRECTION FACTORS, IONIZATION ENERGIES*, AND CALIBRATION CHARACTERISTICS

Correction Factors and Ionization Energies

RAE Systems PIDs can be used for the detection of a wide variety of gases that exhibit different responses. In general, any compound with ionization energy (IE) lower than that of the lamp photons can be measured.* The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. In our PIDs, correction factors can be used in one of three ways:

1) Calibrate the monitor with isobutylene in the usual fashion to read in isobutylene equivalents. Manually multiply the reading by the correction factor (CF) to obtain the concentration of the gas being measured.
2) Calibrate the unit with isobutylene in the usual fashion to read in isobutylene equivalents. Call up the correction factor from the instrument memory or download it from a personal computer and then call it up. The monitor will then read directly in units of the gas of interest.
3) Calibrate the unit with isobutylene, but input an equivalent, "corrected" span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

** Some inorganic compounds like H_2O_2 and NO_2 give weak response at photon energies well above those of their ionization energies. The term "ionization energy" replaces the old term "ionization potential."*

Example 1:

With the unit calibrated to read isobutylene equivalents, the reading is 10 ppm with a 10.6 eV lamp. The gas being measured is butyl acetate, which has a correction factor of 2.6. Multiplying 10 by 2.6 gives an adjusted butyl acetate value of 26 ppm. Similarly, if the gas being measured were trichloroethylene (CF = 0.54), the adjusted value with a 10 ppm reading would be 5.4 ppm.

Example 2:

With the unit calibrated to read isobutylene equivalents, the reading is 100 ppm with a 10.6 eV lamp. The gas measured is m-xylene (CF = 0.43). After downloading this factor, the unit should read about 43 ppm when exposed to the same gas, and thus read directly in m-xylene values.

Example 3:

The desired gas to measure is ethylene dichloride (EDC). The CF is 0.6 with an 11.7 eV lamp. During calibration with 100 ppm isobutylene, insert 0.6 times 100, or 60 at the prompt for the calibration gas concentration. The unit then reads directly in EDC values.

Conversion to mg/m^3

To convert from ppm to mg/m^3, use the following formula:

$$\text{Conc. (mg/m}^3\text{)} = \frac{\text{[Conc.(ppmv) x mol. wt. (g/mole)]}}{\text{molar gas volume (L)}}$$

For air at 25 °C (77 °F), the molar gas volume is 24.4 L/mole and the formula reduces to:

$$\text{Conc.(mg/m}^3\text{)} = \text{Conc.(ppmv) x mol. wt. (g/mole) x 0.041}$$

For example, if the instrument is calibrated with a gas standard in ppmv, such as 100 ppm isobutylene, and the user wants to display to read in mg/m3 of hexane, whose m.w. is 86 and CF is 4.3, the overall correction factor would be 4.3 x 86 x 0.041 equals 15.2.

Correction Factors for Mixtures

The correction factor for a mixture is calculated from the sum of the mole fractions Xi of each component divided by their respective correction factors CFi:

$$CFmix = 1 / (X_1/CF_1 + X_2/CF_2 + X_3/CF_3 + \ldots Xi/CFi)$$

Thus, for example, a vapor phase mixture of 5% benzene and 95% n-hexane would have a CFmix of CFmix = 1 / (0.05/0.53 + 0.95/4.3) = 3.2. A reading of 100 would then correspond to 320 ppm of the total mixture, comprised of 16 ppm benzene and 304 ppm hexane.

For a spreadsheet to compute the correction factor and TLV of a mixture see the appendix at the end of the CF table.

TLVs and Alarm Limits for Mixtures

The correction factor for mixtures can be used to set alarm limits for mixtures. To do this one first needs to calculate the exposure limit for the mixture. The Threshold Limit Value (TLV) often defines exposure limits. The TLV for the mixture is calculated in a manner similar to the CF calculation:

$$TLV\ mix = 1 / (X_1/TLV_1 + X_2/TLV_2 + X_3/TLV_3 + \ldots Xi/TLVi)$$

In the above example, the 8-h TLV for benzene is 0.5 ppm and for n-hexane 50 ppm. Therefore the TLV of the mixture is TLVmix = 1 / (0.05/0.5 + 0.95/50) = 8.4 ppm, corresponding to 8.0 ppm hexane and 0.4 ppm benzene. For an instrument calibrated on isobutylene, the reading corrsponding to the TLV is:

$$\text{Alarm Reading} = TLVmix / CFmix = 8.4 / 3.2 = 2.6 \text{ ppm}$$

A common practice is to set the lower alarm limit to half the TLV, and the higher limit to the TLV. Thus, one would set the alarms to 1.3 and 2.6 ppm, respectively.

Calibration Characteristics

a) **Flow Configuration**. PID response is essentially independent of gas flow rate as long as it is sufficient to satisfy the pump demand. Four main flow configurations are used for calibrating a PID:

1) **A pressurized gas cylinder (Fixed-flow regulator):** The flow rate of the regulator should match the flow demand of the instrument pump or be slightly higher.
2) **A pressurized gas cylinder (Demand-flow regulator):** A demand-flow regulator better matches pump speed differences, but results in a slight vacuum during calibration and thus slightly high readings.
3) **A collapsible gas bag:** The instrument will draw the calibration gas from the bag at its normal flow rate, as long as the bag valve is large enough. The bag should be filled with enough gas to allow at least one minute of flow (~ 0.6 L for a MiniRAE, ~0.3 L for MultiRAE).
4) **The T (or open tube) method:** The T method uses a T-junction with gas flow higher than the pump draw. The gas supply is connected to one end of the T, the instrument inlet is connected to a second end of the T, and excess gas flow escapes through the third, open end of the T. To prevent ambient air mixing, a long tube should be connected to the open end, or a high excess rate should be used. Alternatively, the instrument probe can be inserted into an open tube slightly wider than the probe. Excess gas flows out around the probe.

The first two cylinder methods are the most efficient in terms of gas usage, while the bag and T methods give slightly more accurate results because they match the pump flow better.

b) **Pressure**. Pressures deviating from atmospheric pressure affect the readings by altering gas concentration and pump characteristics. It is best to calibrate with the instrument and calibration gas at the same pressure as each other and the sample gas. (Note that the cylinder pressure is not relevant because the regulator reduces the pressure to ambient.) If the instrument is calibrated at atmospheric pressure in one of the flow configurations described above, then 1) pressures slightly above ambient are acceptable but high pressures can damage the pump and 2) samples under vacuum may give low readings if air leaks into the sample train.

c) **Temperature.** Because temperature effects gas density and concentration, the temperature of the calibration gas and instrument should be as close as possible to the ambient temperature where the unit will be used. We recommend that the temperature of the calibration gas be within the instrument's temperature specification (typically 14°-113° F or -10°- 45° C). Also, during actual measurements, the instrument should be kept at the same or higher temperature than the sample temperature to avoid condensation in the unit.

d) **Matrix.** The matrix gas of the calibration compound and VOC sample is significant. Some common matrix components, such as methane and water vapor can affect the VOC signal. PIDs are most commonly used for monitoring VOCs in air, in which case the preferred calibration gas matrix is air. For a MiniRAE, methane, methanol, and water vapor reduce the response by about 20% when their concentration is 15,000 ppm and by about 40% at 30,000 ppm. Despite earlier reports of oxygen effects, RAE PID responses with 10.6 eV lamps are independent of oxygen concentration, and calibration gases in a pure nitrogen matrix can be used. H_2 and CO_2 up to 5 volume % also have no effect.

e) **Concentration.** Although RAE Systems PIDs have electronically linearized output, it is best to calibrate in a concentration range close to the actual measurement range. For example, 100 ppm standard gas for anticipated vapors of 0 - 250 ppm, and 500 ppm standard for expected concentrations of 250 - 1000 ppm.

f) **Filters.** Filters affect flow and pressure conditions and therefore all filters to be used during sampling should also be in place during calibration. Using a water trap (hydrophobic filter) greatly reduces the chances of drawing water aerosols or dirt particles into the instrument. Regular filter replacements are recommended because dirty filters can adsorb VOCs and cause slower response time and shifts in calibration.

Table Abbreviations:

CF =Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)
NR =No Response
IE =Ionization Energy (values in parentheses are not well established)
C =Confirmed Value; all others are preliminary or estimated values and are subject to change
ne =Not Established ACGIH 8-hr. TWA
C## =Ceiling value, given where 8-hr.TWA is not available

Disclaimer:

Actual readings may vary with age and cleanliness of lamp, relative humidity, and other factors. For accurate work, the instrument should be calibrated regularly under the operating conditions used. The correction factors in this table were measured in dry air at room temperature.

Updates:

The values that are indicated by a "plus" sign in the "C" columns are confirmed values; all others are preliminary and subject to change. Watch for updates of this table on the Internet at **http://www.raesystems.com**

IE data are taken from the CRC Handbook of Chemistry and Physics, 73rd Edition, D.R. Lide (Ed.), CRC Press (1993) and NIST Standard Ref. Database 19A, NIST Positive Ion Energetics, Vers. 2.0, Lias, et.al., U.S. Dept. Commerce (1993). Exposure limits (8-h TWA and Ceiling Values) are from the 1997 ACGIH TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 1997.

[redacted]

Acetaldehyde		75-07-0	C_2H_4O	NR	+	6	+	3.3	+	10.23	C25
Acetic Acid	Ethanoic Acid	64-19-7	$C_2H_4O_2$	NR	+	22	+	2.6	+	10.66	10
Acetic Anhydride	Ethanoic Acid Anhydride	108-24-7	$C_4H_6O_3$	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C_3H_6O	1.2	+	1.1	+	1.4	+	9.71	500
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C_2H_3N					100		12.19	40
Acetylene	Ethyne	74-86-2	C_2H_2					2		11.40	ne
Acrolein	Propenal	107-02-8	C_3H_4O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic Acid	Propenoic Acid	79-10-7	$C_3H_4O_2$			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C_3H_3N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C_3H_6O			2.4	+	1.7		9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C_3H_5Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	H_3N	NR	+	9.7	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	$C_7H_{14}O_2$	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	$C_5H_{12}O$			5				10.00	ne
Aniline	Aminobenzene	62-53-3	C_7H_7N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C_7H_8O			0.8				8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH_3			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C_7H_6O					1		9.49	ne
Benzene		71-43-2	C_6H_6	0.55	+	0.53	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C_7H_5N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C_7H_8O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C_7H_7Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	$C_8H_8O_2$	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF_3	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br_2	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C_6H_5Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C_3H_7OBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	$CHBr_3$	NR	+	2.5	+	0.5	+	10.48	0.5
Bromopropane,1-	n-Propyl bromide	106-94-5	C_3H_7Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C_4H_6	0.8		0.85	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	$C_4H_6O_2$	25	+	3.5	+	1.2		~10	ne
Butane		106-97-8	C_4H_{10}			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	$C_4H_{10}O$	70	+	4.7	+	1.4	+	9.99	20
Butanol, t-	tert-Butanol, t-Buty alcohol	75-65-0	$C_4H_{10}O$	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C_4H_8			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	$C_6H_{14}O_2$	1.8	+	1.2	+	0.6	+	<10	25
Butyl acetate, n-		123-86-4	$C_6H_{12}O_2$			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	$C_7H_{12}O_2$			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	$C_4H_{11}N$	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve	see 2-Butoxyethanol	111-76-2									
Butyl hydroperoxide, t-		75-91-2	$C_4H_{10}O_2$	2.0	+	1.6	+			<10	1
Butyl mercaptan	1-Butanethiol	109-79-5	$C_4H_{10}S$	0.55	+	0.52	+			9.14	0.5
Carbon disulfide		75-15-0	CS_2	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl_4	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve see 2-Ethoxyethanol											
CFC-14 see Tetrafluoromethane											
CFC-113 see 1,1,2-Trichloro-1,2,2-trifluoroethane											
Chlorine		7782-50-5	Cl_2					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO_2	NR	+	NR	+	NR	+	10.57	0.1
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C_4H_5Cl			3					10

Chlorobenzene	Monochlorobenzene	108-90-7	C_6H_5Cl	0.44	+	0.40	+	0.39	+	9.06	10
Chloro-1,1-difluoroethane, 1-	(R-142B)	75-68-3	$C_2H_3ClF_2$			NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	$CHClF_2$	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C_2H_5Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlrohydrin	107-07-3	C_2H_5ClO							10.52	C1
Chloroethyl ether, 2-	bis(2-chloroethyl) ether	111-44-4	$C_4H_8Cl_2O$	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	C_3H_7ClO			3					ne
Chloroform	Trichloromethane	67-66-3	$CHCl_3$	NR	+	NR	+	3.5	+	11.37	10
Chloropicrin		76-06-2	CCl_3NO_2	NR	+	~400	+	7	+	?	0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C_7H_7Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C_7H_7Cl					0.6		8.69	ne
Chlorotrimethylsilane		75-77-4	C_3H_9ClSi	NR		NR		0.82	+	10.83	ne
Crotonaldehyde	*trans*-2-Butenal	123-73-9 4170-30-3	C_4H_6O	1.5	+	1.1	+	1.0	+	9.73	2
Cumene	Isopropylbenzene	98-82-8	C_9H_{12}	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C_6H_{12}	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	$C_6H_{12}O$					1.1		9.75	50
Cyclohexanone		108-94-1	$C_6H_{10}O$	1.0	+	0.9	+	0.7	+	9.14	25
Cyclohexene		110-83-8	C_6H_{10}			0.8	+			8.95	300
Cyclohexylamine		108-91-8	$C_6H_{13}N$			1.2				8.62	10
Cyclopentane 85% 2,2-dimethylbutane 15%		287-92-3	C_5H_{10}	NR	+	15	+	1.1		10.33	600
Cyclopropylamine	Aminocyclpropane	765-30-0	C_3H_7N	1.1	+	0.9	+	0.9	+		ne
Decane		124-18-5	$C_{10}H_{22}$	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	$C_6H_{12}O_2$			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	$CHBr_2Cl$	NR	+	5.3	+	0.7	+	10.59	ne
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	$C_2H_4Br_2$	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	$C_6H_4Cl_2$	0.54	+	0.47	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl_2F_2			NR	+	NR	+	11.75	1000
Dichlorodimethylsilane		75-78-5	$C_2H_6Cl_2Si$	NR		NR		1.1	+	>10.7	ne
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	$C_2H_4Cl_2$			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	$C_2H_2Cl_2$			0.82	+	0.8	+	9.79	5
Dichloroethene, c-1,2-	*c*-1,2-DCE, *cis*-Dichloroethylene	156-59-2	$C_2H_2Cl_2$			0.8				9.66	200
Dichloroethene, t-1,2-	*t*-1,2-DCE, *trans*-Dichloroethylene	156-60-5	$C_2H_2Cl_2$			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	$C_2H_3Cl_2F$	NR	+	NR	+	2.0	+		ne
Dichloromethane	see Methylene chloride										
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	442-56-0 507-55-1	$C_3HCl_2F_5$	NR	+	NR	+	25	+		ne
Dichloropropane, 1,2-		78-87-5	$C_3H_6Cl_2$					0.7		10.87	75
Dichloro-1-propene, 1,3-		542-75-6	$C_3H_4C_{12}$	1.3	+	0.96	+			<10	1
Dichloro-1-propene, 2,3-		78-88-6	$C_3H_4Cl_2$	1.9	+	1.3	+	0.7	+	<10	ne
Dichloro-1,1,1-trifluoroethane, 2,2-	R-123	306-83-2	$C_2HCl_2F_3$	NR	+	NR	+	10.1	+	11.5	ne
Dichloro-2,4,6-trifluoropyridine, 3,5-	DCTFP	1737-93-5	$C_5Cl_2F_3N$	1.1	+	0.9	+	0.8	+		ne
Dichlorvos	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	$C_4H_7Cl_2O_4P$			0.9	+			<9.4	0.1

Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	$C_{10}H_{12}$	0.57	+	0.48	+	0.43	+	8.8	5
Diesel Fuel		68334-30-5	m.w. 226			0.9	+				11
Diesel Fuel #2 (Automotive)		68334-30-5	m.w. 216			0.7	+	0.4	+		11
Diethylamine		109-89-7	$C_4H_{11}N$			1	+			8.01	5
Diethylaminopropylamine, 3-		104-78-9	$C_7H_{18}N_2$			1.3					ne
Diethylbenzene	See Dowtherm J										
Diethylmaleate		141-05-9	$C_8H_{12}O_4$			4					ne
Diethyl sulfide	see Ethyl sulfide										
Diisopropylamine		108-18-9	$C_6H_{15}N$	0.84	+	0.74	+	0.5	+	7.73	5
Diketene	Ketene dimer	674-82-8	$C_4H_4O_2$	2.6	+	2.0	+	1.4	+	9.6	0.5
Dimethylacetamide, N,N-	DMA	127-19-5	C_4H_9NO	0.87	+	0.8	+	0.8	+	8.81	10
Dimethylamine		124-40-3	C_2H_7N			1.5				8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	$C_3H_6O_3$	NR	+	~70	+	1.7	+	~10.5	ne
Dimethyl disulfide	DMDS	624-92-0	$C_2H_6S_2$	0.2	+	0.20	+	0.21	+	7.4	ne
Dimethyl ether	see Methyl ether										
Dimethylethylamine	DMEA	598-56-1	$C_4H_{11}N$	1.1	+	1.0	+	0.9	+	7.74	~3
Dimethylformamide, N,N-	DMF	68-12-2	C_3H_7NO			0.8				9.13	10
Dimethylhydrazine, 1,1-	UDMH	57-14-7	$C_2H_8N_2$			0.8	+	0.8	+	7.28	0.01
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	$C_3H_9O_3P$	NR	+	4.3	+	0.74	+	10.0	ne
Dimethyl sulfate		77-78-1	$C_2H_6O_4S$	~23		~20	+	2.3	+		0.1
Dimethyl sulfide	see Methyl sulfide										
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C_2H_6OS			1.4	+			9.10	ne
Dioxane, 1,4-		123-91-1	$C_4H_8O_2$			1.3				9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	$C_3H_6O_2$	4.0	+	2.3	+	1.6	+	9.9	20
Dowtherm A see Therminol®											
Dowtherm J (97% Diethylbenzene)		25340-17-4	$C_{10}H_{14}$			0.5					
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/ Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+		ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro2,3-epoxypropane	106-89-8	C_2H_5ClO	~200	+	8.5	+	1.4	+	10.2	0.5
Ethane		74-84-0	C_2H_6			NR	+	15	+	11.52	ne
Ethanol	Ethyl alcohol	64-17-5	C_2H_6O			10	+	3.1	+	10.47	1000
Ethanolamine	MEA, Monoethanolamine	141-43-5	C_2H_7NO	5.6	+	1.6	+			8.96	3
Ethene	Ethylene	74-85-1	C_2H_4			9	+	4.5	+	10.51	ne
Ethoxyethanol, 2-	Ethyl cellosolve, Ethylene glycol monoethyl ether	110-80-5	$C_4H_{10}O_2$			1.3				9.6	5
Ethyl acetate		141-78-6	$C_4H_8O_2$			4.6	+			10.01	400
Ethyl acrylate		140-88-5	$C_5H_8O_2$			2.4	+	1.0	+	<10.3	5
Ethylamine		75-04-7	C_2H_7N			0.8				8.86	5
Ethylbenzene		100-41-4	C_8H_{10}	0.52	+	0.52	+	0.51	+	8.77	100
Ethylene glycol	1,2-Ethanediol	107-21-1	$C_2H_6O_2$			16	+	6	+	10.16	C100
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	$C_4H_{10}O_2$	1.1		0.86		0.7		9.2	ne
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C_2H_4O			13	+	3.5	+	10.57	1
Ethyl ether	Diethyl ether	60-29-7	$C_4H_{10}O$			1.1	+			9.51	400
Ethyl 3-ethoxypropionate	EEP	763-69-9	$C_7H_{14}O_3$	1.2	+	0.75	+				ne
Ethyl formate		109-94-4	$C_3H_6O_2$					1.9		10.61	100
Ethyl hexyl acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	$C_{11}H_{20}O_2$			1.1	+	0.5	+		ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	$C_5H_{10}O_3$	13	+	3.2	+	1.6	+	~10	ne
Ethyl mercaptan	Ethanethiol	75-08-1	C_2H_6S	0.60	+	0.56	+			9.29	0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	$C_4H_{10}S$			0.5	+			8.43	ne
Formaldehyde	Formalin	50-00-0	CH_2O	NR	+	NR	+	1.6	+	10.87	C0.3
Formamide		75-12-7	CH_3NO			6.9	+	4		10.16	10
Formic acid		64-18-6	CH_2O_2	NR	+	NR	+	9	+	11.33	5

Furfural	2-Furaldehyde	98-01-1	$C_5H_4O_2$			0.92	+	0.8	+	9.21	2
Furfuryl alcohol		98-00-0	$C_5H_6O_2$			0.80	+			<9.5	10
Gasoline #1		8006-61-9	m.w. 72			0.9	+				300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+		300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	$C_5H_8O_2$	1.1	+	0.8	+	0.6	+		C0.05
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	$C_2HBrClF_3$					0.6		11.0	50
HCFC-22 see Chlorodifluoromethane											
HCFC-123 see 2,2-Dichloro-1,1,1-trifluoroethane											
HCFC-141B see 1,1-Dichloro-1-fluoroethane											
HCFC-142B see 1-Chloro-1,1-difluoroethane											
HCFC-134A see 1,1,1,2-Tetrafluoroethane											
HCFC-225 see Dichloropentafluoropropane											
Heptane, n-		142-82-5	C_7H_{16}	45	+	2.8	+	0.60	+	9.92	400
Hexamethyldisilazane, 1,1,1,3,3,3-	HMDS	999-97-3	$C_6H_{19}NSi_2$			0.2	+	0.2	+	~8.6	
Hexane, n-		110-54-3	C_6H_{14}	350	+	4.3	+	0.54	+	10.13	50
Hexanol, 1-	Hexyl alcohol	111-27-3	$C_6H_{14}O$	9	+	2.5	+	0.55	+	9.89	ne
Hexene, 1-		592-41-6	C_6H_{12}			0.8				9.44	30
Hydrazine		302-01-2	H_4N_2	>8	+	2.6	+	2.1	+	8.1	0.01
Hydrazoic acid	Hydrogen azide		HN_3							10.7	
Hydrogen	Synthesis gas	1333-74-0	H_2	NR	+	NR	+	NR	+	15.43	ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6	C4.7
Hydrogen peroxide		7722-84-1	H_2O_2	NR	+	NR	+	NR	+	10.54	1
Hydrogen sulfide		7783-06-4	H_2S	NR	+	3.3	+	1.5	+	10.45	10
Iodine		7553-56-2	I_2	0.1	+	0.1	+	0.1	+	9.40	C0.1
Iodomethane	Methyl iodide	74-88-4	CH_3I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	$C_7H_{14}O_2$	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C_4H_{10}			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	$C_4H_{10}O$	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C_4H_8	1.00	+	1.00	+	1.00	+	9.24	ne
Isobutyl acetate		110-19-0	$C_6H_{12}O_2$			2.6					150
Isobutyl acrylate	Isobutyl 2-propenoate, Acrylic acid Isobutyl ester	106-63-8	$C_7H_{12}O_2$			1.5	+	0.60	+		ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	$C_3H_2ClF_5O$							~11.7	ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C8H18			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w. 121	1.7	+	0.8	+				ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		ne
Isopentane	2-Methylbutane	78-78-4	C_5H_{12}			8.2					ne
Isophorone		78-59-1	$C_9H_{14}O$					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C_5H_8	0.69	+	0.63	+	0.60	+	8.85	ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C_3H_8O	500	+	6.0	+	2.7		10.12	400
Isopropyl acetate		108-21-4	$C_5H_{10}O_2$			2.6				9.99	250
Isopropyl ether	Diisopropyl ether	108-20-3	$C_6H_{14}O$			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, Wide cut type aviation fuel	8008-20-6 + 64741-42-0	m.w. 115			1.0	+	0.4	+		ne
Jet fuel JP-5	Jet 5, Kerosene type aviation fuel	8008-20-6 + 64747-77-1	m.w. 167			0.6	+	0.5	+		15
Jet fuel JP-8	Jet A-1, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 165			0.6	+	0.3	+		15
Jet fuel A-1 (JP-8)	Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 145			0.67					15

Limonene, D-	(R)-(+)-Limonene	5989-27-5	$C_{10}H_{16}$			0.33	+			~8.2	ne
Kerosene C10-C16 petro.distillate – see Jet Fuels		8008-20-6									
MDI – see 4,4'-Methylenebis(phenylisocyanate)											
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C_9H_{12}	0.36	+	0.35	+	0.3	+	8.41	25
Methane	Natural gas	74-82-8	CH_4	NR	+	NR	+	NR	+	12.61	ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH_4O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	$C_3H_8O_2$	4.8	+	2.4	+	1.4	+	10.1	5
Methoxyethoxyethanol, 2-	2-(2-Methoxyethoxy)ethanol Diethylene glycol monomethyl ether	111-77-3	$C_7H_{16}O$	2.3	+	1.2	+	0.9	+	<10	ne
Methyl acetate		79-20-9	$C_3H_6O_2$	NR	+	6.6	+	1.4	+	10.27	200
Methyl acrylate	Methyl 2-propenoate, acrylic acid methyl ester	96-33-3	$C_4H_6O_2$			3.7	+	1.2	+	(9.9)	2
Methylamine	Aminomethane	74-89-5	CH_5N			1.2				8.97	5
Methyl bromide	Bromomethane	74-83-9	CH_3Br	110	+	1.7	+	1.3	+	10.54	1
Methyl t-butyl ether	MTBE, *tert*-Butyl methyl ether	1634-04-4	$C_5H_{12}O$			0.9	+			9.24	40
Methyl cellosolve	see 2-Methoxyethanol										
Methyl chloride	Chloromethane	74-87-3	CH_3Cl	NR	+	NR	+	0.74	+	11.22	50
Methylcyclohexane		107-87-2	C_7H_{14}	1.6	+	0.97	+	0.53	+	9.64	400
Methylene bis(phenyl-isocyanate), 4,4'-	MDI, Mondur M		$C_{15}H_{10}N_2O_2$	Very slow ppb level response							0.005
Methylene chloride	Dichloromethane	75-09-2	CH_2Cl_2	NR	+	NR	+	0.89	+	11.32	25
Methyl ether	Dimethyl ether	115-10-6	C_2H_6O	4.8	+	3.1	+	2.5	+	10.03	ne
Methyl ethyl ketone	MEK, 2-Butanone	78-93-3		0.86	+	0.9	+	1.1	+	9.51	200
Methylhydrazine	Monomethylhydrazine, Hydrazomethane	60-34-4	$C_2H_6N_2$	1.4	+	1.2	+	1.3	+	7.7	0.01
Methyl isobutyl ketone	MIBK, 4-Methyl-2-pentanone	108-10-1	$C_6H_{12}O$	0.9	+	0.8	+	0.6	+	9.30	50
Methyl isocyanate	CH3NCO	624-83-9	C_2H_3NO	NR	+	4.6	+	1.5		10.67	0.02
Methyl isothiocyanate	CH3NCS	551-61-6	C_2H_3NS	0.5	+	0.45	+	0.4	+	9.25	ne
Methyl mercaptan	Methanethiol	74-93-1	CH_4S	0.65		0.54		0.66		9.44	0.5
Methyl methacrylate		80-62-6	$C_5H_8O_2$	2.7	+	1.5	+	1.2	+	9.7	100
Methyl nonafluorobutyl ether	HFE-7100DL	163702-08-7, 163702-07-6	$C_5H_3F_9O$			NR	+	~35	+		ne
Methyl-1,5-pentane-diamine, 2- (coats lamp)	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	C6H16N2			~0.6	+			<9.0	ne
Methyl propyl ketone	MPK, 2-Pentanone	107-87-9	$C_5H_{12}O$			0.93	+	0.79	+	9.38	200
Methyl-2-pyrrolidinone, N-	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C_5H_9NO	1.0	+	0.8	+	0.9	+	*9.17*	ne
Methyl salicylate	Methyl 2-hydroxybenzoate	119-36-8	C_8H_8O3	1.3	+	0.9	+	0.9	+	~9	ne
Methylstyrene, α-	2-Propenylbenzene	98-83-9	C_9H_{10}			0.5				8.18	50
Methyl sulfide	DMS, Dimethyl sulfide	75-18-3	C_2H_6S	0.49	+	0.44	+	0.46	+	8.69	ne
Mineral spirits	Stoddard Solvent, Varsol 1, White Spirits	8020-83-5 8052-41-3 68551-17-7	m.w. 144			0.7	+	0.39	+		100
Mineral Spirits - Viscor 120B Calibration Fluid, b.p. 156-207°C		8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100
Monoethanolamine - see Ethanolamine											
Mustard	HD, Bis(2-chloroethyl) sulfide	505-60-2 39472-40-7 68157-62-0	$C_4H_8Cl_2S$			0.6					0.0005
Naphtha - see VM & P Naptha											
Naphthalene	Mothballs	91-20-3	$C_{10}H_8$	0.45	+	0.42	+	0.40	+	8.13	10
Nickel carbonyl (in CO)	Nickel tetracarbonyl	13463-39-3	C_4NiO_4			0.18				<8.8	0.001
Nitric oxide		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
Nitrobenzene		98-95-3	$C_6H_5NO_2$	2.6	+	1.9	+	1.6	+	9.81	1
Nitroethane		79-24-3	$C_2H_5NO_2$					3		10.88	100
Nitrogen dioxide		10102-44-0	NO_2	23	+	16	+	6	+	9.75	3

Nitrogen trifluoride		7783-54-2	NF_3	NR		NR		NR		13.0	10
Nitromethane		75-52-5	CH_3NO_2					4		11.02	20
Nitropropane, 2-		79-46-9	$C_3H_7NO_2$					2.6		10.71	10
Nonane		111-84-2	C_9H_{20}			1.4				9.72	200
Norpar 12	n-Paraffins, mostly C_{10}-C_{13}	64771-72-8	m.w. 161	3.2	+	1.1	+	0.28	+		ne
Norpar 13	n-Paraffins, mostly C_{13}-C_{14}	64771-72-8	m.w. 189	2.7	+	1.0	+	0.3	+		ne
Octane, n-		111-65-9	C_8H_{18}	13	+	1.8	+			9.82	300
Pentane		109-66-0	C_5H_{12}	80	+	8.4	+	0.7	+	10.35	600
Peracetic acid	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$	NR	+	NR	+	2.3	+		ne
Peracetic/Acetic acid mix	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$			50	+	2.5	+		ne
Perchloroethene	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C_2Cl_4	0.69	+	0.57	+	0.31	+	9.32	25
PGME	Propylene glycol methyl ether, 1-Methoxy-2-propanol	107-98-2	$C_6H_{12}O_3$	2.4	+	1.5	+	1.1	+		100
PGMEA	Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate	108-65-6	$C_6H_{12}O_3$	1.65	+	1.0	+	0.8	+		ne
Phenol	Hydroxybenzene	108-95-2	C_6H_6O	1.0	+	1.0	+	0.9	+	8.51	5
Phosgene	Dichlorocarbonyl	75-44-5	CCl_2O	NR	+	NR	+	8.5	+	11.2	0.1
Phosgene in Nitrogen	Dichlorocarbonyl	75-44-5	CCl_2O	NR	+	NR	+	6.8	+	11.2	0.1
Phosphine		7803-51-2	PH_3	28		3.9	+	1.1	+	9.87	0.3
Photocopier Toner	Isoparaffin mix					0.5	+	0.3	+		ne
Picoline, 3-	3-Methylpyridine	108-99-6	C_6H_7N			0.9				9.04	ne
Pinene, α-		2437-95-8	$C_{10}H_{16}$			0.31	+	0.47		8.07	ne
Pinene, β-		18172-67-3	$C_{10}H_{16}$	0.38	+	0.37	+	0.37	+	~8	100
Piperylene, isomer mix	1,3-Pentadiene	504-60-9	C_5H_8	0.76	+	0.69	+	0.64	+	8.6	100
Propane		74-98-6	C_3H_8			NR	+	1.8	+	10.95	2500
Propanol, n-	Propyl alcohol	71-23-8	C_3H_8O			5		1.7		10.22	200
Propene	Propylene	115-07-1	C_3H_6	1.5	+	1.4	+	1.6	+	9.73	ne
Propionaldehyde	Propanal	123-38-6	C_3H_6O			1.9				9.95	ne
Propyl acetate, n-		109-60-4	$C_5H_{10}O_2$			3.5				10.04	200
Propylamine, n-	1-Propylamine, 1-Aminopropane	107-10-8	C_3H_9N	1.1	+	1.1	+	0.9	+	8.78	ne
Propylene carbonate		108-32-7	$C_4H_6O_3$			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	$C_3H_8O_2$	18		5.5	+	1.6	+	<10.2	ne
Propylene oxide	Methyloxirane	75-56-9 16088-62-3 15448-47-2	C_3H_6O	~240		6.6	+	2.9	+	10.22	20
Propyleneimine	2-Methylaziridine	75-55-8	C_3H_7N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C_3H_8S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C_5H_5N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C_4H_9N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol:1-Methoxy-2-acetoxypropane)	107-98-2	$C_4H_{10}O_2$ / $C_6H_{12}O_3$			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8 50642-23-4	$C_4H_{10}FO_2P$			~3					
Stoddard Solvent - see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C_8H_8	0.45	+	0.40	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO_2			NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF_6	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO_2F_2	NR		NR		NR		13.0	5
Tabun	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	$C_5H_{11}N_2O_2P$			0.8					15ppt

Tetrachloroethane, 1,1,1,2-		630-20-6	$C_2H_2Cl_4$					1.3		~11.1	ne
Tetrachloroethane, 1,1,2,2-		79-34-5	$C_2H_2Cl_4$	NR	+	NR	+	0.60	+	~11.1	1
Tetrachlorosilane		10023-04-7	$SiCl_4$	NR		NR		15	+	11.79	ne
Tetraethyllead	TEL	78-00-2	$C_8H_{20}Pb$	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	$C_8H_{20}O_4Si$			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	$C_2H_2F_4$			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C_2F_4			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF_4			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C_4H_8O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	$C_4H_{12}O_4Si$	10	+	1.9	+			~10	1
Therminol VP-1®	Dowtherm,3:1 Diphenyl oxide: Biphenyl	101-84-8 92-52-4	$C_{12}H_{10}O$ $C_{12}H_{10}$			0.4	+				ne
Toluene	Methylbenzene	108-88-3	C_7H_8	0.54	+	0.50	+	0.51	+	8.82	50
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	$C_9H_6N_2O_2$	1.4	+	1.4	+	2.0	+		0.002
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	$C_6H_3Cl_3$	0.7	+	0.46	+			9.04	C5
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	$C_2H_3Cl_3$			NR	+	1	+	11	350
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	$C_2H_3Cl_3$	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichoroethylene	79-01-6	C_2HCl_3	0.62	+	0.54	+	0.43	+	9.47	50
Trichloromethylsilane	Methyltrichlorosilane	75-79-6	CH_3Cl_3Si	NR		NR		1.8	+	11.36	ne
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	$C_2Cl_3F_3$			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	$C_6H_{15}N$	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester, Boron ethoxide	150-46-9	$C_6H_{15}O_3B$			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	$C_6H_{15}O_4P$	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	$C_2H_3F_3$					34		*12.9*	ne
Trimethylamine		75-50-3	C_3H_9N			0.9				7.82	5
Trimethylbenzene, 1,3,5-	- see Mesitylene	108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	$C_3H_9O_3B$			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	$C_3H_9O_4P$			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	$C_3H_9O_3P$			1.1	+		+	*8.5*	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	$C_{10}H_{16}$	0.4	+	0.3	+			~8	100
Undecane		1120-21-4	$C_{11}H_{24}$			2				9.56	ne
Varsol – see Mineral Spirits											
Vinyl actetate		108-05-4	$C_4H_6O_2$	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C_2H_3Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C_2H_3Cl			2.0	+	0.6	+	9.99	5
Vinyl-1-cyclohexene, 4-	Butadiene dimer, 4-Ethenylcyclohexene	100-40-3	C_8H_{12}	0.6	+	0.56	+			9.83	0.1
Vinylidene chloride - see 1,1-Dicholorethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C_6H_9NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B - see Mineral Spirits - Viscor 120B Calibration Fluid											
V. M. & P. Naphtha	Ligroin; Solvent naphtha; Varnish maker's & painter's naptha	64742-89-8	m.w. 111 (C_8-C_9)			~1					300
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C_8H_{10}	0.50	+	0.43	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C_8H_{10}	0.57	+	0.59	+	0.69		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C_8H_{10}			0.45	+	0.62	+	8.44	100
None				1		1		1			
Undetectable				1E+6		1E+6		1E+6			

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Appendix I:

Example of Automatic Calculation of Correction Factors, TLVs and Alarm Limits for Mixtures

(Calculations performed using Excel version of this database, available on request)

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Benzene	0.55	0.53	0.6	0.01	1	0.5	2.5
Toluene	0.54	0.5	0.51	0.06	10	50	150
Hexane, n-	300	4.3	0.54	0.06	10	50	150
Heptane, n-	45	2.8	0.6	0.28	50	400	500
Styrene	0.45	0.4	0.42	0.06	10	20	40
Acetone	1.2	1.1	1.4	0.28	50	750	1000
Isopropanol	500	6	2.7	0.28	50	400	500
None	1	1	1	0.00	0	1	
Mixture Value:	2.1	1.5	0.89	1.00	181 ppm	56 ppm	172 ppm
TLV Alarm Setpoint when Calibrated to Isobutylene:	26 ppm	37 ppm	62 ppm				
STEL Alarm Setpoint, same Calibration	86 ppm	115 ppm	193 ppm				

SAMPLE PACKAGING AND SHIPMENT
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual labeling, packing and shipping packages samples from job sites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed guidelines set forth by the Department of Transportation (DOT) for the shipment of potentially hazardous samples from environmental sites.

2.0 PURPOSE

This Standard Operating Procedure (SOP) provides instructions that are to be followed in the packaging, labeling, and shipment of samples collected during field operations.

3.0 INTRODUCTION

As with all field work, the ease and efficiency with which sample handling is conducted is proportional to the amount of preparation before entering the field. Organization and a thorough understanding of the sampling plan are essential for the person designated to complete paperwork and ship samples. Sufficient amounts of packaging materials must be assembled, shipping requirements determined, and shipping offices located before the trip.

While the completion of some of the paperwork in the office is advisable, this practice must be tempered by judgment. The completion of too much paperwork can be a problem if sampling plans or circumstances change in the field. Each person must determine the balance between too much and too little pre-field paperwork and preparation through experience.

Sample packaging, labeling, and shipment procedures are designed (1) to preserve sample quality so that analyses will yield results representative of site conditions, (2) to protect and inform sample handlers, including shippers and laboratory personnel, and (3) to provide a paper trail to allow cross referencing of sample collection locations with analytical results. For the purpose of sample packaging and shipment, samples are categorized as “hazardous” samples unless it can be reasonably assumed that dioxins are not present and all other contaminants are at concentrations below 10 ppm. If both these conditions are met, the sample can be packaged and shipped as an “environmental” sample. If the contaminants are known, higher limits may qualify as “environmental” samples. Procedures for handling these two types of samples follow.

4.0 PREPARATION FOR FIELD WORK

- Determine sample locations.
- Determine number of samples (including QA/QC samples).
- Determine analyses required.
- Number stations unambiguously.
- Determine probable concentrations of samples.
- Determine number and type of sample bottles required.
- Determine packaging materials required (e.g., strapping tape, ice chests, bubble wrap, etc.).
- Contact all interested parties (e.g., USACE, EPA, state agencies, site owners, site operators, etc.).

- Assemble sample bottles and packaging materials.
- Check applicable United States Department of Transportation (USDOT) shipping regulations.
- Make plans for sample shipments (e.g., locate Fed-Ex, obtain laboratory address, etc.).
- To avoid confusion, prior to sampling, bottles can be temporarily numbered with station numbers.
- Plan for likely site conditions (e.g., hazards on the site, weather, accessibility of the site, etc.).

5.0 SAMPLE HANDLING

Once samples have been sealed in the ice chests, they are to be expeditiously transported to the analytical laboratory. If the laboratory is located near the sampling site, the sampling team may drive the samples to the laboratory. Otherwise, samples are to be routinely shipped by the overnight service.

There are two types of airbills, the nonrestricted materials airbill for the shipment of environmental samples and the restricted articles airbill for the shipment of hazardous materials. Environmental samples are generally collected from sources not expected to show significant contamination, e.g., ponds, streams, and off-site soils. Samples from obviously contaminated sources such as on-site soils and groundwater, drums, leachate, and tanks must be considered as hazardous materials and shipped according to USDOT regulation. If enough information is known about a site to determine that any contamination is present at sufficiently low concentrations, then samples from these sources may be shipped as low level environmental samples.

5.1 Packaging

Samples suspected of containing dioxins at any concentrations, or suspected of containing other hazardous contaminants at concentrations over 10 ppm are to be overpacked and shipped according to USDOT regulations. The following procedure is to be used for environmental sample packaging.

- Decontaminate outside of sample containers.
- Affix sample labels to corresponding sample containers.
- Add preservatives to water samples as required.
- Use ziplock bubble baggies to protect glass sample bottles and jars.
- Enclose all other sample containers in sealed ziplock baggies.
- Place bagged sample containers in an ice chest lined with bubble wrap, checking against chain-of-custody record to ensure all samples are listed and are in the correct ice chest.
- Fill 1 to 3 ziplock bags with ice and include in the ice chest shipment if required by sampling and analysis plan. All ice should be double bagged in heavy-duty ziplock bags.
- Add packing material to ice chest to fill any remaining space.
- Detach and retain the pink copy of the chain-of-custody form.
- Seal remaining two copies of the chain-of-custody in a ziplock bag. Tape the bag to the inside of the ice chest lid.
- Affix airbill or airbill sticker to outside of the ice chest.
- Ensure “This End Up” is written or affixed onto all four sides of the ice chest.
- Ensure “Fragile” is written on two sides of the ice chest.

- Seal the ice chest with two custody seals (one on the front and one on the back). Place one layer of clear packaging tape over the custody seals.
- Tape ice chest shut using three rounds of strapping tape on either end.
- Affix shipping labels to all ice chests.
- Remove extraneous stickers from the ice chest.
- Ensure that ice chests have a return address on them.

Before relying on a shipping service, call that service to locate the drop off point nearest the site, then call that site to obtain the business hours and prepare them for your shipment. Occasionally, service operators are not aware that they can ship environmental or hazardous samples and it is inconvenient to have them attempt to learn the procedures just before the shipment deadline. Also, the shipping deadline for laboratories on the East Coast may be several hours earlier than the West Coast deadline. Calling in advance can identify these considerations.

5.2 Custody Seal

This form is used to show that no tampering of the samples has occurred between the time the samples leave the field personnel and the time when they arrive at the laboratory.

5.3 Environmental Samples Airbill

Federal Express is used to ship the vast majority of samples to analytical laboratories. This section describes the procedures used when shipping samples via Federal Express. However, this does not prevent samplers from utilizing other carriers.

Federal Express requires a completed "Nonrestricted Materials Airbill" for the shipment of environmental samples. A separate airbill is required for each destination but multiple ice chests can be shipped under one airbill if they are being sent to the same laboratory. The Federal Express Nonrestricted Materials Airbill is completed as follows.

(1)	Date	The date the samples are shipped.
	Sender's FedEx Account Number	CALIBRE FedEx account number should be printed here.
	Sender's Name	Sample team leader's name.
	Phone	Phone number of sample team's office.
	Company	CALIBRE followed by sample team office address.
(2)	Internal Billing Reference	Project/task number.
(3)	Recipient	Name of laboratory contact, laboratory name, phone number, and address.
(4)	Service	Check "FedEx Standard Overnight" box.

(5)	Packaging	Check “Other Pkg.” Box.
(6)	Special Handling	Check “No” box.
(7)	Payment	Check “Sender” box.
(8)	Release Signature	Leave blank, <u>do not sign.</u>

5.4 Hazardous Materials Airbills

Unlike the regular airbill, the Dangerous Goods or Restricted Articles airbill has two parts. In addition to the upper portion, which is identical to the regular airbill, the Restricted Articles airbill has a lower portion entitled “Shipper’s Certification for Dangerous Goods”. Every effort must be made to fill out this portion correctly, as shippers may be subject to fines for the improper transport of restricted articles.

(1-5) These sections are filled out in the same way as the regular airbill.

(6) Check the box labeled “49 CFR”.

(7) Write in the number of ice chests being shipped on that airbill.

(8)	Proper Shipping Name	One of the following will usually apply; Solid, NOS”, “Flammable Liquid, NOS”, “Flammable Solid, NOS”, “Compressed Gas, NOS”, “Corrosive”, or “Hydrogen”. Regulations require that the hazardous constituents must be entered along with the NOS designation (i.e., “Compressed Gas, NOS [0.1% hexane in air]).
(9)	Class or Division	One of the following will usually apply;” Nonflammable Gas”, “Flammable Liquid”, “Flammable Solid”, or “Flammable Gas”.
(10)	UN or NA Number	Consult USDOT Tables for proper UN or NA number. UN numbers should be written “UN1992” not “1992”.
(11)	Subsidiary Risk	This column is filled out when the substance has more than one hazard as listed in USDOT Tables.
(12)	Total Net Quantity	Write the total quantity of hazardous materials in the shipment in appropriate units.
(13)	Radioactive Materials	Check box if materials are radioactive.
(14)	Transport Details	Shipping limitations as follows: a. Flammable Liquids

- Less than 32 oz. – Passenger aircraft
- 32 oz. to 10 gal. – Cargo aircraft

b. Flammable Solids
  - Less than 25 lbs. – Passenger or cargo aircraft
  - 25 lbs. To 1,000 lbs. – Cargo aircraft
  - Greater than 1,000 lbs. requires more extensive procedures.

Twenty five lbs. being the total weight of the ice chest (an empty ice chest weighs approximately 18 lbs.).

(15) Print shipper's name and title.

(16) Write in name of the city the shipment is being made from.

(17) Write in telephone number of 24 hour emergency response contractor.

(18) Shipper's signature.

5.5 Carrier Sticker

The carrier sticker is attached by carrier employees to the additional ice chests when more than one is going to the same laboratory. These are bar code stickers that are adhesive backed and are easily attached to the outside of the ice chest.

5.6 Warning Labels

USDOT regulations require warning labels for hazardous materials. USDOT regulations must be consulted and adhered to for all shipments.

6.0 SAMPLE SHIPMENT

When shipping hazardous materials (which may include samples or equipment), personnel must be aware that specific regulations govern the packaging, labeling, and transport of these items. Hazardous materials are defined by the Hazardous Materials Regulation Board and set forth in 49 CFR Parts 171-178, and must be shipped in strict accordance with USDOT procedures. CALIBRE staff members should be aware that regulatory agencies have the authority to levy substantial financial penalties on violators. These regulations apply to shipment by non-commercial (i.e., personal, rented, or company vehicles) as well as by commercial carrier. Persons making shipments should remember that only designated air carrier offices will accept hazardous materials.

6.1 Environmental Samples

Samples that are not expected to contain significant levels of contamination, such as those taken from streams, ponds, and off-site soils are considered environmental samples. That is, all low concentration samples are shipped as "Environmental Samples". These samples have no packaging, labeling, or shipping requirements beyond the usual procedures. Most air carriers require an address of the sender and of the receiver to be on the ice chest. The primary concern in the case of

"Environmental Samples" is that the samples reach their destination in a timely and undamaged state.

6.2 Hazardous Materials Samples

Samples taken from such potentially contaminated sources as on-site soils, drums, storage tanks, impoundments, lagoons, or leachates or from obviously contaminated locations must be treated as hazardous material samples and be shipped accordingly. If there is any doubt, a sample should be shipped as hazardous material. Both medium and high concentration samples are shipped as hazardous materials.

Hazardous materials must be packaged differently than the more common environmental samples. The sample is placed in a bubble baggie then placed in a metal paint can, one sample per can. The dead air space is filled with vermiculite and the can is sealed with metal clips. The paint cans are labeled with the following: Sample Tag#, Project Name, date, and any applicable warning labels. The cans are then shipped in an appropriately labeled ice chest.

6.3 Known Materials

Hazardous materials are further divided into known materials and unknown materials depending on the situation at the site. If <u>all</u> the hazardous substances in the sample are known or can be accurately identified, the sample is packaged, labeled, and shipped according to the instructions for that material, as detailed in the USDOT Hazardous Materials Table, 49 CFR 172.101 and the HM181 Rule – new package requirements. These change too frequently to include here.

6.4 Unknown Materials

When one or more substances in the sample cannot be identified, the sample must be shipped as an "unknown material". The appropriate transportation procedures are determined by classifying the sample through a process of elimination using the USDOT Hazardous Materials Table.

<u>Radioactive Materials</u>. If radiation survey instruments indicate, or there is a reasonable suspicion the samples contain radioactive materials, they must be shipped as radioactive materials. Regulations governing transport of radioactive materials are given in 49 CFR parts 173.389 to 173.398.

<u>Poison A</u>. USDOT defines Poison A as extremely dangerous non-radioactive poisonous gas or liquid of such a nature that a very small amount of gas or vapor of the liquid will be dangerous to life. Most Poison A materials are gases and would not be commonly found in field activities. All samples found in closed containers do not have to be shipped as Poison A. Judgment based on available information must be used to decide if a sample is Poison A. Special efforts to be familiar with all regulations governing transport of Poison A samples should be made <u>personally</u> by all team leaders expecting to ship such samples. Begin with 49 CFR 173.2.

<u>Flammable Liquids</u>. The next two categories in the USDOT classification are flammable gas and non-flammable gas. In usual circumstances, sampling does not include gases, nor are sampling containers expected to contain a significant amount of gas in their airspace. For samples containing unknown materials, other classifications listed below flammable liquid are not usually considered. In order to classify a substance as non-flammable, a flash point test is required. Such tests would be

impractical or even dangerous in the field. Thus, unknown hazardous samples are usually shipped as flammable liquids. The phrase “flammable liquid” does not necessarily mean the sample is either flammable or a liquid; it merely refers to a shipping classification in accordance with USDOT regulations. If the sample is a solid or a sludge, it may be shipped as a “flammable solid”. Any unknown material that is not classified as Poison A, flammable gas, or nonflammable gas should be shipped as a flammable liquid or a flammable solid.

“Flammable liquid” and “flammable solid” samples must be packed in paint cans as “high” or “medium” concentration samples for shipment. The following information must be placed on each paint can:

- Laboratory name and address.
- “FLAMMABLE LIQUID, NOS UN1993” or “FLAMMABLE SOLID, NOS UN1325 (NOS means Not Otherwise Specified or Not Otherwise Stated).
- “DANGEROUS WHEN WET” if applicable.
- Sample Tag #.
- The date.

The ice chest in which the paint cans are packed should have the following labels:

- Laboratory name and address.
- “FLAMMABLE LIQUID, NOS UN1993” or “FLAMMABLE SOLID, NOS UN1325.
- “DANGEROUS WHEN WET” if applicable.
- “CARGO AIRCRAFT ONLY”.
- “LABORATORY SAMPLES”.
- “INSIDE PACKAGES COMPLY WITH PRESCRIBED SPECIFICATIONS”.
- “THIS END UP”.

Unknown hazardous materials can be transported by truck, rail, or overnight carriers, but must not be transported by passenger carrying aircraft.

7.0 SHIPMENT COORDINATION

Once samples have been shipped to the analytical laboratory, the sample team leader must notify the appropriate client and/or laboratory contact. Notification must be on the day of the shipment and if after hours, the team leader may need to leave a detailed message. The following information is to be provided:

- Team leader name.
- Telephone number for following day contact.
- Site or project name.
- Exact number of samples shipped by matrix and environmental or hazardous concentrations.
- Shipping company and airbill numbers.
- Method of shipment (overnight).
- Date of shipment.
- Analyses requested to be performed by laboratory and sample matrix.
- Any irregularities or problems with samples including special handling instructions.
- Status of sampling mission (i.e., final shipment or future sampling schedule).

SOIL SAMPLING
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in collection of soil samples at job sites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed guidelines set forth by the Environmental Protection Agency (EPA) for the collection of representative soil samples used to determine whether concentrations of specific pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health, welfare, or the environment.

2.0 PURPOSE

This Standard Operating Procedure (SOP) provides instructions that are to be followed in collecting samples of either soil or sediments.

3.0 SOIL SAMPLING

Soil samples may be collected by either using hand tools, i.e., disposable scoop, trowel, shovel, bucket auger, or by a power driven sampling device such as a split spoon. The sample collection method should be noted in the field logbook. Samples collected for volatile organic compound analysis should be taken with Encore samplers using encore techniques.

Once the sampling location has been selected, any vegetation and/or loose material shall be removed from a circular area approximately 2 feet in diameter. The purpose of this step is to prohibit surface material from falling into the sample hole and possibly contaminating the sample. Also, a level surface will facilitate hole depth measurements.

To prevent potential surface contamination from any subsurface sample contaminants, plastic sheeting should be placed adjacent to the sample location. All subsurface material that is collected must be placed on this sheeting.

3.1 Shovel and Trowel/Scoop

When the prescribed sample depth is reasonably shallow (down to approximately 4 feet), a decontaminated shovel and disposable scoop or trowel can be used following the sequence of steps described below:

1) Label all jars with required tags and labels. Fill out all information except the actual date and time. Sort jars, one set per sampling location with additional sets as needed for QA/QC samples.

2) Note exact location of the sample in the field logbook. If possible, photograph the location.

3) At the time of individual sample collection, record date and time on all sample containers and in the field logbook. Cover all container labels with wide, transparent, waterproof tape to ensure label integrity.

4) Use a decontaminated shovel to remove the overburden to the prescribed depth and place excavated material on the plastic sheeting.

5) If the samples are being analyzed for volatile organic compounds (VOCs), collect the VOC fraction first. VOC sample containers should be tightly packed using a disposable scoop, leaving no airspace in the jar.

6) Using the scoop, fill the remaining jars at least ¾ full.

7) Wipe off the outside of the jar and place it in a bubble baggie. Place the bagged jar in a cooler, with ice if the sample plan calls for ice.

8) Replace excavated material from the plastic sheeting into hole and cap with removed vegetation or other material.

9) Decontaminate the sampling equipment for the next sample.

10) Field soil sample duplicates are to be collected either by compositing (except in the case of VOC analysis) the soil in a clean container (a composite field duplicate) or sampling from a close adjacent location (a collocated field duplicate). Follow the site-specific sample plan and document the duplicate collection process in the field logbook.

3.2 Bucket Auger

A bucket auger may be used for sample collections at intermediate depths depending on surficial geologic conditions (1 to 15 feet). Augers do not work well in rocky soils.

1) Label all jars with required tags and labels. Fill out all information except the actual date and time. Sort jars, one set per sampling location with additional sets as needed for QA/QC samples.

2) Note exact location of the sample in the field logbook. If possible, photograph the location.

3) At the time of individual sample collection, record date and time on all sample containers and in the field logbook. Cover all container labels with wide, transparent, waterproof tape to ensure label integrity.

4) On the auger, use a tape measure to locate the sample depth up from the bottom of the auger head and mark it.

5) Place the auger above the selected sample location and turn the “T” handle to screw the auger into the soil.

6) Remove the soil and repeat until sample depth is reached. Expel the soil plug by holding the auger upside down and tapping the handle on the ground. Place excavated material on a plastic sheet.

7) After reaching the desired depth, decontaminate the auger and remove one more soil plug. Collect the sample and place into sample containers using a disposable scoop.

8) If the samples are being analyzed for volatile organic compounds (VOCs), collect the VOC fraction first. VOC sample containers should be tightly packed using a disposable scoop, leaving no airspace in the jar.

9) Using the scoop, fill the remaining sample containers at least ¾ full.

10) Wipe off the outside of the jar and place it in a bubble baggie. Place the bagged jar in a cooler, with ice if the sample plan calls for ice.

11) Replace excavated material from the plastic sheeting or use bentonite and cement grout if downward migration of contaminants is a concern.

12) Decontaminate the sampling equipment for the next sample.

13) Field soil sample duplicates are to be collected either by compositing the soil in a gallon baggie (a composite field duplicate) or sampling from a close adjacent location (a collocated field duplicate). Follow the site-specific sample plan and document the duplicate collection process in the field logbook.

3.3 Split Spoon

A split spoon sampler is used to take subsurface soil samples by being forcefully driven into the soil at the bottom of a bore hole. Samples may be retrieved along the entire length of the bore hole to obtain an unbroken record of the subsurface layers or at selected intervals.

The split spoon is threaded on to the end of the drill rod in place of the drill bit. The bore hole may contain casing (steel or plastic pipe), depending on future use of the hole and the rigidity of the penetrated formation. The sampler is lowered on the drill rod to the bottom of the boring by heavy steel cable connected to the drilling mast. The sampler is forced into the soil by a drive weight that is dropped repeatedly onto the drive head located at the top of the drill rod. Weights up to 350 pounds are available but the most commonly used for a two-inch diameter sampler is a 140-pound weight. The weight is typically allowed to fall a distance of 30 inches. The sampler is driven into the soil to a depth that is about 6 inches shorter than the length of the sampler itself. Split spoon samplers are manufactured in 18-inch and 24-inch lengths with 2-inch to 3-inch outside diameters.

Occasionally, bedrock or extremely compacted soils are encountered that make further advance of the sampler extremely difficult or impossible without damage to the sampler. This is known as "refusal" and is defined as "penetration of less than 1 foot for 100 blows"; a blow being the act of striking the drive rod with the drive weight. Six inches for 50 blows is also commonly recognized as refusal. Upon refusal, the bore hole is to be either abandoned or the sampler removed and replaced by a drill bit.

Split spoon sample collection procedure:

1) Label all jars with required tags and labels. Fill out all information except the actual date and time. Sort jars, one set per sampling location with additional sets as needed for QA/QC samples.

2) Note exact location of the sample in the field logbook. If possible, photograph the location.

3) At the time of individual sample collection, record date and time on all sample containers and in the field logbook. Cover all container labels with wide, transparent, waterproof tape to ensure label integrity.

4) Receive sampler from driller and place on a secure bench or rack for opening.

5) Separate the sample tube (a flat-blade screwdriver is useful) exposing the sample or, if used, brass liners.

6) Run a knife between the liners to separate and immediately seal the cut ends with Teflon film if VOCs analysis is required. Wrap with Teflon plumber's tape, cap with plastic lids, and wrap with grey duct tape. Apply sample label.

7) If no liner is used, the sample may be collected from the open spoon using a disposable scoop.

8) If the samples are being analyzed for volatile organic compounds (VOCs), collect the VOC fraction first. VOC sample containers should be tightly packed using a disposable scoop, leaving no airspace in the jar.

9) Using the scoop, fill the remaining sample containers at least ¾ full.

10) Wipe off the outside of the jar and place it in a bubble baggie. Place the bagged jar in a cooler, with ice if the sample plan calls for ice.

11) Replace excavated material or use bentonite and cement grout if downward migration of contaminants is a concern.

12) Decontaminate the sampling equipment for the next sample.

13) Field soil sample duplicates are to be collected either by compositing the soil in a gallon baggie (a composite field duplicate) or sampling from a close adjacent location (a collocated field duplicate). Follow the site-specific sample plan and document the duplicate collection process in the field logbook.

3.4 Tube Sampler

A tube sampler may be used for collecting sediment samples underneath water. Depending on the volume of sample material desired, tubes ranging from ½ to 2 inches can be used. The tube can be made of glass, clear plastic, PVC, or other material as appropriate for the sediment composition being sampled.

If taking both a water sample and a sediment sample, the water sample must be taken first because turbidity created in the water while taking the sediment sample would result in a non-representative water sample.

Split spoon sample collection procedure:

1) Label all jars with required tags and labels. Fill out all information except the actual date and time. Sort jars, one set per sampling location with additional sets as needed for QA/QC samples.
2) Note exact location of the sample in the field logbook. If possible, photograph the location.
3) At the time of individual sample collection, record date and time on all sample containers and in the field logbook. Cover all container labels with wide, transparent, waterproof tape to ensure label integrity.
4) Insert the tube into the sediment to the prescribed depth. Seal the top end of the tube with a gloved hand or a cap and remove the tube. The suction created causes the sediment to remain in the tube. Place sediment in the tube on plastic sheeting by removing the gloved hand or cap from the top of the tube and allowing the sediment to flow out.
5) If the samples are being analyzed for volatile organic compounds (VOCs), collect the VOC fraction first. VOC sample containers should be tightly packed using a disposable scoop, leaving no airspace in the jar.
6) Using the scoop, fill the remaining jars at least ¾ full.
7) Wipe off the outside of the jar and place it in a bubble baggie. Place the bagged jar in a cooler, with ice if the sample plan calls for ice.
8) Replace sediment from the plastic sheeting into hole.
9) Decontaminate the sampling equipment for the next sample.
10) Field sediment sample duplicates are to be collected either by compositing the sediment in a gallon baggie (a composite field duplicate) or sampling from a close adjacent location (a collocated field duplicate). Follow the site-specific sample plan and document the duplicate collection process in the field logbook.

3.5 Encore Sampling

The following attachment describes the procedures to use in Encore sampling. Note that if Encore procedures (SW 846 Method 5035A) are not used, the absence of VOCs below 200 ug/Kg cannot be demonstrated.

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Collecting and Preparing Soil Samples for VOC Analysis

Implementation Memorandum #5

To: Interested Parties
From: Tim Nord, Section Manager
Date: June 17, 2004
Re: Collecting and Preparing Soil Samples for VOC Analysis

Intent of this Memorandum

The purpose of this technical memorandum is to set forth guidance regarding the implementation of Method 5035A[1]. This technical memorandum provides detailed guidance on:

- How to collect soil volatile organic compound (VOC) samples;
- How to prepare and preserve soil VOC samples; and
- How to store soil VOC samples.

This guidance contains information on four methods that you may use to collect and prepare soil VOC samples for analysis. If you are collecting soil VOC samples, then you will need to use one or any combination of these four methods:

1. On-site laboratory,
2. Lab preservation,
3. Field preservation, and
4. Alternative methods.

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[1] Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples, EPA SW-846.

Details on each of these four methods are provided in the body of this tech memo.

Table of Contents

What is Method 5035A?

EPA Method 5035A sets forth the requirements and procedures applicable to the collection and preparation of soil samples for volatile organic compound (VOC) analysis, including:

- Recommended or required sampling equipment (e.g., 40-mL volatile organic compound analysis (VOA) vials, etc.);
- How to collect undisturbed soil samples;
- How to preserve samples in the field by chemical (e.g., methanol) or physical (e.g., freezing) methods;
- How to transport and store samples; and
- Analytical options (i.e., low-level vs. high-level method).

Method 5035A was developed and approved for use in July 2002 by the U.S. Environmental Protection Agency (EPA). The method was included by EPA as a new method under SW-846, "Test Method for Evaluating Solid Wastes: Physical/Chemical Methods" (3rd Ed.).

When Should I Use Method 5035A?

WAC 173-340-830(3) specifies acceptable analytical methods for sites where a remedial action[2] is being conducted under the Model Toxics Control Act (MTCA) regulation[3]. EPA Method 5035A, which sets forth the requirements and procedures for the collection and preparation of soil samples for VOC analysis, is one of those methods.

Therefore, you must comply with the requirements of Method 5035A if:

- You are conducting remedial action under the MTCA cleanup regulation; and

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[2] A "remedial action" includes remedial investigation /feasibility study (RI/FS) or site characterization (WAC 173-340-350).
[3] Chapter 173-340 WAC

- As part of that remedial action, you are collecting soil samples for VOC analysis.

Who is the Intended Audience for this Guidance?

The intended users of this guidance are those individuals involved in the collection and preparation of soil samples for VOC analysis, including:

- Site managers;
- Field sampling personnel;
- Laboratory analysts;
- Quality assurance personnel; and
- Data quality assessors.

The target audience for this guidance is anyone conducting petroleum- or chlorinated hydrocarbon investigations or cleanups. For example, you must use this sampling protocol for volatile hazardous substances such as benzene or trichloroethylene (TCE).

Why Do Soil VOC Samples Need to be Preserved?

A significant body of scientific evidence has found that VOCs will volatilize and biodegrade during sample collection and transport, which typically results in significant losses of initial VOC concentrations. Consequently, the consensus opinion of EPA and the scientific community is that you must take significant precautions when collecting and preparing soil samples for VOC analysis, including the use of preservation techniques, to limit the impacts of volatilization and biodegradation. Both of these mechanisms are discussed in more detail below.

Volatilization[4]

With respect to volatilization, when VOCs are released to the soil, they immediately start to partition from the liquid phase to the gaseous phase. This rate of volatilization is compound specific. Various soil properties also impact this rate of volatilization, including grain size, moisture content, and porosity. VOCs within disaggregated or disturbed soil samples also tend to volatilize at faster rates.

In most solid materials, the molecular diffusion coefficients of VOCs in the gaseous phase are high enough to allow for the immediate volatilization of those VOCs from a freshly exposed sample surface, resulting in a loss to the surrounding atmosphere. If the sample matrix is porous, these losses will continue as VOCs below the surface diffuse outward.

In summary, the primary goal of VOC sample collection and preservation techniques is to minimize or eliminate the loss of the compounds of concern through direct volatilization to the atmosphere.

Biodegradation[5]

The biodegradation of VOCs involves compound loss by biological processes mediated by naturally-occurring organisms found within the sample. Aerobic processes

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[4] See Refs 1, 7, 9, 11, 18, 0, 27.

[5] See Refs 8, 10, 13, 16, 17, 24.

are of greatest concern, but anaerobic organisms can also result in significant compound loss. The rate of biodegradation is dependent upon several factors, including indigenous microbes, the chemical properties of the soil VOC, the original VOC concentration, and temperature.

Most soil sample collection procedures involve intrusive sampling operations that can create or enhance aerobic conditions within a sample. Aerobic conditions can occur by disaggregation of the soil particles or by simple exposure to the air. Once collected, soil VOC samples must be preserved or immediately placed in a sealed container. This must be done to minimize VOC losses from uncontrolled aerobic processes. If you do not take these precautions, then aerobic conditions will persist during handling and storage.

What is the Definition of VOC?

VOCs[6] are organic chemicals that easily vaporize at room temperature. This includes low molecular weight aromatics, hydrocarbons, halogenated hydrocarbons, ketones, acetates, nitriles, acrylates, ethers and sulfides. Most VOCs typically have boiling points in the range of 150-200° C.

Should I Use this Sampling Method for Semi-volatiles?

No, you do not have to use this sampling method for semi volatiles (e.g., benzo(a)pyrene). The EPA Method 8270C is used for analyzing semi-volatiles.

Development of EPA Method 5035A

EPA Method 5035 was first published in Update III of the third edition of SW-846 on June 13, 1997. Since that time, the scientific community has continued to conduct research on soil sampling methods that minimize VOC losses. In this same time period (1997-03), EPA has also continued to provide information on issues related to Method 5035A.

On August 7, 1998, EPA published a clarification memorandum[7] on the use of SW-846 methods, including Method 5035. In the Aug-98 memorandum, EPA recommended the following:

- As a matter of policy, all soil VOC samples should be preserved in some manner, whenever possible.
- Do not use sodium bisulfate as a preservative in calcareous soil. Use the EnCore® Sampler instead.
- If methanol is used as a preservative, then check for losses by re-weighing, in the field, sample vials that were previously weighed in the laboratory.

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[6] See also WAC 173-340-200 definition of VOC and EPA VOC definition in Method 5035A, Appendix A, Section A.1.1.

[7] See Ref 6.

If the difference between the laboratory/field weight is > 0.2 g, then methanol loss may have occurred and the vial should not be used.

- Use a soil-to-solvent ratio of 1:1, e.g., 5 g soil and 5 mL of methanol.

In July 2002, EPA published an update to Method 5035 in the fourth update of SW-846. The updated method is now known as Method "5035A". The updated (Jul-02) Method 5035A now contains an appendix with 32 pages of additional information.

For further information regarding the requirements of Method 5035A as well as the basis for those requirements, please refer to the method, which is available electronically (EPA 5035A).

Which Soil VOC Sampling Method Should I Select?

You will need to use one or any combination of the following four methods: 1) on-site laboratory, 2) lab preservation, 3) field preservation or 4) alternative methods. **Detailed instructions on how to collect and preserve soil VOC samples using methanol or sodium bisulfate are provided in Appendix A: Soil VOC Sampling Instructions (p. 14).** Advantages and limitations of each of these four methods are discussed below.

Option 1: Mobile or On-site Labs

- The key advantage of this option is that you ***don't need to preserve*** any samples. You also get quantitative information in real time, which is extremely helpful for site characterizations. The one possible disadvantage of this option is cost.

Option 2: Lab Preservation

- If you opt for lab preservation, then you will collect ***unpreserved*** soil VOC samples, place them on ice @ 4 ± 2° C and ship them to the lab for preservation and analysis. Under Method 5035A, you will ship all unpreserved samples to the lab and the lab will receive and extract the samples ***within 48 hours of sample collection.*** Some sampling devices (e.g., **En Core® Sampler)** require you to submit samples to the lab within 48 hours.

- **Sample containers.** You may use some type of zero headspace extraction (ZHE) container (e.g., **En Core® Sampler**) or an empty 40-mL VOA vial with 0.25 mm thick PTFE-lined septa. *Do not use core barrel liners or sample cores wrapped in aluminum foil - this will not prevent volatilization!*

- **Preservation methods.** Once the samples arrive at the lab, they must either be ***preserved*** or ***analyzed*** within 48 hours from the time of sample collection. The chemical preservation method that is used will depend on the type of analysis, i.e., low- (sodium bisulfate) or high- (methanol) concentration method. Samples that are chemically preserved in the lab must then be analyzed within required holding times (normally 14 days). You may also, as an option, utilize a physical preservation method by having the lab **freeze**[8] **non-preserved** soil VOC samples to **≤ -7° C** for up to **14 days**.

Note: If you do have the lab freeze samples, then the samples must be extracted with methanol only. You cannot freeze samples for the low-concentration (sodium bisulfate) method.

Advantages of Lab Preservation

- You do not need to bring preservative chemicals to the field. Also, you do not need to weigh samples prior to and after collection. Lastly, if you opt for preservation by freezing, it's convenient for the lab because the sample can be stored in a cooler for the 14-day holding time.

Limitations on Lab Preservation

- The one limitation of lab preservation is you must ship samples to the lab within ***48 hours from the time of sample collection!*** This does not mean, however, that the sample must be analyzed within 48 hours. What it does mean is that you must ship samples to the lab within 48 hours. The lab must then preserve the sample with sodium bisulfate, methanol, or by freezing to < -7° C. If this is done within 48 hours, the holding time is 14 days.

Option 3: Field Preservation

- If you opt for field preservation, then you will collect soil VOC samples and preserve in the field by chemical preservation methods using sodium bisulfate or methanol, or by a physical preservation method such as freezing.

- **Sample containers.** If you opt for chemical field preservation, then you will be using 40-mL VOA vials with PTFE-lined septa. The vials may be pre-preserved and pre-weighed in the lab, or, you can do this in the field.

- **Preservation methods.** The chemical preservation method that you use will depend on whether you use the low- or high-concentration method. If you plan to use the low-concentration method, you must add 5 mL of sodium bisulfate to a 5 g soil sample. If you use the high-concentration method, you must add 5 mL of laboratory-grade methanol to a 5 g soil sample.

Advantages of Field Preservation

- The main advantage of field preservation is that the lab does not need to receive the samples within 48 hours.

Limitations on Field Preservation

- The main disadvantage of field preservation is that you must, in the field, do things that are normally done in laboratory. Thus, a lot more things can go wrong; however, field

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[8] See Appendix A of Method 5035, Section A.8.2.1.

preservation is certainly not an impossible task, and it can be easily accomplished if you are careful and pay attention to details. For example, you must try to add a precise quantity (~ 5 mL) of preservative and soil (~ 5 g). You must also weigh sample vials prior to and after sample collection.

- You can significantly reduce error by using field kits with pre-preserved and pre-weighed vials; however, these kits can be fairly costly.

- Methanol is a toxic flammable liquid, which presents issues when collecting and shipping samples.

Option 4: Alternative Methods

- Ecology may, on a case-by-case basis, approve of alternative soil VOC sampling methods. This option is designed primarily for future changes in soil VOC sampling technology. *However, Ecology expects that as a matter of policy, all soil VOC samples must be collected in a manner that minimizes volatilization and biodegradation!*

Low- vs. High-Concentration Method: Which One Should I Select?

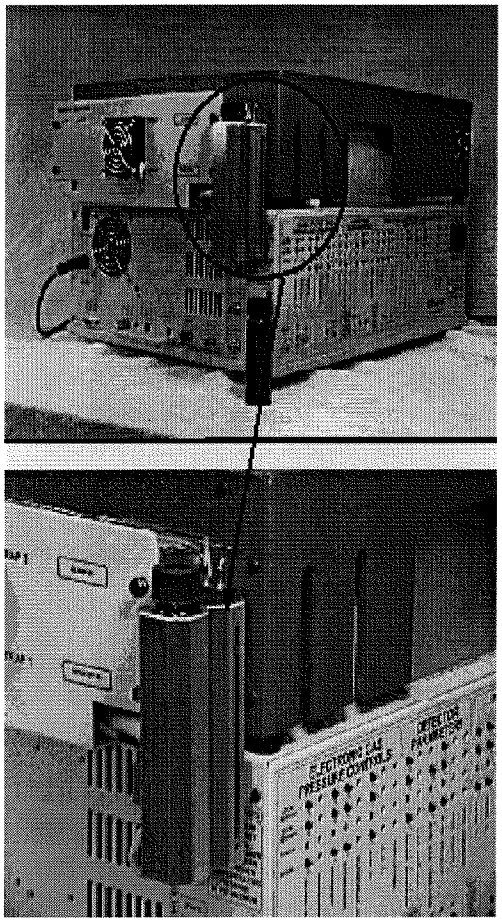
EPA Method 5035A has two main components: a "low-concentration" method and a "high–concentration" method. A brief synopsis of each is as follows:

- The low-concentration method uses sodium bisulfate as a preservative. Detection limits of < 200 ug/kg can be obtained with this method provided soil VOC concentration are < 200 ug/kg.

- The low-concentration method is designed to minimize VOC losses by using the sample container as the "purging" device (hence the name closed-system-purge and trap). Here's how this works: when you collect the sample, it is sealed and sent to the lab. The entire sample vial is then placed, unopened, into the purge and trap "instrument carousel" (Figure 1, p.8). The vial is then heated to 40°C and the volatiles are purged into a "trap".

- The high-concentration method uses methanol as a preservative. The high-concentration method works best for soil VOCs with concentrations > 200 ug/kg. In the high-concentration method, the lab will take a small aliquot (~ 50-100 uL) of the soil-methanol solution and inject it directly into the gas chromatograph (GC). EPA Method 8021B or 8260B is then used for analysis.

Figure 1: EPA Method 5035A "Low-Concentration" Method.



Source: SRI INSTRUMENTS, 20720 Earl Street, Torrance, Calif. 90503 U.S.A.

1. UPPER PHOTO. The 40-mL VOA Vial is inserted into a Gas Chromatograph (GC) with an "Adjustable Temperature Thermostatted Sleeve".

2. LOWER PHOTO. Two needles puncture the septum, one allowing the sparge gas (helium) to enter the vial, the other exhausts the sample into the adsorbent traps.

The advantages and limitations of these two preparation procedures are as follows:

Low-Concentration Method Advantages

- The key advantage of this method is that it allows you to quantify soil VOCs at low concentrations, i.e., < 200 ug/kg. In particular, since you are not adding methanol, there is no dilution factor in the sample extract.

Limitations

- You are not supposed to use this method if soil VOC concentrations are > 200 ug/kg (they will likely exceed the working range of the analytical instrument).
- Because it is a closed-system-purge and trap, the lab can analyze each sample only one time. Thus, it is recommended that you collect 2-3 samples per sample location.
- Calcareous (or sandy) soil will react with the acid solution, which can result in broken or shattered VOA vials.
- Sodium bisulfate is not an efficient extraction medium for VOCs, which impacts recovery rates. This is because VOCs are less likely to dissolve into an acid solution comprised of sodium bisulfate and water.

- Recent studies[9] found that the sodium bisulfate acid solution may oxidize naturally-occurring soil waxes and humic material, which results in increased soil acetone levels.

High-Concentration Method Advantages

- The key advantage of this method is that VOCs will readily dissolve into methanol, which makes it a very efficient extraction medium. Studies[10] on methanol extraction have found that results tended to be more accurate when compared to results from the low-concentration purge and trap method.

- Unlike the low-concentration method, the lab can analyze the sample more than once if necessary.

Limitations

- Prior to analysis, the lab must ***dilute***[11] the sample, which means practical quantitation limits (PQLs)[12] will be ***higher***. For example, if you mix add 5 mL of methanol with 5 g of soil and the lab extracts 100 uL for analysis, the dilution is 50 (5,000 uL/100 uL = 50). With a dilution of 50, you can probably expect to achieve laboratory reporting limits/ PQLs of ~ 25-50 ug/kg.

- Methanol is a highly flammable and toxic liquid, which presents issues for shipping and sample collection. Also, methanol can be easily contaminated by atmospheric sources of VOCs, e.g., car exhaust.

How Do I Know if Soil VOC Concentrations are < or > 200 ug/kg?

If you opt for the low-concentration method, you will need to check and make sure that soil VOC concentrations are < 200 ug/kg. To do this, you may use field screening instruments[13], or you may instruct the lab to screen samples. Also, before you make any decisions about which method to use, you should always check Ecology's soil cleanup standards. Cleanup levels for nine (9) common VOCs are provided in Table 1.

Table 1: State of Washington Method A Soil VOC Cleanup Levels (Unrestricted Land Use).

Volatile Organic Compound (VOC)	Cleanup Level (ug/kg)
Benzene	30
Ethyl Benzene	6,000
MTBE	100
Naphthalene	10,000
Tetrachloroethylene	50
Toluene	7,000
Trichloroethane-1,1,1	50
Trichloroethylene	30
Xylene	9,000

Source: Table 740-1 (Chapter 173-340 WAC)

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[9] See Refs 3, 17, 26.

[10] See Refs 1, 14, 15, 18, 19, 22, 0.

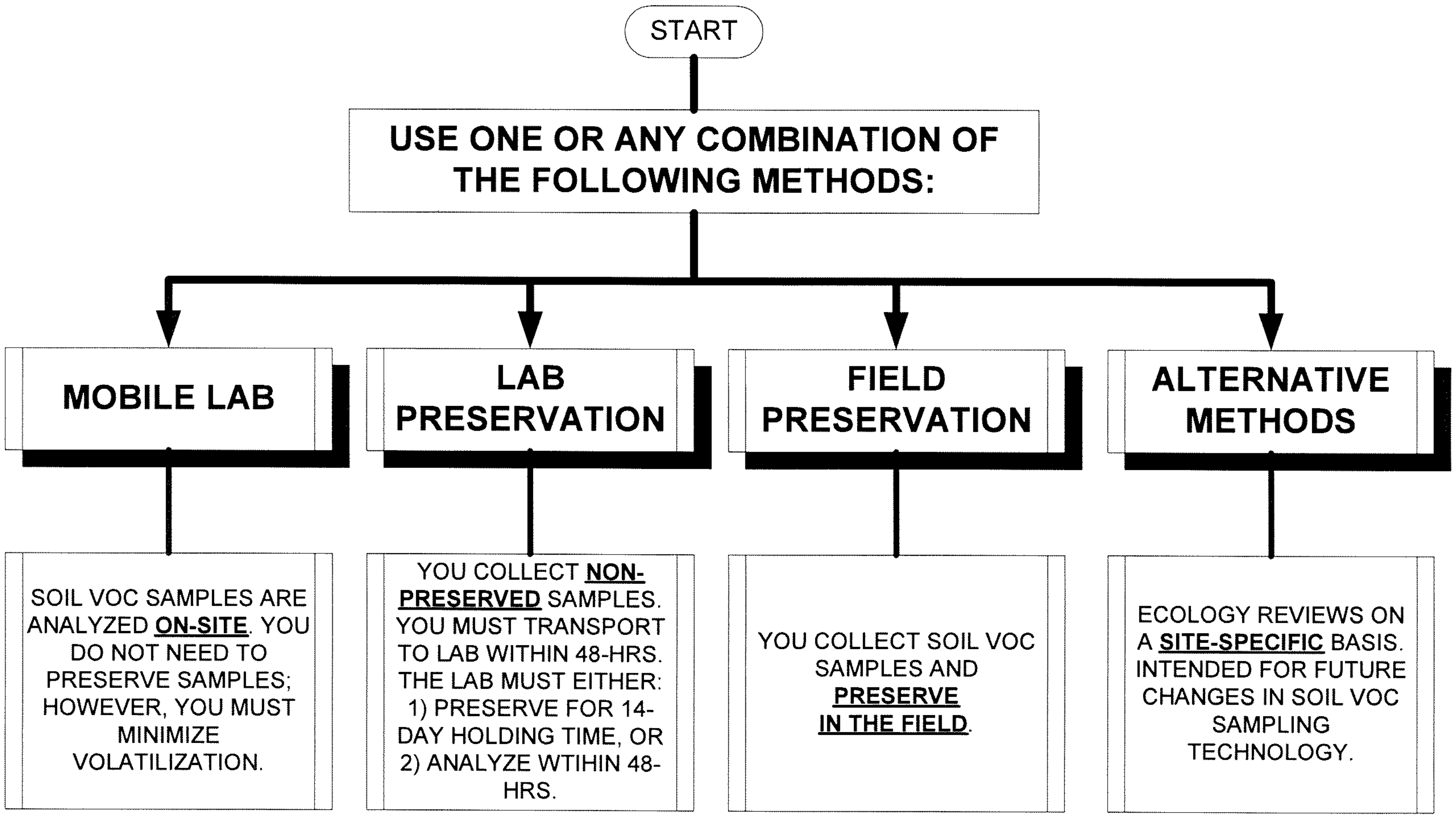
[11] See also EPA 5035A, Section 8.2.2.

[13] See Ref 19.

WASHINGTON DEPARTMENT OF ECOLOGY

EPA Method 5035A

SOIL VOC SAMPLING



START

USE ONE OR ANY COMBINATION OF THE FOLLOWING METHODS:

MOBILE LAB

SOIL VOC SAMPLES ARE ANALYZED **ON-SITE**. YOU DO NOT NEED TO PRESERVE SAMPLES; HOWEVER, YOU MUST MINIMIZE VOLATILIZATION.

LAB PRESERVATION

YOU COLLECT **NON-PRESERVED** SAMPLES. YOU MUST TRANSPORT TO LAB WITHIN 48-HRS. THE LAB MUST EITHER: 1) PRESERVE FOR 14-DAY HOLDING TIME, OR 2) ANALYZE WTIHIN 48-HRS.

FIELD PRESERVATION

YOU COLLECT SOIL VOC SAMPLES AND **PRESERVE IN THE FIELD**.

ALTERNATIVE METHODS

ECOLOGY REVIEWS ON A **SITE-SPECIFIC** BASIS. INTENDED FOR FUTURE CHANGES IN SOIL VOC SAMPLING TECHNOLOGY.

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   1241 Bellevue Street
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Appendix A: Soil VOC Sampling Instructions

OVERVIEW

The instructions provided here are **guidelines**. You are, however, legally obligated to follow and meet the criteria specified in WAC 173-340-830. We recognize and understand that sampling protocols vary and that how you do things will vary. Ecology also recognizes that with respect to analytical methods, the "performance based"[14] approach is now gaining widespread acceptance. Ecology compiled these instructions based on a review of other state 5035A policies, the instructions in Method 5035A itself and consultation with others who had historical knowledge of how best to implement Method 5035A.

SOIL VOC SAMPLING INSTRUCTIONS PLEASE NOTE

If you opt for lab preservation, then you may skip STEPS 1-6 and go directly to STEP 7. *The instructions provided in this tech memo are only for the sampling and preservation of soil VOC samples when using methanol or sodium bisulfate as the preservative. The instructions do not include a description of other sampling or preservation procedures, including those involving the freezing of the soil samples. For a complete description of sampling and preservation procedures see EPA Method 5035A.*

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[14] EPA defines this is as "a set of processes wherein the data quality needs, mandates or limitations of a program or project are specified, and serve as criteria for selecting appropriate methods to meet those specified needs in a cost effective manner."

WHAT EQUIPMENT WILL I NEED?

Laboratory Preservation

- **Sample containers.** You may use a zero Headspace Extraction (ZHE) container (e.g., **En Core® Sampler)** or other equivalent container.

- **Shipping arrangements.** Products like the En Core® sampler must be shipped to the lab within 48 hours. ***Depending upon the product you use, you must make shipping arrangements ahead of time!***

Field Preservation

- **Vials.** You must use 40-mL "VOA" glass vials with septum sealed Teflon-lined screw caps. All vials must be pre-weighed to the nearest 0.1 g. Record the vial tare weight on the sample label. You can either have the lab do this or you can do it in the field with your field balance.

- **Preservative**. If you are using the **low-concentration method**, then you must use sodium bisulfate ((NaHSO4) preservative. You must mix the preservative (~ 1 g) with at least 5 mL of organic-free reagent water so that the pH of the acid-water solution is ≤ 2. You can either have the lab do this or you can do it in the field. If you are using the **high-concentration method**, then you will need to use laboratory-grade methanol (CH3OH).

- *NOTE: Ecology recommends that you use pre-preserved and pre-weighed vials.*

- **Safety equipment.** Methanol is a toxic and flammable liquid. You will need to wear rubber gloves and other appropriate safety equipment.

- **Soil Sampling Syringes.** Ecology recommends that you use syringes to collect soil samples. Syringes have three distinct advantages: 1) they essentially allow you to collect ***undisturbed samples***, 2) they are calibrated with marks or lines that allow you to pre-determine how much sample is equal to 5 g, and 3) most syringes are designed to prevent ***headspace air*** above the sample contents. You may use several types of commercially available syringes, including: En Novative Technologies Inc. EasyDraw® syringe and Powerstop Handle®, Environmental Sampling Supply (ESS) "Lock N' Load", etc.

- **Balance.** You will need a portable "field" balance that is capable of weighing to 0.1 g. You will also need reference weights so that you can periodically check the balance for accuracy.

SOIL VOC SAMPLING INSTRUCTIONS

- *Note: If you opt for lab preservation, then you may skip STEPS 1-6 and go directly to STEP 7. The following instructions are only for the sampling and preservation of soil VOC samples when using methanol or sodium bisulfate as the preservative. The following instructions do not include a description of other sampling or preservation procedures, including those involving the freezing of the soil samples. For a complete description of sampling and preservation procedures see EPA Method 5035A.*

STEP 1. CHECK LOCATION

- If you are using methanol, then select an area that is free of car exhaust (it will contaminate the methanol).

STEP 2. CHECK SAFETY GEAR

- You should always wear gloves, goggles and other appropriate safety gear.
- *NOTE: methanol (Chemical Abstract Number 67-56-1) is a toxic and flammable liquid. You will need to use proper safety precautions. Ecology recommends that you wear Nitrile Rubber or Viton gloves. Avoid inhalation and make sure you store and use the methanol in a ventilated area, away from ignition sources. In the event of eye contact, flush with large volumes of water and seek medical attention immediately!*

STEP 3. CHECK FIELD BALANCE, AND FIELD-WEIGH 40-mL VOA VIALS

a) Check the calibration of your field balance. Follow manufacturer's instructions and record the check in your field notebook.

b) Reweigh each 40-mL VOA vial that you will be using that day. ***If the difference between the lab tare weight and the field weight is > 0.2 g, then do not use the vial!***

STEP 4. PREPARE METHANOL BLANKS

a) Ecology recommends preparing at least one methanol blank per sample cooler. Here's how this works: while you are collecting your soil VOC samples, you will leave the blank methanol vial open to check for any atmospheric VOCs. When you are done collecting soil samples, you will cap the blank vial and ship it to the lab along with the other samples.

b) **Preparing a methanol blank:** check with the lab about a methanol preservation sampling kit. You will need a tube of methanol and a pre-weighed 40-mL vial. When you are ready in the field, cut off the top of the methanol tube and carefully pour the contents into the 40-mL vial. Affix a label entitled "methanol field blank". Record the identification number in your field notebook. While collecting soil VOC samples, leave the blank methanol vial open. When done collecting soil samples, cap the blank vial and ship it to the lab along with the other samples.

STEP 5. CALIBRATE SOIL SYRINGE

a) If the syringe is already calibrated for 5 g (e.g., EasyDraw Syringe® and Powerstop Handle®; Figure 4, p. 21), then load or insert the syringe into the handle slot that is marked "5 g".

b) If you do not have a pre-calibrated syringe, then do this:

- Weigh an empty syringe on your field balance and record the weight,
- Insert the empty syringe into the soil and collect ~ 5 g soil. Cap the syringe. Make sure you wipe off any excess dirt.
- Reweigh (syringe + soil) and subtract syringe weight to determine soil weight.
- If the soil weight is ~ 5 g, then record how far you had to insert the syringe into the soil to achieve ~ 5 g. Use a trial-and-error method until you determine how far you must insert the syringe.

STEP 6. CHECK FOR CALCAREOUS SOILS

- *NOTE: this step applies only if you are using sodium bisulfate as a preservative. If you are preserving with methanol, then skip this step and go to STEP 7. If you are working in calcareous or carbonate soils, then do not use the sodium bisulfate preservative! The acid solution will react with the soil, which may result in excessive gas buildup and a shattered or broken VOA vial. If you do encounter calcareous soil, then use distilled water as a preservative! If you want to check to see if the soil contains carbonates, then squirt a few drops of hydrochloric acid (HCL) onto the soil. If it fizzes or effervesces, then the soil is calcareous.*

STEP 7. COLLECT SOIL SAMPLES

a) As a general rule of thumb, you should probably **collect at least two samples for every one location you sample**. This is particularly true for the low-concentration (sodium bisulfate) method, as the lab can analyze the sample only one time.

b) If you are using a methanol blank to check for contamination, then open it and place it in a secure area. Cap the vial when you are done collecting samples.

c) If you are using a syringe (e.g., En Core EasyDraw®) to collect samples, you will need to collect an undisturbed soil sample from a freshly exposed surface. To do this, gently push the syringe into the soil to a depth that is ≅ 5 g soil (see Figure 2, p. 20). Remove the syringe from the soil and quickly wipe the barrel end clean. Immediately cap the syringe. Make sure you wipe off any excess dirt.

- *NOTE: the En Core EasyDraw® syringe is not the same device as the En Core® Sampler! The syringe is supposed to be used only to collect and extrude soil into the VOA vial.*

d) If you are using the En Core® Sampler, use the steel T-handle to push the sampler into the soil. Skip Step 8 and go to STEP 10.

e) If the syringe or En Core® Sampler does not penetrate the soil, use a stainless steel spatula or scoop. Try to scoop or remove ~ 5 g soil. Once you've collected your sample, gently fill your 40-mL VOA vial with the appropriate preservative. Go to STEP 8.

STEP 8. EXTRUDE SOIL SAMPLES TO VOA VIALS AND RE-WEIGH.

a) Remove the syringe cap and extrude the 5 g soil sample from the syringe into the 40-mL VOA vial (Figure 3, p. 20). Quickly brush off any soil from the vial threads and **immediately seal the vial with septum and screw-cap!**

- *NOTE: once you've collected the soil sample, you must try to extrude it into the VOA vial with within 10 seconds! Before you screw the cap on, make sure you inspect the VOA vial threads and wipe off any dirt!*

b) **Low-concentration Method.** If you are using the *low-concentration* method (soil VOCs < 200 ug/kg), then you must, for a 5 g soil sample, add ~ 1 g of sodium bisulfate (NaHSO4) to each 40-mL vial. If you are collecting soil samples significantly < or > 5 g, then add ~ 0.2 g of preservative for 1 g of sample, e.g., 25 g sample = 5 g preservative. Add at least 5 mL of organic-free reagent water so that the pH of the acid-water solution is ≤ 2.

c) **High-concentration Method.** If you are using the *high-concentration* method (soil VOCs > 200 ug/kg), then you must add 5 g of soil with 5 mL of laboratory grade methanol (CH3OH).

d) Gently swirl the vial for ~ 10 seconds to break up the soil particles. DO NOT SHAKE!

e) **Re-weigh** the 40-mL vial. **Your target weight is 5 ± 0.5 g.** Record the sample weight to the nearest 0.1 g in your field notebook. **Do not record the weight on the sample label!**

- *NOTE: **do not** open the vial if you've added too much (or too little) soil. The lab can add more methanol to achieve a 1:1 ratio. The desired ratio of grams soil / mL methanol is 1:1, within a tolerance of +/- 25%. Ratios outside this range may be acceptable, depending upon data quality objectives. In all cases, however, the soil sample must be completely immersed in methanol.*

STEP 9. COLLECT ADDITIONAL SOIL SAMPLES FOR MOISTURE CONTENT ANALYSIS

a) ***For every one location you sample, you must collect at least one soil sample for moisture content analysis!*** The lab must have this information so that it can normalize the soil VOC concentration to a dry-weight basis. You should collect ~ 10 g of soil for moisture content analysis. Do not add preservative to the sample designated for moisture content analysis. Use the EasyDraw® syringe, a 4-oz wide mouth glass jar, a 40-mL VOA vial, or other suitable container for your moisture content analysis. Make sure you label the vial so that the lab knows it's for moisture content analysis!

- *NOTE: Because water is completely miscible with methanol, naturally-occurring soil moisture may result in under-reporting of the true, dry-weight VOC concentrations. As a general rule of thumb, a 1% increase in moisture content (by weight) will result in a negative bias of ~ 1%; however, moisture contents < 25% by weight are generally not considered significant by most labs.*

STEP 10. ICE SAMPLES AND SHIP TO LAB

a) **Once they are sealed and weighed, immediately place all samples on ice @ 4 ± 2° C!**

b) If you are shipping methanol-preserved samples, you must comply with the following requirements:

Methanol Shipping Requirements

- Each 40-mL vial must have < 30 mL of methanol (30 mL falls under the federal exemption for small quantities of flammable liquids).
- The "cooler" or container that you use for shipping must have a total methanol volume of < 500 mL (that's 50 samples @ 10 mL of methanol each).

Appendix A: Soil VOC Sampling Instructions

- You must have sufficient absorbent material in the cooler in case one of the vials breaks. You must have enough to completely absorb the vial's contents.
- The cooler or package weight must not exceed 64 pounds.
- Each cooler or container must be clearly labeled as containing < 500 ml methanol.
- The shipping of methanol is regulated by the U.S. Department of Transportation, Title 49 of the Code of Federal Regulations. The DOT number is UN 1230.

Figure 2: Using a Syringe to Collect the Soil Sample.

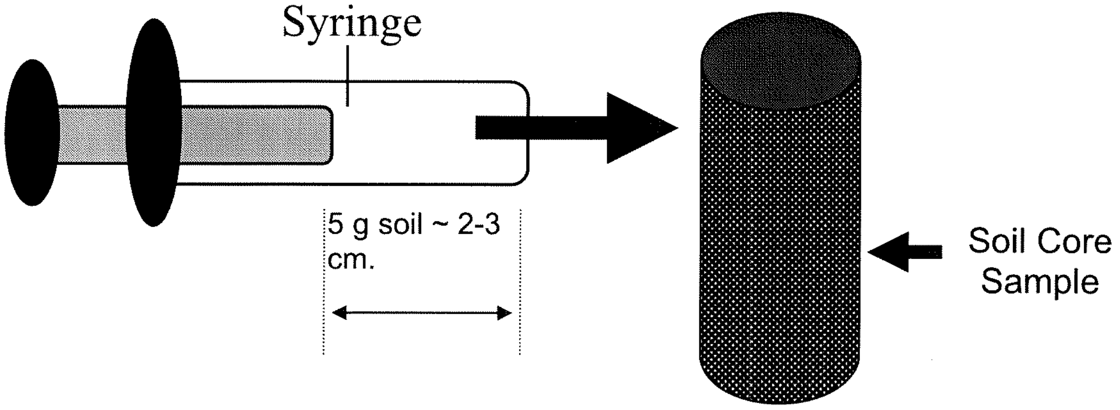
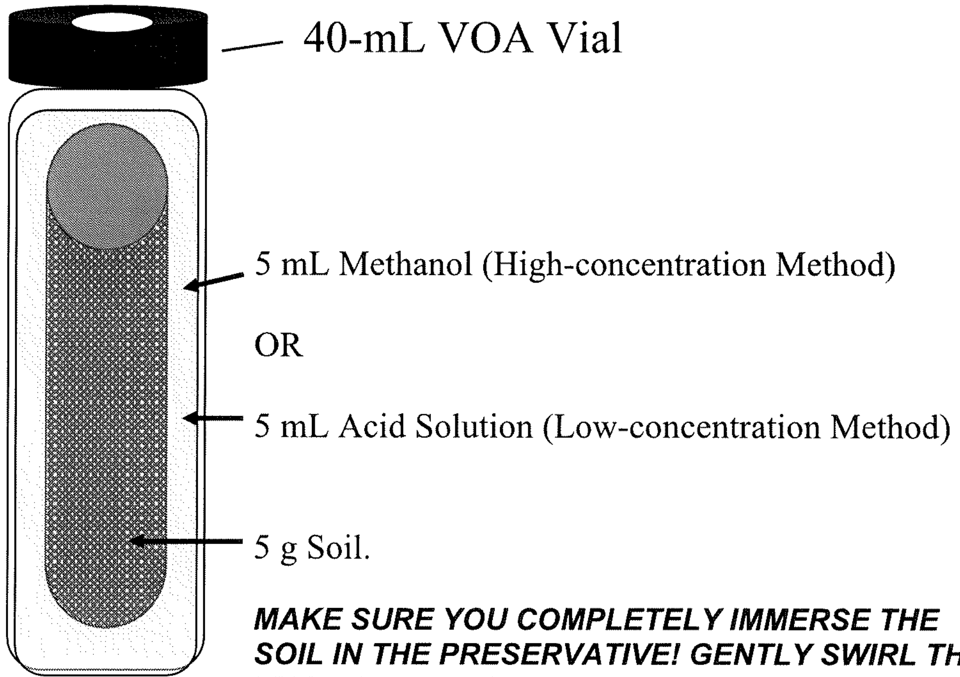


Figure 3: Vial and Sample.



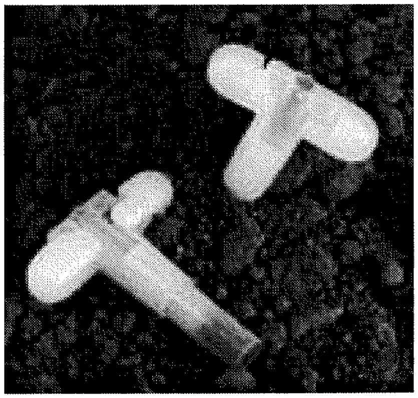
MAKE SURE YOU COMPLETELY IMMERSE THE SOIL IN THE PRESERVATIVE! GENTLY SWIRL THE VIAL TO IMMERSE THE SAMPLE. DO NOT SHAKE IT!

Figure 4: Sample Collection Equipment.

40-mL VOA Vial and Plastic Syringe

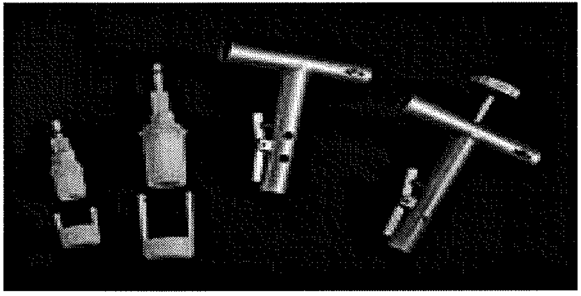
“EasyDraw® Syringe & Powerstop Handle®

Terra Core™ Soil Sampler



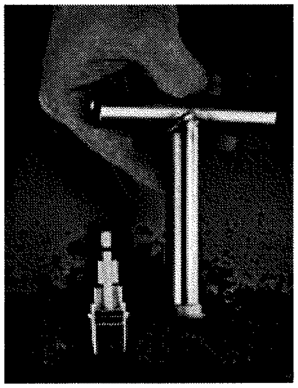
En Novative Technologies, Inc.

“En Core®” Soil Core Sampler



En Novative Technologies, Inc.

“En Core®” T-Handle



En Novative Technologies, Inc.

Field Balance

Portable Scout* Series Electronic Balance by Ohaus*

WELL CONSTRUCTION AND DEVELOPMENT
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in well construction and development at job sites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed guidelines set forth by the Washington Administrative Code (WAC 173-160) or other state agency for monitoring well construction and development.

2.0 PURPOSE

This Standard Operating Procedure (SOP) provides instructions that are to be followed in construction and development of wells.

3.0 WELL CONSTRUCTION MATERIALS

The following materials will be used in the construction of groundwater monitoring wells, soil vapor extraction wells, enhanced reductive dechlorination injection wells, and dual phase extraction wells.

- 2, 4, or 6-inch I.D. schedule 40 PVC flush threaded blank casing
- 2, 4, or 6-inch I.D. schedule 40 PVC slotted casing (screen) of appropriate slot size
- 2, 4, or 6-inch I.D. schedule 40 PVC threaded and slip caps
- Stainless steel well centralizers
- Mild steel protective casing of appropriate diameter
- Locking standpipe cap
- Traffic-rated watertight flush mount well housing enclosure
- Steel bollards
- Locking compression plugs or seals
- Shale trap
- Combination or key lock
- Filter pack sand
- Type I or II Portland cement
- Concrete
- Bentonite powder, pellets, or chips

4.0 WELL DEVELOPMENT EQUIPMENT

The following materials and equipment are needed for development of wells:

- 2, 4, or 6-inch surge block
- Appropriate high volume pump (centrifugal, submersible, etc.)
- DOT approved 55-gallon drums
- Teflon, PVC, or stainless steel bailer with cord or cable

5.0 WELL CONSTRUCTION PROCEDURES

The following steps describe the typical procedure for construction of a groundwater well:

1) All wells are to be constructed in accordance with the regulations of the state in which they are constructed and with ASTM Procedure D-5092.

2) A monitoring well consists of a PVC Schedule 40 well casing, slotted screen, threaded or slip bottom cap, and compression plug. Following completion of the boring, install the monitoring well through the center of the hollow stem auger, drive casing, or open boring. The casing string must be centered in the borehole and held in tension during installation. Other types of wells are similar with additional components as shown on the design diagrams.

3) Place clean, well graded silica sand around the well screen to serve as the filter pack. The grade of the sand is chosen on the basis of the aquifer units encountered. The filter pack is emplaced as the auger or temporary casing is withdrawn from the boring. Caution must be taken to prevent the sand from bridging when it is being emplaced. The filter pack must extend a little above the top of the screen.

4) Place a 2-foot to 3-foot thick pellet or chipped bentonite seal above the sand pack as the auger or casing is withdrawn. Bentonite seals should not be placed in the vadose zone as they will desiccate, losing their ability to seal. If the screen extends into the vadose zone, use a tremie pipe to slurry in Portland cement for the seal.

5) Fill the remainder of the annulus between the well casing and the borehole with cement/bentonite grout (approximately 5% bentonite) or a high-solids bentonite slurry (11 – 13 pounds per gallon) to the approximate depth of frost penetration, or no higher than one foot below ground surface. If the water level is higher than the seal, use a tremie pipe to place the grout. At depths greater than 15 feet, use of a tremie pipe is advisable.

6) Install either a threaded cap or a locking watertight compression seal on the monitoring well.

7) Place a protective steel casing with locking cap over the well casing set in concrete to a depth approximately equal to frost penetration or at least two feet below ground surface. In traffic areas, place a traffic-rated flush mount enclosure over the well set in concrete. The top of the flush mount should be approximately one inch above grade to prevent runoff from entering the well. A concrete apron should be constructed to grade down to the existing asphalt or concrete surface.

8) For above ground completions, ensure that the well casing extends two to three feet above ground and is surrounded by traffic bollards set three feet deep in concrete.

6.0 WELL DEVELOPMENT PROCEDURES

The following steps describe the typical procedure for construction of a groundwater well:

1) Prior to development, measure the depth in each well to static water level and total casing depth to a mark on the top of the well casing. Well development should not commence until 24 hours after completion of well construction to allow for grout and concrete to cure.

2) Each well development cycle consists of surging and pumping. Surging should consist of a minimum of ten surges with an appropriately sized surge block over the full length of the screen. In the case where the screen extends to above the water table, water may have to be added to the well to develop the top of the filter pack.

3) After surging, water is pumped out of the well until the pumped stream starts to clear. At that point, stop pumping and initiate another surge cycle. When the pumped water clears substantially in less than a minute, the well may be deemed to be developed. Perform a minimum of three surge and pump cycles.

4) Surging should not be performed on wells completed in fine-grained materials due to the potential for formation erosion.

5) During development of each well and at the completion of development, record the following field parameters and observations:

   - Depth to water
   - Development time and volume
   - Development flow rate
   - Other observations (color, odors, sheen)

7.0 WELL CONSTRUCTION AND DEVELOPMENT WASTE

Place all drill cuttings and development water in appropriately labeled DOT approved drums for characterization and proper disposal by client.

WELL DRILLING, CONSTRUCTION, AND SAMPLING IN ROADWAYS
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual conducting work on any roadway at jobsites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed applicable OSHA standards for safe work practices.

2.0 PURPOSE

This standard operating procedure (SOP) provides instructions that are to be followed in drilling, construction, and sampling of wells in the roadways. The activities and requirements listed in this SOP are designed to ensure that work in roadways is accomplished in a safe manner and follows all municipal or other regulations and codes.

3.0 PERMIT

Before any work can be done in roadways or on sidewalks at CALIBRE job sites, a permit must be acquired from the city Public Works department and/or other appropriate agency. All rules and requirements listed on the permit or permits must be followed.

For example, permit contact information for the MSLC site in Modesto, CA is as follows:

Wendy Correia
Public Works Department
1010 Tenth Street
Modesto, CA 95353

Samira Marei
Caltrans, District 10
908 N. Emerald Avenue
Modesto, CA 95351

4.0 PRESAMPLING ACTIVITIES

Local police and/or local permit inspector should be notified of the time and location of the road closure/work.

Before drilling or sampling, the road lane with the wells must be closed with a barricade and a “Road Closed” sign. The area where the work will be accomplished must be cordoned off with fluorescent orange traffic cones. Placement and spacing should be in accordance with permit requirements. A flagger with a “stop/slow” paddle will direct traffic away from the job site activities.

5.0 ACTIVITIES DURING DRILLING, CONSTRUCTION, AND SAMPLING

Work activities in the roadway should be performed only during daylight hours unless special circumstances dictate otherwise. Additionally, work must be performed on Saturdays or Sundays or after 1800 hours on weekdays when daylight conditions allow in areas of high traffic.

Orange or other brightly colored safety vests should be worn by all personnel on site. During activities in the roadway, one person must observe and control traffic using a “stop/slow” paddle.

Barricade and traffic cones must be removed after activities in the roadway have been completed, well vault covers replaced and secured, and all equipment removed from the roadway.

UTILITY CLEARANCE REQUIRED PRIOR TO INTRUSIVE INVESTIGATION OR REMEDIATION ACTIVITIES
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in any intrusive investigation or remediation work (well/test boring, drilling, direct push sampling, test pit excavations or similar subsurface investigation work) at job sites will abide by the procedures outlined in this document. These procedures are designed to meet or exceed guidelines set forth by the Washington Utilities Coordinating Council (WUCC) or other similar agencies in different states.

2.0 PURPOSE

This Standard Operating Procedure (SOP) provides instructions that are to be followed for utility clearance prior to starting intrusive investigation or remediation work. Underground utility clearance (gas, water, sewer, power, communication, other) is an initial step prior to any intrusive/drilling work, all steps must be completed and documented.

3.0 STEPS FOR UTILITY CLEARANCE

Subsurface utility drawings must be requested from the client/property owner or other appropriate entity. Personnel will conduct a field inspection of the site and review available subsurface utility drawings. The field inspection must look for obvious (or potential) signs of utilities such as alignment of storm drains, location of utility meters, power lines connecting down from power poles, power lines connecting up to service connections, or saw cuts in the surface cover. Field locations will then be marked on the ground and on a suitable base map that can be provided to other parties. Detailed information on the locations must be recorded (map page from Thomas Guide, cross streets that are nearby, and distance from easily identified reference locations such as corner of a specific building).

Prior to the installation of any new wells a utility clearance will be performed and the utility clearance SOP reviewed. The utility clearance will be performed using the following steps:

1) Review available as-built drawings of utility locations,
2) Complete any client-specific review/permitting required (dig permits or other),
3) Call the Utility Notification Center (UNC) at least 48 hours prior to drilling,
4) Engage third party utility survey/clearance in moderate or high risk areas, and
5) If necessary, hand dig the first 2-5 feet.

3.1 COMPLETE ANY CLIENT-SPECIFIC UTILITY CLEARANCE PROCESSES

Various customers/clients may have existing processes in place for utility clearance on their property (such as dig permits or other). The project Work Plan needs to determine any client-specific (or locality-specific) processes/documentation required and the required steps followed and documented. The client-specific requirements may overlap with the subsequent steps listed below, however both are required if they do not overlap.

3.2 CONTACT UTILITY NOTIFICATION CENTER

The Utility Notification Center (UNC) will be notified at least 48 hours prior to initiation of subsurface investigation or remediation so that subscribers can mark their nearby utilities. The call will be documented (time, date and reference number provided). Any return information provided will be documented (typically a return phone call from various utility providers that local utilities have been marked and that specific utilities are present or not present in the area).

3.3 INDEPENDENT UTILITY SURVEY

Many project locations are on private property where limited (if any) clearance is provided by the UNC service. As appropriate based on the UNC information, as-built drawings and the general nature of development in the area, CALIBRE will retain an independent utility locator to assess the potential presence of subsurface utilities and structures in the area (beyond the as-built utility review and UNC clearance noted above). Subsurface anomalies detected during the utility survey will be marked with paint and/or flagging. The area around each location will be cleared to a minimum of 5 feet from the marked location to allow for alternate locations in case of refusal during drilling at the primary location.

3.4 MANUAL CLEARANCE IN CONGESTED AREAS

If the area indicates many nearby utilities, a manual clearance of utilities (visual inspection within the hole) must be completed. Two options (potentially more) exist for this: manually dig down with a post-hole digger or contract with a vacuum truck equipped with an air knife to clear each boring location. In most soils a post-hole digger can be used to clear to a depth of 3 to 4 feet. A vacuum truck with an air knife can clear to an approximate depth of 6- to 8-feet (potentially deeper). If a subsurface utility or other obstruction is encountered, the boring locations will be adjusted as necessary. During preparation of the site-specific health and safety plan (HASP), a determination will be made as to the depth of manual clearance required for any given boring.

4.0 DOCUMENTATION

All steps noted above are to be documented in site logbooks and retained in the project files.

Appendix C
Construction Stormwater
Pollution Prevention Plan (SWPPP)

This Short Form Construction Stormwater Pollution Prevention Plan (SWPPP) has been prepared for the project (less than 1-acre and only required an Abbreviated Drainage Plan.).

Project and Contact Information

Project Name/Description	Bordeaux Dump Removal, under MTCA	
Contact/Owner	Mike Mayberry	Phone number ___360 943 8320
Erosion Control Supervisor	Tom McKeon	Phone number ___425 643 4634
Emergency (after hour) contact	Justin Neste	Phone number ___360 981 5606

Site Information

Site address 13434 _Halo-Kuntux Lane, Littlerock WA
Parcel # 13609210400_________________________
Soil type Everett gravels and sand___________________________________

Eligibility for Abbreviated Drainage Plan/ Short Form SWPPP

Have you reviewed Volume I, Chapter 3 to confirm that your project is eligible to use the Abbreviated Drainage Plan? **YES**

Project Narrative

The Bordeaux Dump Site (Site) is located on property in a rural area of Thurston County southwest of Littlerock, Washington. The Remedial Action Plan for the Site has been prepared to meet the Model Toxics Control Act (MTCA) requirements listed in Washington Administrative Code (WAC) 173-340-400. The scope and level of detail required for this remedial design report has been tailored to the site-specific conditions and the nature and complexity of the planned cleanup. The planned remedial actions (excavation, characterization,waste designation and disposal) is a routine cleanup. The removal area is small (~ 1/5 of an acre), the work area for stock piles, access and the excavation is approximately 1/3 of an acre.

The Site soils are sand and gravel with a very high infiltration capacity. The work is required under a Consent Decree filed with Thurston County Superior Court.

Note: From October 1 thru April 30, clearing, grading, and other soil disturbing activities are not permitted unless it can be demonstrated that no silt laden water will discharge from the site and except with authorization from Thurston County Development Services.

Project Description (check all that apply)
Project Type

Subdivision, Type NA, the action is a MTCA site restoration not a development
Single Family Residential Project (building permit)   NA
Large Lot (>2.5 acres)   Yes
Grading Permit,   substantial equivalence must be met
Commercial Development   No
Land Clearing   Yes   ~1/3 acre
Conversion of native vegetation to landscaping or pasture   No
Other ___excavation of contaminated soil from dump and then backfill the area

Project Areas

Total site area	1,040,000 SF
What is the area of land disturbance?	15,000 SF (< 2% of total site area)
Area of existing impervious surfaces	0 SF
Area of new impervious surfaces	0 SF
Total area of new, replaced, and existing impervious surface after project improvements	0 SF
Area of existing native vegetation to be converted to landscaping or pasture	0 SF
Will there be stormwater runoff or sediment discharges to adjoining properties or waters of the U.S. from the site?	NO
If a grading permit is required, what is the total volume of grading?	Permit not required per RCW 70.1 05D.090, approx. 900 CY to be regraded

Existing Site Conditions

1. What existing vegetation is present on the site? (check all that apply)

Description	**EXIST? (Y/N)**	**% of Total Area**
Forest	Y	100%
Pasture/prairie grass	N	
Pavement	N	
Lawn/landscaping	N	
Brush	Y	100%
Deciduous Trees	Y	25%
Other		

2. How does surface water drainage flows across/from the site?

Sheet flow/dispersion (with runoff from site)	none
Sheet flow/dispersion (no runoff from site)	none
Infiltration – no surface drainage leaving site	Yes
Ditch/swale	none
Stream	none
Storm Sewer/catch basin or inlet	none
Other	

3. Which of the following site condition(s) or other features of note are present on the site?

Steep slopes (>20%)	None
Large depression	None
Underground tanks	None
Springs/Seeps	None
Easements	None
Existing structures	None
Existing utilities	None
Existing roadways	Halo Kuntux Lane
Waters	None

Adjacent Areas

1. Which of the following adjacent areas could be impacted by site disturbance?

Streams*	None
Lakes*	None
Wetlands*	None
Steep slopes*	None
Residential Areas	None
Roads	Halo Kuntux Lane (private) and Bordeaux Rd are the closest roads, site actions will not impact these roads
Ditches, pipes, culverts	None
Marine Bluff*	None

2. Description of downstream drainage path leading from the site to the receiving water body.
The nearest surface water bodies to the site are Mima Creek and the Black River, which are located approximately 2,000 feet to the southwest and 6,000 feet to the east of the site, respectively. Site actions are not expected to result in impacts to surface water or sediments in Mima Creek or the Black River. One intermittent creek (unnamed) flows past the property at the northeast corner (in the upslope direction. There are no observed areas of erosion or sediment deposition on site. Precipitation falling on the site infiltrates directly into the highly permeable outwash gravels that comprise the surface topography of the site. The down slope areas of the site are forested (planted Doug Firs) with a thick understory, the soil type is sand and gravel (based on numerous test pits) and the topography is a minor slope (~ 2 ft drop for 100 ft run). From the Site area, the down slope distance to Bordeaux Rd is 640 ft, a drainage ditch exists along the North side of Bordeaux Rd. The drainage ditch connects to an unnamed intermittent creek located 940 feet to the East. The unnamed intermittent creek connects to Mima Creek to the South and the final receiving water body is the Black River.

Abbreviated Erosion Control Plan

Enter estimated start/end dates for the following construction activities/milestones.
Construction Schedule Estimated Start/End Date

1. Permit : not applicable but substantive requirements must be met; (start date :yet to be determined, TBD)__________________

2. Mark clearing limits (see Figures 1 and 2) and date TBD

3. Establish construction access (see Figure 1) and date TBD

4. Install sediment controls (see Figure 2) and date TBD

5. Demolition NA

6. Grading (see Figure 2) and date TBD

7. Utility construction NA

8. Building or structure construction NA

9. Landscaping/final site stabilization (see Figure 2) and date TBD

The following elements address general water quality protection strategies for limiting site impacts, preventing erosion and sedimentation, and managing activities and pollutant sources during construction. The planned elements of the Construction SWPPP are:

Element/ Description	Requirement	Applicable BMP(s)	Confirmation
Mark Clearing Limits	Prior to beginning land-disturbing activities, mark clearing limits and delineate sensitive areas and their buffers with high visibility fence	BMP C101: Preserving Natural Vegetation BMP C102: Buffer Zones BMP C103: High Visibility Plastic Fence	Will comply
Establish Construction Access	Provide stabilized construction entrance (e.g., quarry spalls or crushed rock); clean public roads if any sediment is transported off site. If an existing driveway will be used for construction access, describe condition and show on Site Plan.	BMP C105: Stabilized Construction Entrance	Will comply
Install Sediment Controls	Provide suitable sediment control BMP to prevent sediment from leaving site.	BMP C233: Silt Fence	Will comply
Stabilize Soils	All unworked and exposed soils shall be stabilized to prevent erosion. From October 1 through April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days.	BMP C120: Temporary and Permanent Seeding BMP C123: Plastic Covering	Will comply
Protect Slopes	Design and construct cut and fill slopes to minimize erosion.	BMP C120: Temporary and Permanent Seeding BMP C130: Surface Roughening	N/A (no slopes exposed)
Protect Drain Inlets	Protect conveyance system from sediment by providing filtration of stormwater prior to entering inlets.	BMP C220: Storm Drain Inlet Protection	N/A (no drain/inlets)
Control Pollutants	Handle and dispose of construction debris in dumpster or by hauling to waste transfer station so that it does not contaminate stormwater.		Will comply
Control Dewatering	Manage dewatering water from construction activities to prevent sediment discharge from site. Manage highly turbid dewatering water separate from stormwater.		N/A (no dewatering):
Maintain BMPs	Maintain BMPs to insure continued function.		Will comply
Manage the Project	Phase the project to avoid soil disturbance from Oct. 1 through April 30 if possible. Modify BMPs if not effective or to meet changed conditions.		Will comply

Site Plan

The site plan, drawn to scale, includes the following items:

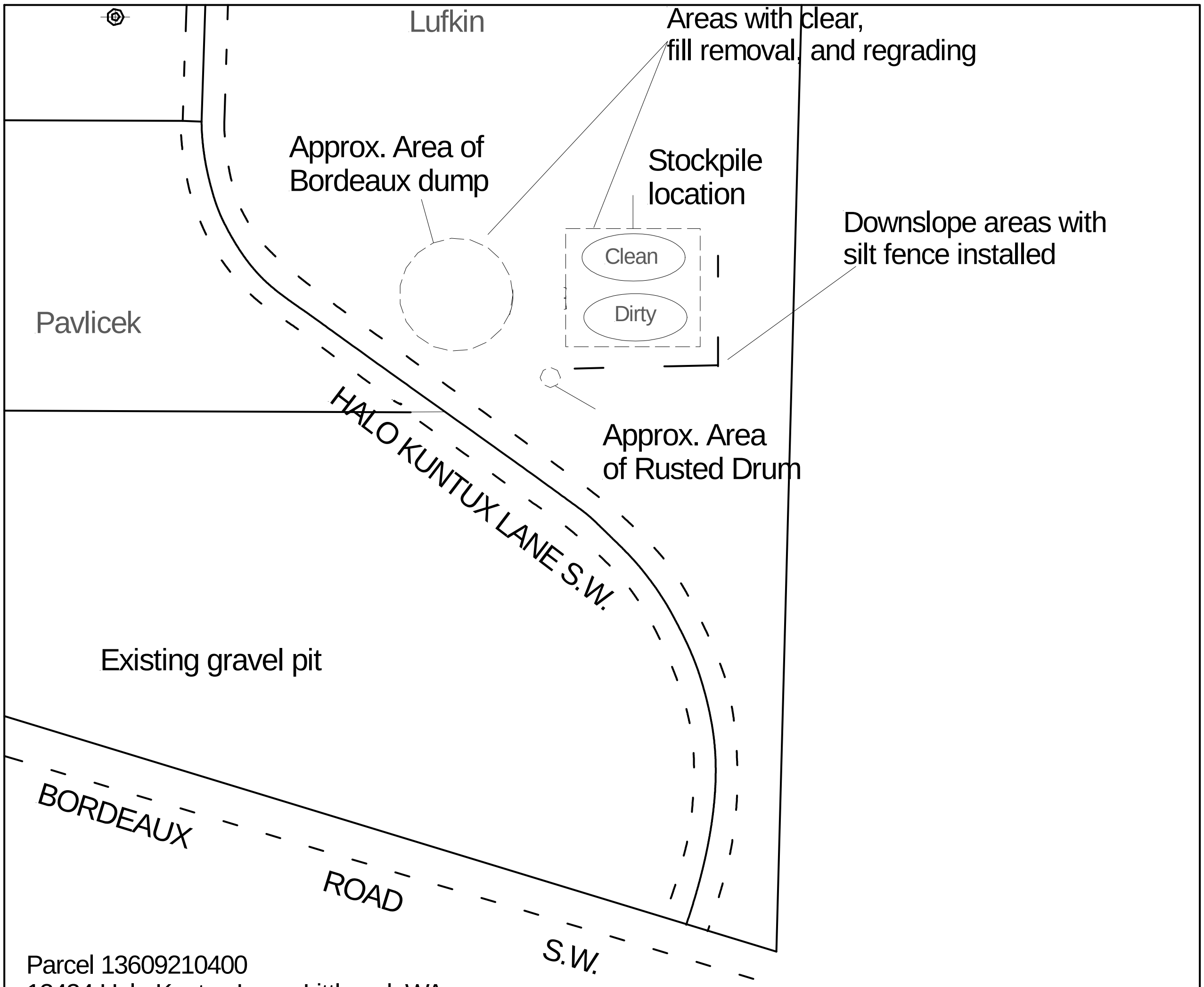
Address, Parcel Number, and Street names
North Arrow
Boundaries of existing vegetation (e.g., tree lines, grassy areas, pasture areas, fields, etc.)
Any onsite or adjacent critical areas and associated buffers (e.g., wetlands, steep slopes, streams, etc.).
Any FEMA base flood boundaries and Shoreline Management boundaries.
Existing and proposed contours.
Areas that are to be cleared and graded.
All cut and fill slopes, indicating top and bottom of slope catch lines
Existing surface water flow direction(s).
Final grade contours and indicate proposed surface water flow direction and surface water conveyance systems (e.g., pipes, catch basins, ditches, etc.).
All erosion control techniques to be used during and after construction.

Preservation of Natural Drainage Systems and Outfalls

The natural drainage patterns will be maintained, and discharges from the project site (if any) will occur at the natural location to the maximum extent practicable. Utilizing existing natural drainage paths will minimize erosion and sediment problems. Runoff discharged from the project site (if any) will be managed in a manner that does not cause a significant adverse impact to downstream receiving waters and down gradient properties.

Onsite Stormwater Management

The project will employ onsite stormwater management BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible.



Parcel 13609210400
13434 Halo Kuntux Lane, Littlerock WA
All areas have existing vegetation (e.g., planted doug firs + understory)
No onsite or adjacent critical areas and associated buffers exist.
Area is outside of FEMA base flood boundaries and Shoreline Management boundaries.
See next figure(2) for topographic contours
Areas that are to be cleared and graded as shown
See next figure (2) for existing surface water flow direction.
Erosion control techniques to be used during and after construction as shown.

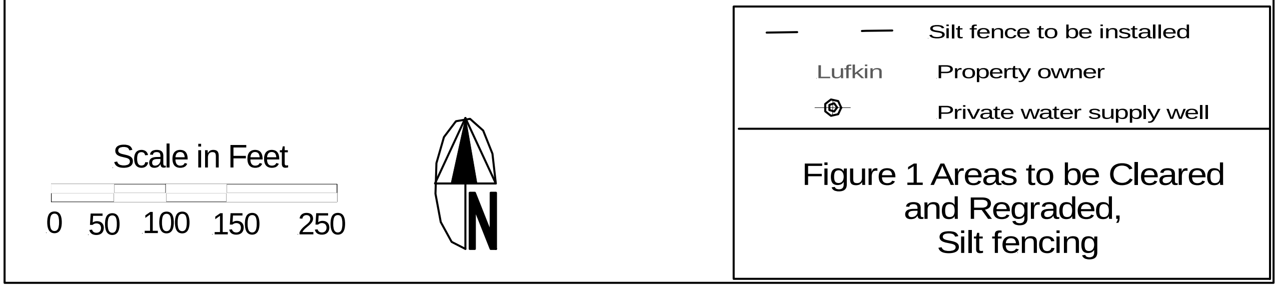
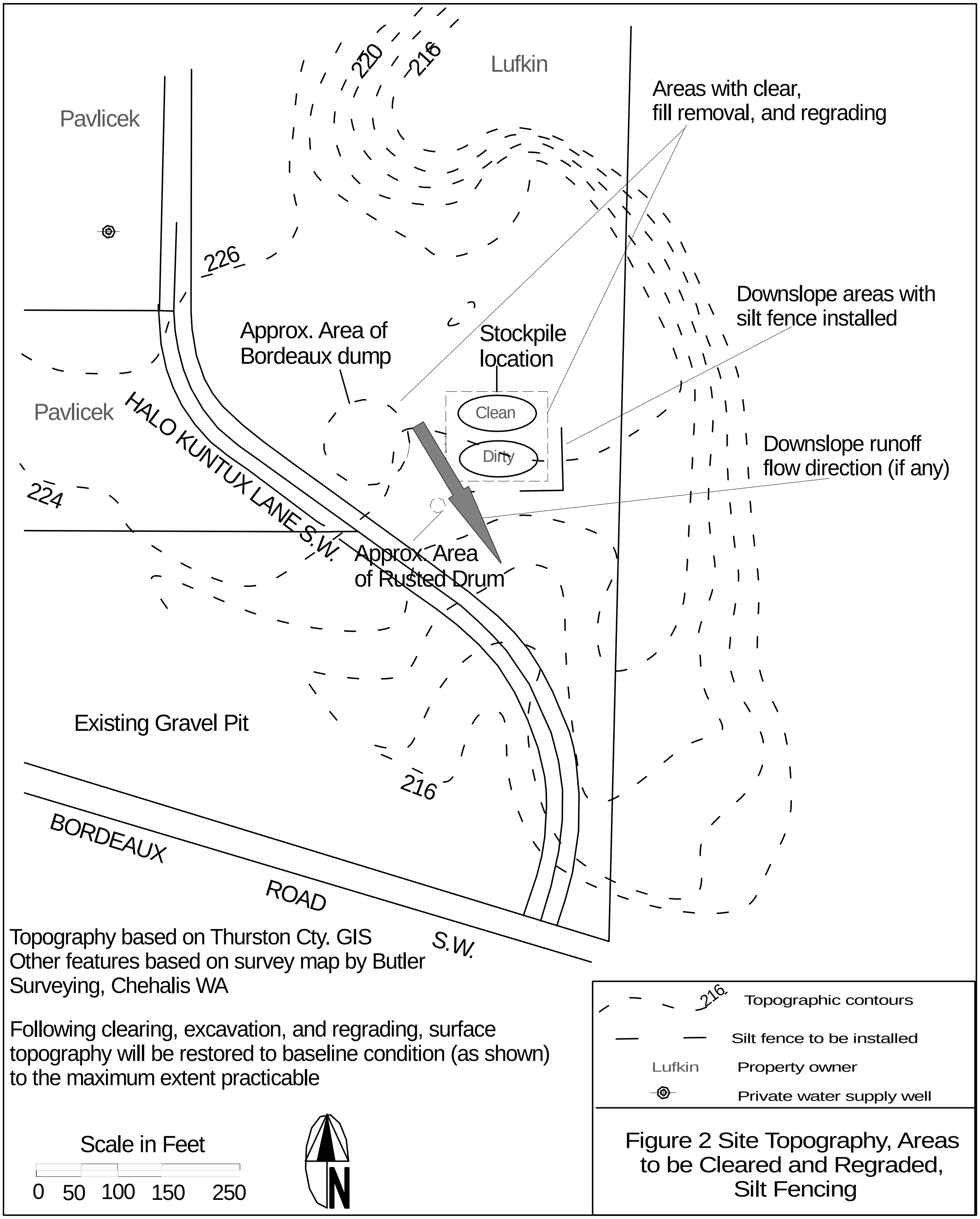


Figure 1 Areas to be Cleared and Regraded, Silt fencing



Topography based on Thurston Cty. GIS
Other features based on survey map by Butler
Surveying, Chehalis WA

Following clearing, excavation, and regrading, surface topography will be restored to baseline condition (as shown) to the maximum extent practicable

Figure 2 Site Topography, Areas to be Cleared and Regraded, Silt Fencing

Appendix D

HEALTH AND SAFETY PLAN FOR INVESTIGATION AND REMEDIATION WORK

BORDEAUX DUMP SITE
THURSTON COUNTY, WASHINGTON

Prepared by:

CALIBRE SYSTEMS, INC.

Revision 0

September 2010

TABLE OF CONTENTS

TABLES

FIGURES

LIST OF ACRONYMS

AOC	Area of Concern
APR	Air-Purifying Respirator
bgs	Below Ground Surface
CFR	Code of Federal Regulations
COPC	Chemical of Potential Concern
DCE	Dichloroethene
DQO	Data Quality Objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FID	Flame Ionization Detector
FSP	Field Sampling Plan
FTL	Field Team Leader
GIS	Geographic Information System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSO	Health and Safety Officer
IDW	Investigation Derived Waste
IDLH	Immediately Dangerous to Life and Health
ACGIH	American Conference of Governmental Industrial Hygienists
MTCA	Model Toxics Control Act
MUL	Maximum Use Level
mg/kg	milligrams/kilogram
MSDS	Material Safety Data Sheet
NGVD	National Geodetic Vertical Datum
NIOSH	National Institute for Occupational Safety and Health
PCE	Tetrachloroethene
PCP	Pentachlorophenol
PEL	Permissible Exposure Limit
PID	Photo Ionization Detector
PM	Project Manager
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
OSHA	Occupational Safety and Health Administration
SAP	Sampling and Analysis Plan
SCBA	Self-Contained Breathing Apparatus
SVOC	Semivolatile Organic Compound
TBD	To Be Determined
TCE	Trichloroethene
TCLP	Toxic Characteristic Leaching Procedure
TLV	Threshold Limit Value
TPH	Total Petroleum Hydrocarbons
VC	Vinyl Chloride
VOC	Volatile Organic Compound
WAC	Washington Administrative Code
ug/L	micrograms per liter

1.0 Health and Safety Plan

CALIBRE has developed this Health and Safety Plan (HASP) defining procedures, monitoring, action levels, and contingencies to allow employees to safely implement remedial actions, sampling, and groundwater monitoring at the Bordeaux Dump Site (Site) located near Littlerock in Thurston County, Washington (Figure 1-1). All site work will be performed in accordance with Washington Department of Ecology (Ecology) and Washington Industrial Safety and Health Act (WISHA) requirements. This plan has been prepared in accordance with CALIBRE's Corporate Health and Safety Program Plan (CALIBRE 2006).

This HASP is a required deliverable under the Cleanup Action Plan (CAP) for the Bordeaux Dump Site (Ecology 2009). Implementation of the CAP is required under the terms of Consent Decree No. 10-2-01899-6 (entered in Thurston County Superior Court on 20 August 2010). This HASP is one part of the management plans for implementation of remedial actions at the Site (focused on safety issues). The additional Site management plans provide additional details on planned implementation and Standard Operating Procedures (SOPs).

1.1 Introduction and Objectives

The Site is located in a rural area of Thurston County southwest of Littlerock and is accessed via Halo Kuntux Lane, a private gated road connecting to Bordeaux Road on the southern boundary of the property. The Site investigation area (defined in Agreed Order No. 2888) originally comprised approximately 44 acres. Based on the RI/FS results, Ecology concluded that there are two separate and discrete sites within the property. These sites are the Hytec Fiberglass Debris Landfill area, and the Bordeaux Dump (the Bordeaux Dump also includes a single burn barrel located in close proximity). This HASP is for the Bordeaux Dump area.

The protection of employees, subcontractors, and the public is the first concern during activities at remedial action sites. Health and safety concerns that require evaluation and mitigation at the Site include remedial actions involving excavations, well drilling and construction, sampling, groundwater monitoring, site security, noise, traffic, heavy equipment operation and other physical hazards.

1.2 Regulatory Requirements and Organization of this HASP

This HASP has been prepared to meet the requirements of WAC 296-843. The WISHA requirements for a preliminary site evaluation (WAC 296-843-110) have been completed as part of the approved Site RI/FS. This HASP has been prepared based on the results of the RI/FS and additional industry standard safe–work practices. The HASP includes monitoring (see Section 4) and ongoing evaluation of health and safety hazards (per the requirements of WAC 296-843-130) with specific plans/procedures to change or upgrade safety procedures as conditions warrant.

The requirement for site access controls (WAC 296-843-140) are described in Section 2.3 (as well as other sections related to specific tasks). Decontamination procedures for equipment and personnel (WAC 296-843-150) are described in Section 6.

Emergency response procedures (WAC 296-843-160) are described in Sections 1.3 and 7. Specific procedures to minimize/control the potential for employee exposure to site contaminants (WAC 296-843-170) are described in Sections 1.4, 2, 6 and 8.

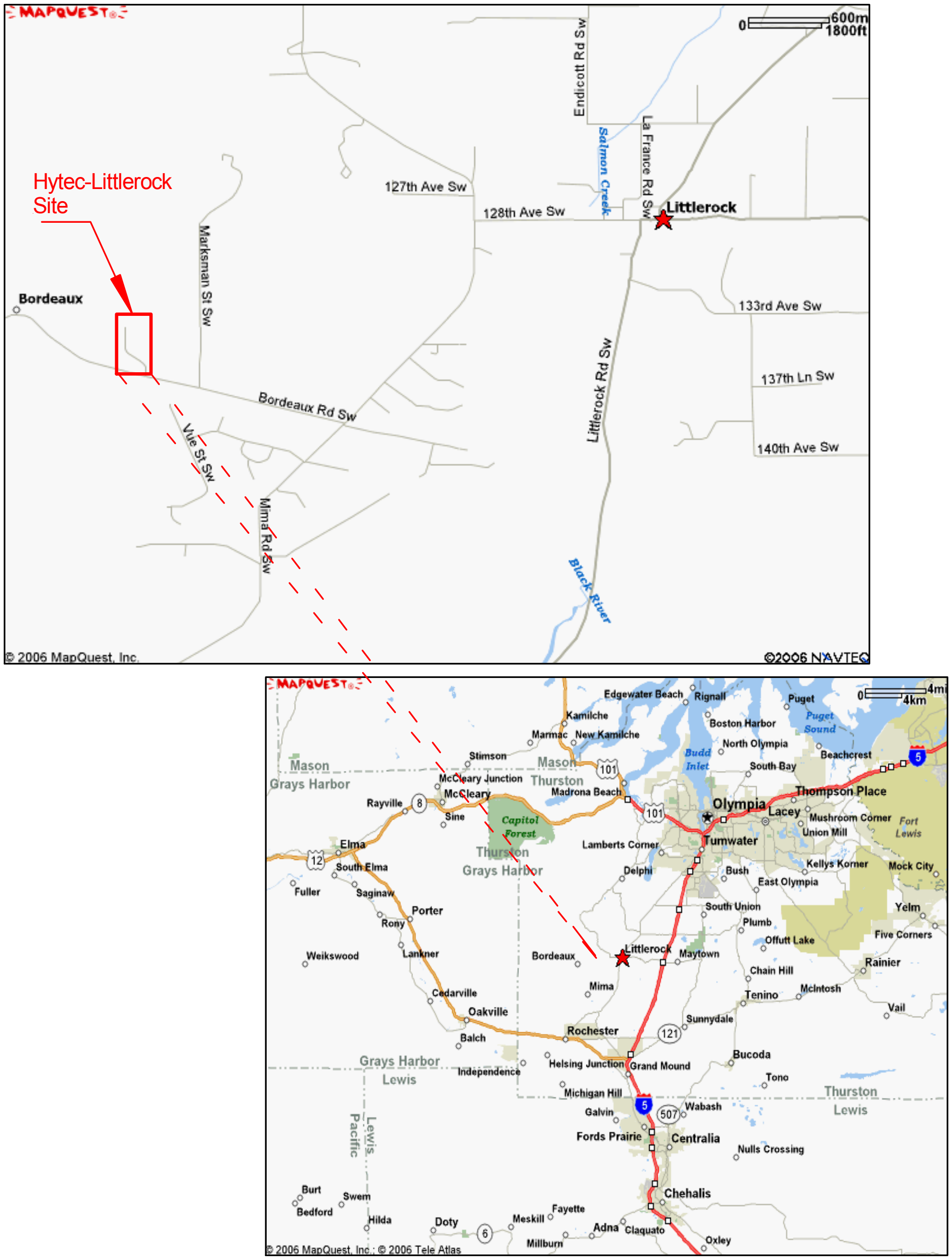


Figure 1-1. Site Vicinity and Location, Hytec-Littlerock Site

The planned use of personal protective equipment (WAC 296-843-190) is described in Section 2; this is tied directly to the prior site evaluation data and will be adjusted as necessary based on the ongoing site monitoring.

The personnel training requirements (WAC 296-843-200) are described in Section 3 which meet (or exceed) the 40-hr HAZWOPER training required under OSHA and WISHA regulations and will also include daily safety briefings. In addition, all site personnel are required to read this specific HASP, abide by all rules/guidelines/procedures described herein, and acknowledge that understanding in the signature page.

The medical surveillance requirements (WAC 296-843-210) are presented in Section 5. Regarding the WISHA requirements for recordkeeping and information access (WAC 296-843-220):

- All CALIBRE employees working on-site will be provided a copy of this HASP.
- Ecology has been provided a copy of this HASP; upon request a copy will be made available other local regulatory authorities as necessary.
- All CALIBRE subcontractors or other designated contractors shall have their own HASP which meets all WISHA requirements and shall present an appropriate plan upon request for site access. If requested, the information presented in this HASP shall be provided to CALIBRE subcontractors to assist them in preparation of the own HASP.
- CALIBRE's corporate health and safety program (CALIBRE 2006) describes procedures for medical surveillance records that meet or exceed the WISHA requirements.

This HASP is one part of the management plans to be developed for implementation of remedial actions at the Site. The focus of this HASP is identify/evaluate site hazards and establish appropriate safety procedures to implement the CAP requirements in a manner to protect workers and the surrounding community. The additional Site management plans (required as part of the CAP planning) provide additional details on planned implementation and Standard Operating Procedures (SOPs).

1.3 Health and Safety Organization and Key Personnel

The project manager (PM) will assign a field operations manager for each task. The field operations manager will be responsible for ensuring full implementation of the appropriate requirements of this plan. The field operations manager will also assign one qualified staff member as the site safety officer (SSO) for the duration of each project task involving field work on site. The SSO will have responsibility for day-to-day implementation of the safety program at that site. The corporate safety manager will provide technical assistance to the PM and SSO to comply with the health and safety requirements of this plan.

In the event that unexpected conditions that pose health and safety concerns are encountered during field operations, the SSO will suspend work on the task generating the safety concern until appropriate mitigation measures and/or modifications to the safety plan are prepared. The SSO will immediately notify the PM in the event of such a work suspension. If the SSO and the PM do not concur on either the need for the work suspension or the apparent required modification(s) to the safety plan, the SSO and the PM will immediately contact the corporate safety manager for resolution of the issue.

Subcontractors will be responsible for implementing their own safety program and providing their own protective equipment in accordance with the requirements of this plan and their own corporate health and safety program.

1.4 Hazard Assessment

The procedures for remedial actions and investigative activities including soil and groundwater sampling, direct-push sampling, well drilling and installation, are presented in the Standard Operating Procedures (SOPs).

General safety concerns and apparent hazards associated with each field task are discussed in the following sections along with standard procedures/requirements to mitigate potential hazards. These hazard discussions presented below are general in nature and in some cases include potential hazards that are highly unlikely given the site conditions and tasks planned in the CAP.

1.4.1 Slip, Trip, and Fall Hazards

Slipping, tripping, and falling in the field are common causes of injuries to personnel. These hazards can be minimized by awareness and alertness on the part of employees. All personnel should wear proper footwear (e.g., leather or rubber work boots with traction soles) to minimize slipping. The PM and SSO must ensure that employees follow good housekeeping practices to prevent development of these hazards. During site preparation, trip and fall hazards should be removed or, in the case of unmovable objects (e.g., unmovable subsurface structures, etc), the hazards should be clearly marked and identified.

1.4.2 Weather Related/Heat Stress Hazards

Common sense must prevail when assessing weather conditions. In conditions of extreme heat, the SSO must ensure that all personnel drink adequate quantities of liquids (e.g., 1-2 gallons of water per person per day) and adjust the work schedule to prevent heat stress. A specific area near the Site will be used as a shaded cool-down location for breaks. Whenever impervious clothing is in use, the threat of heat stress among field staff increases dramatically. Workers can suffer heat stress in relatively low temperatures when wearing impervious clothing. All staff must be alert for the signs of heat stress in themselves and other staff. Personnel working in impermeable protective clothing are to be monitored whenever ambient temperatures exceed 70 ^{o}F. A thermometer with disposable covers will be included in the site first aid kit. Personnel whose oral temperatures exceed 100.4 ^{o}F will discontinue working until their temperatures return to a normal range of approximately 98 ^{o}F to 100 ^{o}F.

If winter conditions create potential hazards due to inclement cold weather, site personnel will bring rain suits to the site and wear adequately layered/insulated clothing for protection. If cold conditions warrant it, personnel will be instructed to seek warm shelter from the weather (either in a heated car or in a building).

If dangerous adverse weather conditions such as electrical storms, high winds, or heavy rain create conditions which make field activities unsafe, the SSO will terminate field work until conditions improve.

1.4.3 Chemical Exposure Hazards

The primary chemical hazards known/expected to be present at the site are presented in Table 1. The chemicals listed in Table 1 represent the compounds of concern that have been detected in soil samples. Other compounds detected in soil samples have been at concentrations that are less than residential standards. The single groundwater sample from the Site met drinking water standards for VOCs and metals, trace levels of PAHs detected (< 0.5 ug/L and J flagged) slightly exceeded a drinking water standard; these groundwater concentrations are not an issue of concern for Health and Safety in for the remedial action. For relative comparison, the data in Table 1 includes the MTCA standards for soil contact in residential and industrial settings; none of the measured concentrations exceed the MTCA standards for an industrial setting.

All existing characterization/sampling data represent environmental media; concentrations of a material in a container (a drum or some process waste) could potentially be higher than values listed in Table 1 and other compounds may be present. The single drum found in the area is a burn barrel used for burning trash.

Personnel involved in field operations may encounter any or all of these types of chemicals (and potentially others) simultaneously. All personnel need to recognize potential chemical hazard conditions and take appropriate precautions. Those precautions include respiratory protection, dermal protection, and control of equipment contamination. This discussion is not intended to be a detailed statement of chemical hazard protection, but rather, a presentation of the types of situations where chemical hazards may be encountered. Field personnel should not work in potential chemical hazard areas unless they are fully trained in evaluation of chemical hazards and appropriate protective measures, and are adequately equipped with personal protective equipment.

All field personnel must have a workable knowledge of the levels of hazard associated with various concentrations of chemicals to which exposure is possible. These benchmark concentrations include:

- Immediately Dangerous to Life and Health (IDLH) -- exposure of unprotected workers to IDLH concentrations will result in death or serious, permanent, injury;
- Permissible Exposure Limit (PEL) and Threshold Limit Value (TLV) (published by the National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH), respectively) -- in general, PELs and TLVs are time weighted average concentrations to which a worker may be exposed for 8 hours per day, 40 hours per week, and experience no detrimental health effects;
- Action Level -- the concentration of the chemical(s) of concern, which, when encountered, results in some specified, pre-determined response from field personnel. Such a response may include use of engineered controls to reduce exposure and/or use of air-purifying respirators (APRs), exchanging APRs for self-contained breathing apparatus (SCBA), or evacuation of the area. Action levels and appropriate responses are specified in the site-specific information section of this plan; and
- Maximum Use Level (MUL) -- the maximum concentration of a specific chemical for which a specific respiratory protection device will provide adequate worker protection.

For specific chemical products used during sampling (e.g., sample preservatives, acids), personnel must obtain and review the appropriate material safety data sheets (MSDS) for those products.

1.4.4 Site Preparation Hazards

Hazards associated with site preparation activities are primarily physical hazards. A summary of common site preparation hazards for remedial actions, well drilling, groundwater monitoring, and sampling are summarized in Table 2.

1.4.5 Well Construction and Direct-Push Hazards

Well drilling, construction, and direct-push borings will be performed by a drilling subcontractor licensed to perform such work in the State of Washington. Hazards common to well drilling and construction and direct-push sampling can be found in Table 2. Drilling and boring operations will require area controls in the vicinity of the drill rig to keep non-essential personnel at a safe distance (traffic cones and flagging).

1.4.6 Heavy Equipment Operation

Excavators, loaders, dump trucks, truck-mounted drilling equipment, backhoes, forklifts, trucks, and other equipment are the expected types of heavy equipment that will be used during field activities. Operation of heavy equipment can result in a substantial hazard to workers. Access controls will be used to keep any non-essential personnel at a safe distance from all work areas with equipment operation.

The following procedures will be followed when heavy equipment is in use:

1. Use common sense. Do not assume that the equipment operator can keep track of your whereabouts. Never walk directly in back of, or to the side of, heavy equipment without the operator's knowledge. Visual contact with operator is not sufficient recognition for personnel to move into an area near or around the operating equipment; a positive verbal OK or pre-designated hand signal (as OK) shall be the minimum recognition.
2. Maintain visual contact of moving equipment at all times.
3. Establish hand signal communication when verbal communication is difficult.
4. All heavy equipment must have backup alarms.
5. All equipment must be shut down during refueling.
6. Use chains, hoist, straps, and any other equipment to safely aid in moving heavy materials.
7. Never use a piece of equipment unless you are familiar with its operation. This applies to heavy as well as light equipment (i.e., steam cleaners, hand tools, chain saws, etc.).
8. Be sure that no underground or overhead power lines, sewer lines, gas lines, or telephone lines, will present a hazard in the work area.
9. Restrict all non-essential people and vehicles out of the work area.
10. Prohibit loose-fitting clothing or loose long hair around moving machinery, this is particularly important around rotating equipments/machinery (saws, drills, PTOs, etc.)
11. Instruct equipment operators to immediately report any abnormalities such as equipment failures, unusual odors, vibrations, etc.
12. Implement an ongoing maintenance program for all tools and equipment. Inspect all tools and moving equipment regularly to ensure that parts are secured and intact. Promptly repair or replace any defective items.
13. Store tools in clean, secure areas so that they will not be damaged, lost or stolen.
14. When an equipment operator must negotiate in tight quarters, provide a second person to ensure adequate clearance.
15. All heavy equipment must properly leveled and supported prior to use.
16. Heavy equipment and trucks will be operated in specific site control zones and marked traffic lanes (as appropriate).

1.4.7 Excavation Safety

Pre-job planning is a critical step to implementing accident-free excavations and trenching. The following concerns must be addressed by a qualified person in planning the excavation.

1. Contact the appropriate utility clearance (800-424-5555) to locate underground lines at least 3 days prior to starting excavations. If the site is in a developed area where other private utilities are expected or possible, review utility drawings and additionally hire a private utility-locate service.
2. Evaluate soil conditions and select and construct appropriate protective systems in accordance with OSHA requirements: Protective systems are required for entry if a trench is 5 ft or deeper. If the trench is less than 5 ft but is hazardous due to soil or the nature of the trench, then protective systems are required. Determine proximity to structures that could affect choice of protective systems. For example, ensure roads, sidewalks, or buildings are not too close to allow the use of a trench box or adequate sloping.
   Appropriate protective systems to prevent a cave-in may include:
      - trench boxes
      - shoring
      - benching of trench sides
      - sloping of trench side

   When benching a side of a trench, the height of the lower bench shall not be more than the lesser of five feet or width of the trench measured at the bottom. Trench boxes must extend eighteen inches above the top of the trench if the trench is to be sloped above the box. The base of a trench box must be not more than 2 feet above the trench floor.
   The vertical height between the floor of the trench and the toe of a ramp used for trench access shall not exceed thirty inches, the degree of angle of a ramp used for trench access may not be more than 45 degrees.
3. An excavation more than four feet in depth and occupied by employees shall have either a ladder or a ramp. Provide safe ingress/egress to any excavation. If the excavation is 4 ft or greater, ensure one or more egress routes (ladders or ramps) are within 25 ft of any worker entering an excavation. Ladders must extend at least three feet above the top of the trench. Ramps, runways, etc to be used by employees for trenches shall be capable of supporting not less than three times the imposed load.
4. Inspect the site daily at the start of each shift, following a rainstorm, or after any other event which may change or increase hazards.
5. Test for low oxygen, and hazardous gases and vapors, especially when internal combustion engine-driven equipment is running, or the soil has been contaminated by leaking lines or storage tanks. All fuel-powered equipment produces carbon monoxide and adequate ventilation is required. Provide appropriate respiratory protection when necessary (for possible gases/vapors) and suitable ventilation/supplied air for possible low oxygen environments.
6. Provide appropriate protections if water accumulation is a problem. Water flow and accumulation must be inspected and must be controlled.
7. Keep excavations open the minimum amount of time needed to complete operations.
8. For equipment use, a minimum of 15 feet in clearance shall be maintained from energized overhead electrical lines (including excavators, dump trucks, materials, personnel, and ladders).
9. Plan for traffic control when necessary.
10. An open cut into a roadway shall be provided with a barricade on all sides.
11. Barricades must be a minimum of 3 feet in height.

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1.4.8 Emergency Response Procedures

The emergency response procedures describe required actions to deal with unforeseen conditions or accidents that may happen as a result of site work. The possible hazards associated with each field task are summarized previously (along with planned mitigation measures to prevent accidents). The planned emergency response procedures are detailed in a Contingency Plan Standard Operating Procedure. The general details are as follows. The simplest emergency response is identifying an unforeseen condition that requires work to stopped and development of a revised implementation plan that addresses the newly identified hazard. Emergency response procedures are also to be implemented in the event of an accident. The two general types of plausible accidents include some type of physical injury or some type of a chemical spill or release. Minor injuries (cuts, scrapes, and bruises) may be dealt with using the on-site first aid kit. Procedures for dealing with higher level injuries are described Section 7 and may include personnel transport to a hospital and or an emergency call to 911.

In the event of a chemical spill, or release or fire, the first consideration is; Does the release result in changes to exposure conditions in the immediate work area (e.g., a visible gas cloud, an unidentified odor, high PID readings or low O_2 readings) and has personnel exposure occurred? All of these specific examples deal primarily with some type of vapor release. In this event, personnel are to evacuate the area to the edge of an exclusion zone (or upwind if required), a head count is to be completed, and monitoring at the edge of the exclusion zone continued. The second consideration is; Could the release result in exposure to neighbors in the immediate vicinity? If this second consideration is plausible, call 911 immediately and contact the neighbors to escort them in an upwind direction. This second consideration seems highly unlikely given the present site knowledge. However, the risk of fire is always present with equipment operation and re-fueling operations will occur regularly. Procedures for dealing with potential chemical exposures to personnel are described in Section 7. Procedures for dealing with fire are described in Section 7 (use on-site equipment for small fires that may be readily contained or call 911).

If a spill or release does not result in changes to exposure conditions in the immediate work area (as demonstrated by PID readings, O_2 readings, LEL readings and colorimetric tubes), response actions with a spill containment kit may be appropriate (use of absorbent media, excavation of affected soil and containment on plastic). These specific examples may apply to some types of liquids and/or solids. The decision to implement a spill response action may only be made after the SSO has completed sufficient field readings to approve its' safe implementation.

2.0 Procedures/Practices to Limit Exposure Potential

The following procedures and practices should be used for all field activities at the site including excavations, drilling, well construction, direct-push sampling, groundwater monitoring, and other field activities as appropriate.

2.1 Engineering Controls

The PM and SSO will evaluate the need for engineered controls to reduce potential exposures to airborne contaminants in initial planning. The SSO will continue to evaluate the need for engineered controls before initiating upgraded respiratory protection programs and will notify the PM. Engineered controls can be as simple as setting up a drill rig or conducting soil or groundwater sampling so that personnel are working in the upwind side. Alternative engineered controls include the use of enhanced ventilation at a work site (e.g., use of a large industrial fan) to reduce contaminant concentration by dilution, where appropriate. Enhanced ventilation is particularly useful around drill rigs and bore holes and may also have merit in certain excavations. Shielding may be used in some instances to protect workers from contaminants. Shielding can work by physically deflecting the flowpath of contaminants away from workers. Exposure potential can also be reduced by drumming, or otherwise containerizing contaminated drill cuttings (or other materials) or placing drums in overpack containers.

When drilling in areas of known or suspected high levels of subsurface contamination, the SSO will ensure that the drillers have sufficient bentonite plug material available to securely plug the bore hole if required.

2.2 Contamination Avoidance

Many potential chemical exposures can be prevented by individual employees through contamination avoidance. The following practices will minimize the potential for casual exposure:

- No unauthorized personnel will be allowed to enter areas of known or suspected environmental contamination. All personnel (authorized) shall maintain a safe distance from operations handling contaminated materials.
- All personnel will practice good personal hygiene during field operations. This includes washing face and hands after leaving any work area and before eating. Dirty and potentially contaminated work clothing will be decontaminated at the site and cleaned before re-use.
- No personnel will be allowed to eat, chew gum or tobacco, or smoke in any area of known or suspected contamination.
- All personnel and equipment will be decontaminated when leaving any area of known or suspected contamination.

2.3 Personal Protective Equipment

All personnel will use appropriate personal protective equipment (PPE) to prevent injury and chemical exposure when working in areas of known or suspected contamination. Maintaining a specific inventory of versatile equipment at the site will enhance employee safety. The following equipment will be available on-site for use when appropriate:

1. Approved Hard-Hat;
2. Safety Glasses (with side shields) or Goggles;
3. Approved Hearing Protection (e.g., muffs or ear plugs);
4. Neoprene, Nitrile/Latex, and/or Leather Gloves;
5. Steel Toe Work Boots;
6. High Visibility Coveralls, Jacket, or Vest; and
7. Impermeable Coveralls (e.g. Tyvek or Saranex)

The selection of PPE requirements will depend on the task and chemical hazards present (see Table 3 and Section 8 for action levels). This equipment will include both enhanced dermal protection and respiratory protection that may be upgraded by the SSO at any time.

2.3.1 Dermal Protection

Dermal protection (i.e., protection of the skin) will be provided by using appropriate protective clothing. General site construction work will be performed wearing work boots and leather gloves. This level of PPE is appropriate where no splash hazards exist and potential exposures are limited to concentrations of chemicals below established exposure limits.

When working with highly-contaminated soils or water, personnel will wear impermeable coveralls, impermeable gloves (neoprene or nitrile/latex), and impermeable footwear. The garment joints at wrist and ankle will be sealed to the gloves and footwear with tape. For work with most soils and dilute aqueous solutions, the recommended garment is Saranex coated Tyvek. This material is available in a wide variety of sizes and configurations. Recommended gloves are inner gloves of thin nitrile or latex rubber, with outer gloves of neoprene rubber. These materials are appropriate for most contaminated soils and dilute aqueous solutions. Required footwear is steel-toed boots made of either neoprene rubber or PVC. Both of these materials are highly resistant to most contaminants. The PM and SSO will assess the compatibility of these recommended materials with site contaminants and determine the need for modifications in PPE requirements.

Employees must be aware of, and alert for, the signs of heat stress that may be associated with the use of any impermeable garment. These garments reduce the body's natural ability to dissipate excess body heat and un-monitored exertion when wearing them can result in severe heat stress.

If splash hazards exist, additional splash protection may be required. This may include full-face shields over goggles or respirators, and the use of special chemical splash suits.

2.3.2 Respiratory Protection

Project staff will initiate most project tasks using Level D respiratory protection (i.e., no respiratory protection equipment required with routine air monitoring). Use of Level C protection (i.e., air purifying respirators) may be required for specific tasks dealing with drum excavations and that decision will be based on monitoring and/or other factors found when drums are inspected.. Field personnel will keep APRs at the work site for use if action levels are exceeded and upgrade to Level C is required. Level A or B protection (i.e., self-contained or supplied air breathing apparatus) will not be present on-site. If such equipment is required based on site monitoring, action levels or other considerations, on-site personnel will stop work (or stop the task causing the condition) and develop a revised plan for project implementation.

Appropriate respiratory protection will be used by employees whenever the concentration of airborne chemicals in the workers' breathing zone exceeds the action levels defined in Table 3. Workers will keep to the upwind side of possible airborne contaminant sources whenever possible. A flag or ribbon will be posted at each work area to indicate the wind direction.

When APRs are required, employees will use either MSA full-face Ultra-Twin or Advantage 1000 respirators equipped with appropriate approved cartridges. If an employee cannot be fitted in either of these APRs, then they may wear another comparable respirator that provides proper fit. Half mask APRs will not be used unless specific site conditions pose increased hazards if full-face APRs are used (e.g., under some weather conditions, fogging of APR face pieces may occur, causing reduced visibility and increased risk of injury). Under such conditions, half-face APRs may be used if they provide adequate protection and can be used with face shields to provide full dermal coverage. All personnel using APRs must be fit tested prior to using respiratory protection equipment and have clearance by a medical professional to wear a respirator.

2.3.3 Area Access Controls

Whenever specific dangerous activities are occurring as part of the planned work, access controls will be used to demarcate areas where only essential project personnel may enter. When drill rigs are operating the controlled access area will be an area around the rig with a radius at least as high as the mast on the drill rig (where feasible). The controlled access area will be marked with cones and a high visibility tape. Site personnel will also be responsible to notify any other workers in the immediate vicinity of the controlled access area. Passage into and out of the controlled access area will be through a zone with appropriate decontamination facilities as necessary.

3.0 Personnel and Subcontractor Training

All personnel assigned environmental restoration projects at the site shall have completed, at a minimum, the appropriate formal training courses and maintained the appropriate refresher training. The Occupational Safety and Health Administration (OSHA) has determined that activities related to investigation and restoration activities at potential and known hazardous waste sites (e.g., CERCLA or Superfund sites), fall under the scope of 29 CFR 1910.120. That standard requires 40 hours of initial training of the Hazardous Waste Operations and Emergency Response (HAZWOPER) and 8 hours annual refresher training, plus three days supervised on-site training for workers. An additional 8 hours of training are required for supervisors. The WISHA requirements established under WAC 296-843 are similar although there are variable levels of training required depending on the type and frequency of on-site work and the use of respirators. The Bordeaux Dump Site is not a CERCLA or a National Priorities List site. However, the intent of the regulations and the Site conditions (regulated as a MTCA site) are sufficiently similar that following the federal regulations is appropriate and this will meet or exceed the WISHA requirements. All subcontractor personnel will have completed the minimum training in compliance with 29 CFR 1910.120, as appropriate, in addition to any requirements specified by other regulations, or this plan.

Daily safety meetings, detailing specific hazards of the work to be performed and safety precautions and procedures for each project task, will be conducted by the SSO at the beginning of each shift and will be documented in writing.

The SSO will record the credentials of all on-site personnel. In order to be qualified for duty in exclusion zones or any other area where there is a potential for exposure to chemical contaminants, the following items must be current (i.e., conducted within the last 12 months preceding the expected date of completion of field operations):

- 8-Hour Annual Refresher Training (if 40-hour training was received more than 12 months prior);
- Respirator Fit Test and medical clearance (if APRs are used).

Copies of all training, APR Fit testing, and medical clearance will be presented by personnel and kept on file.

4.0 Site Monitoring

Air monitoring will be an essential element of site safety for all field activities where there exists potential for exposure to airborne contaminants. The specific air monitoring requirements that are appropriate will depend on the conditions encountered and the type of work to be completed. A sample checklist for activity specific monitoring requirements is listed in Section 8. A summary of the action levels associated with different monitoring parameters is presented in Table 3. The PM and SSO will confirm that the appropriate required air monitoring instruments are identified in the safety plan and are made available and used properly during site operations. All air monitoring instruments will be operated in accordance with manufacturer's operating instructions. All monitoring instruments used during site monitoring will be intrinsically safe. All air monitoring instruments will be calibrated daily and tested periodically for positive response.

For specific chemicals, three action levels will be defined, based on the need for enhanced respiratory protection. The initial action level will be 20% of the exposure limit measured in the breathing zone of the site workers. At the initial action level, the on-site personnel will take the appropriate response with enhanced personal protective equipment or modified work practices (e.g., engineered controls such as enhanced ventilation) to reduce potential exposure levels.

The second action level for respiratory protection will be specified at 50% of the NIOSH PEL, measured in the site workers' breathing zone for a minimum period of 15 minutes. At this action level (also known as the Level C action level), the SSO will assess the practicality of enhancing engineered controls (e.g., ventilation) to reduce concentrations. If the enhanced engineering controls cannot reduce exposure below 50% of the REL (in the breathing zone) then respiratory protection will be upgraded to level C (use of APRs).

The third action level for respiratory protection will be specified at 50% of the NIOSH limit (a MUL considering the PEL and a 10 times APF with the use of level C APRs) measured in the site workers' breathing zone for a minimum period of 15 minutes). At this action level (also known as the Level B action level), the SSO will assess the practicality of enhancing engineered controls (e.g., ventilation) to reduce concentrations. If the enhanced engineering controls cannot reduce exposure below 50% of the NIOSH limit (the MUL considering the 10 times APF, in the breathing zone), that specific work task will be stopped and this plan will be modified if it is determined that supplied air or self-contained breathing apparatus is required for specific tasks/work areas.

At any time during site operations when any action level is exceeded, the SSO will immediately implement additional air monitoring at the work area, or exclusion zone boundary to ensure that the initial, or Level D, action level is not exceeded at the boundary. If the Level D action level is exceeded at the boundary of the exclusion zone, the SSO will enlarge the exclusion zone adequately to prevent exposure of unprotected individuals.

Routine air monitoring of the workers' breathing zone will be conducted periodically by the SSO. If strong odors or irritation of eyes or mucous membranes are noted by any personnel, work will be suspended and monitoring performed immediately to ensure the proper level of protection. If deemed necessary, additional monitoring will be conducted during drilling when sample cores or sampling devices are tripped from the boring.

5.0 Medical Surveillance

All personnel working on-site in areas where chemical exposure could occur shall be part of a medical surveillance program if they fall under any of the requirements listed in WAC 296-843-21005. All personnel working on-site who may be required to use a respirator shall have a respirator medical evaluation.

Workers will be instructed to report any illness or physical discomfort to the SSO, who will evaluate the situation and take appropriate action. Physiological reactions that are plausibly caused by site contaminants (characterized by dizziness and nausea) is grounds to remove the affected worker from the work site and have the worker undergo medical surveillance and clearance by a physician. Air monitoring of the site will be performed and documented if an air-borne exposure episode occurs, and respiratory protective equipment will be upgraded as necessary.

Another potential medical hazard is heat stroke in hot weather and frostbite in cold weather. Workers should be aware of the symptoms of the on-set of both of these ailments. A shaded area and drinking water will be made available at the site during hot weather, and a heating hut or similar provisions should be nearby in the winter. All medical episodes will be recorded.

6.0 Decontamination and Disposal Procedures

6.1 Contamination Prevention

One of the most important aspects of decontamination is the prevention of contamination. Good prevention measures should minimize worker exposure and also help preclude cross-contamination when sampling. Procedures for contamination avoidance include the following:

Do not walk through areas of obvious or known contamination;
Do not handle or touch contaminated materials directly;
Make sure all personal protective equipment has no cuts or tears prior to donning;

- Fasten all closures on suits, covering with tape, if necessary;
- Take particular care to protect any skin injuries;
- Stay upwind of airborne contaminants; and
- Do not carry cigarettes, gum, etc. into contaminated areas.

Equipment and Samples

- If feasible, take care to limit the amount of contamination that comes in contact with heavy equipment and vehicles;
- If contaminated tools are to be placed on non-contaminated equipment/vehicles for transport to the decontamination pad, use plastic to keep the equipment clean;
- Bag sample containers prior to emplacement of sample material;
- When non contaminated tools, instruments, or sampling supplies are to be used in a contaminated area, use plastic to keep the equipment clean.

The PM and SSO will specify the decontamination requirements for personnel and equipment to be implemented for each task. The exclusion zone and the work site in general must include an established support area and personnel and equipment decontamination areas. The minimum decontamination that will be required for all field operations will consist of Level D decontamination as described below.

6.2 Decontamination

The majority of field activities and sampling are expected to be conducted using Level D PPE. Decontamination for activities requiring Level D protection will consist of the following (note that not all of the equipment described below must be used for Level D PPE):

- Remove gloves and, if soiled dispose of gloves, otherwise wash and rinse;
- Remove, wash, and rinse hard hat (if soiled);
- Remove, wash, and rinse goggles;
- Remove safety boots or shoes; and
- Wash and rinse face and hands.

If an upgrade to Level C is required, more extensive decontamination will also be required as follows:

Step/ Station Number	Operation	Procedure
1	Equipment Drop	Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, a cool down station may be set up within this area.
2	Outer Garment, Boots, and Gloves Wash and Rinse	Scrub outer boots, outer gloves, and splash suit with decontamination solution or detergent water. Rinse off with water.
3	Outer Boot and Glove Removal	Remove outer boots and gloves. Deposit in container with plastic liner.
4	Canister or Mask Change	If worker leaves exclusion zone to change canister or mask, this is the last step in the decontamination procedure. Worker's canister or mask is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
5	Boot, Glove, and Outer Garment Removal	Boots, chemical-resistant splash suit, and inner gloves are removed and deposited in separate containers lined with plastic.
6	Face Piece Removal	Face piece is removed. Avoid touching face piece with fingers. Face piece deposited on plastic sheet.
7	Field Wash	Hands and face are thoroughly washed. Shower as soon as possible.

Personnel decontamination corridors will be established at each exclusion zone. All personnel will follow appropriate decon procedures when leaving the exclusion zone.

Vehicle and large equipment decontamination generally requires construction of a temporary decontamination station. A simple decon area may be built of heavy-gauge polyethylene sheeting over a solid base surrounded by wood beams to form a containment area. After equipment cleaning, decontamination solutions from the pad will be pumped into drums at the side of the pad. Equipment and vehicle decontamination generally consists of pressure washing with detergent solution followed by water rinse.

6.3 Disposal

The PM will make arrangements for proper disposal of all waste materials generated at the site during all field activities. CALIBRE’s policy is that the disposal of any hazardous wastes generated during remedial actions at a client's facility are the responsibility of the client. The anticipated categories of waste may be generated during CAP implementation include:

a) non-regulated solid waste;
b) undesignated solid waste that may be regulated;
c) designated regulated waste; and

d) wash water from decon procedures.

CALIBRE personnel will segregate all non-regulated solid waste materials from regulated or potentially-regulated materials. Field personnel will maintain clearly-identified containers or stockpiles for each of the three categories of waste. The PM will ensure that drums and other containers of regulated or potentially-regulated materials are clearly labeled with the contents. The PM will ensure that all containers of potentially-regulated materials are sampled and analyzed prior to determination of their designation as regulated or non-regulated.

Non-regulated solid wastes will be disposed properly by packaging them in garbage bags and transporting to the nearest solid waste disposal facility. Specific requirements for used and decontaminated disposable personal protective equipment (e.g., coveralls and gloves) are to cut the items into pieces (e.g., cut off arms and legs of coveralls and bisect the torsos, cut used rubber gloves in half) to prevent scavenging and re-use, bag the items, and dispose as solid waste. Note: heavily contaminated personal protective equipment may require sampling and analysis prior to designation.

All purge water and/or decontamination solutions will be containerized and sampled prior to disposal if contaminants are known or suspected to be present in the solutions. Sampling and analysis will be conducted to determine if the solutions contain regulated contaminants that would cause the solutions to be regulated as hazardous waste.

No regulated wastes will be disposed on site by burial, burning, or discharge. Excess soil from excavations that is proven to be non regulated (based on sampling that meets residential standards) may be used as on-site fill. Some slash from clear and grub operations may be left on-site or potentially burned on-site (pending approval from Thurston County).

7.0 Emergency Procedures and Contacts

The following general emergency procedures are applicable to almost every activity:

In the event of personnel exposure to hazardous materials, all work in the area will stop immediately, and affected personnel will assemble at the support area. Procedures for specific types of exposure are as follows:

- Skin Contact -- Flush the area with copious quantities of cold water for at least 15 minutes. Do not let contamination spread to other personnel. Seek medical attention. If injuries are severe, summon an ambulance.
- Eye Contact-- Wash/rinse affected area for at least 15 minutes. An emergency eye wash system will be present on site. Seek medical attention.
- Inhalation -- Remove the person from further exposure. Summon an ambulance, contact the hospital, and be prepared to provide respiratory support if the person has difficulty breathing.
- Ingestion -- Dilute the material with large quantities of water. Summon an ambulance and contact the hospital or poison control center immediately for further instructions.

In the event of personal injury at the site, all work will stop and first aid will be rendered as needed. If necessary, call an ambulance using the local ambulance number listed in the emergency information section of the plan. In the event of potential or actual fire or explosion, or actual uncontrolled release of hazardous materials, all work will stop and all personnel will evacuate the site to the upwind direction. Call the local fire department and/or HazMat team and notify other personnel at the site and neighboring locations. If a fire is small and appears to be readily contained, personnel should use the on-site fire-fighting equipment (e.g., fire extinguishers, shovels, or water, as appropriate) to extinguish the fire. If the fire is extensive, or involves structures or vehicles, personnel will evacuate the site, warning the occupants of neighboring facilities, and await the arrival of fire department personnel. Site workers will provide fire department personnel with as much information regarding the fire as possible. Critical information required by the fire department upon arrival will include the nature, location, and type of any hazardous or flammable materials present and any other hazards present.

8.0 Site-Specific Health and Safety Forms

8.1 Emergency Contacts

These emergency contacts will be posted in vehicles likely to be used during an emergency.

911 Available in this area for police or fire emergencies.	
Hospital:	Providence St. Peter Hospital
Telephone #:	(360) 491-9480 1-888-492-9480 (toll free)
Address:	413 Lilly Road NE Olympia, WA 98506-5166
Facility Address:	13435 S.W. Halo Kuntux Lane Littlerock, WA (Southwest of Littlerock, North of Bordeaux Rd)
Facility Telephone #:	None
Poison Center Telephone #:	800-732-6985 or 800-962-1253
Fire, Police, Ambulance	911
National Response Center (NRC) Telephone #:	(800) 424-8802
Program Manager Project Manager	Gaynor Dawson (509) 521-5430 Tom McKeon (425) 241-8449
CALIBRE Health and Safety Manager	John Frerich (425) 226-6435
CALIBRE Site Health and Safety Officer	Grant Dawson (509) 430-6752

Utilities: (800) 424-5555

In case of emergency, also notify: CALIBRE Health and Safety Manager, John Frerich, (425) 226-6435.

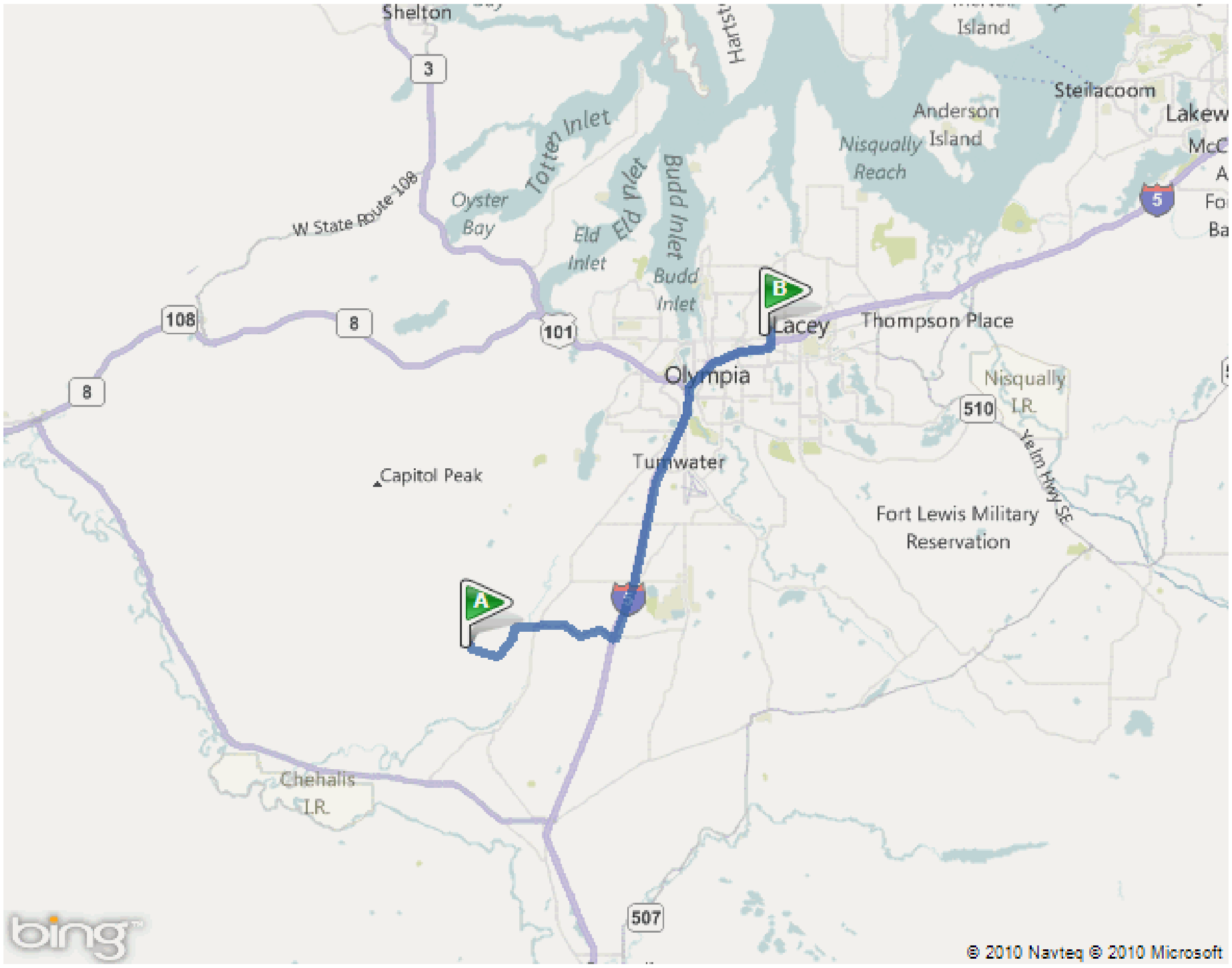
8.2 Directions to Hospital:

1. Depart Halo Kuntux Ln SW toward Bordeaux Rd SW	0.3 mi
2. Turn left onto Bordeaux Rd SW	0.9 mi
3. Bear left onto Mima Rd SW	1.3 mi
4. Turn right onto 128th Ave SW	3.6 mi
5. Turn left onto SR-121 / Maytown Rd SW	0.2 mi
6. Take ramp right for I-5 North toward Olympia	12.1 mi
7. At exit 107, take ramp right toward Pacific Ave.	0.5 mi
8. Bear right onto Pacific Ave SE	0.3 mi
9. Turn left onto Lilly Rd SE	0.4 mi
10. From Lilly Rd, turn left into the main hospital entrance	

Providence St Peter Hospital, Phone: 360/491-9480

A map with written driving directions to the hospital highlighted is provided on Figure 8-1.

Figure 8-1 Medical Facility Access Route



8.3 Site Characterization Form

Estimated Volume 1,000 cubic yards (approx.)

Check all that apply:

Product:			Lead hazard:	X
Waste:	Burnt trash		Flammable:	
Liquid:			Corrosive:	
Sludge:			Reactive:	
Solid:	X		Toxic:	
Other (Describe):	Site soil contains lead above residential standards but less than industrial standards			

If a mixture, list components: Compounds expected include; Lead, zinc

TYPE OF SITE

(Check all that apply):

- ____ Active
- X Inactive
- ____ Industrial facility
- ____ Gas station
- ____ Treatment, Storage, Disposal Facility
- ____ Research & Development Facility
- ____ Military base
- X Other (Landfill)

UTILITIES

Utilities	Telephone	Date Cleared	Utility Present? (Y/N)
Electric Company	1-800-424-5554		
Water Company			
Gas Company			
Phone Company			

Facility Drawings Reviewed for Underground Structures/Utilities? (Y/N?) ____

8.4 Protective Equipment Form

MINIMUM:
Hard Hat
Safety Glasses/Goggles
Steel Toe/Shank Boots
Coveralls or work clothes
Hearing Protection
Leather gloves
(Full face APR with organic vapor cartridges must be available on site)

ADDITIONAL: (Specify by Task, Complete Additional Sheets As Needed)

TASK # ______________________________

RESPIRATORY PROTECTION REQUIRED (Y/N?) N

Check all that apply:

SCBA			
Airline:			
Airline with Egress:			
Air purifying respirator (FF):	on site	Cartridges:	Organic vapor
Air purifying respirator (HF):		Cartridges:	
Gas Mask or Powered APR for Level C		Cartridges	

PROTECTIVE CLOTHING REQUIRED (Y/N?) Yes (if potential for contact with contaminants in air, water, or soil).

Check all that apply:

Heavy Splash Suit	PVC		Neoprene		Other	
Medium Splash Suit	PVC		Neoprene		Other	
Light Splash Suit	PVC		Neoprene		PE	
	Tyvek		Saranex		Other	
Gloves	PVC	X	Neoprene		Other	
Boots	PVC	X	Neoprene		Other	
Boot Covers	PVC		Other			
Face Shield						
Hard Hat		X				

8.5 Air Monitoring Form and Action Levels

MONITORING INSTRUMENTATION: (NOTE: Monitoring instruments must be used for all operations unless appropriate rationale or restrictions are provided).

Check all that apply:

________ Organic Vapor Analyzer (FID) or
X Photo ionization Detector (PID) Minimum Lamp Energy; 10.2 eV
X Combustible Gas Indicator (CGI)
X Oxygen Meter
X Detector Tubes (specify): Draeger tube (or equivalent) for styrene, vinyl chloride, benzene
________ Other, specify: ________

IF MONITORING INSTRUMENTS ARE NOT USED, SPECIFY RATIONALE OR JUSTIFICATION <u>OR</u> ACTIVITY/AREA RESTRICTIONS

ACTION LEVELS:

If the PID indicates airborne volatile concentrations of less than 1 ppmv and/or the indicator tubes indicate less than 1 ppmv, work may proceed in Level D without respiratory protection. If required, use engineering controls (fans) to get breathing zone to background levels.

If the PID indicates airborne volatile concentrations greater 1 ppmv and less than 10 ppmv, identify VOC type with colorimetric detector tube; continue operations in level D PPE, use engineered controls if necessary. If type and source of vapor are not identified use Level C PPE (respirator) and/or engineered controls.

If the PID indicates airborne volatile concentrations greater 10 ppmv, identify VOC type with colorimetric detector tube; if type and source of vapor are identified, evaluate MUL and use Level C PPE (respirator) & engineered controls if approved by SSO If type and source of vapor are not identified, stop work. Use engineered controls to reduce concentrations in breathing zone to levels below 10 ppmv.

OTHER CONSIDERATIONS/RATIONALE

The maximum lead levels detected at Bordeaux site are < 1,000 mg/Kg. At this level (1,000 mg/kg lead) the total suspended particulate (TSP) concentrations would have to exceed 50 mg/m^3 in order for the lead PEL to be exceeded :
(the PEL/ max concentration = 0.05/1000 e-6 = 50 mg/m^3).

This TSP concentration is infeasible for the planned work (e.g., intense desert sandstorms are in the range of 10 mg/m^3 and site work would be impossible). Exposure to lead as airborne dust won't be an issue unless conditions change.

9.0 Chemical Properties Data for Expected Contaminants at Site

Analytical results from selected samples from the Bordeaux Dump Site are shown in Table 1. The single groundwater sample from the Site met drinking water standards for VOCs and metals, trace levels of PAHs detected (< 0.5 ug/L and J flagged) just barely exceeded a drinking water standard; these concentrations will not be an issue of concern for Health and Safety in for the remedial action. The chemical/physical properties for the identified chemicals of concern at this site is presented in Attachment A. The relevant HASP information (from NIOSH) includes:

Other common names/synonyms/trade names
Chemical and physical properties (vapor pressure, ionization potential, and others)
Exposure limits
Physical description (odor)
Incompatibilities & reactivities
Exposure symptoms
Respirator recommendations

Attachment B presents Technical Note TN 106 from RAE Systems. TN 106 presents correction factors, ionization energies, and calibration characteristics for a wide variety of compounds. These factors are used to develop appropriate chemical-specific correction factors when a PID is calibrated to isobutylene gas (as is common).

10.0 Health and Safety Plan Verification Form

The plan verification is an essential part of the plan and forms the basis for obligating personnel to comply with the safety requirements presented in the plan.

The following personnel have read and understand this plan and will perform all field work in compliance with the plan and other policies of CALIBRE:

Signature	Company	Date
Signature	Company	Date
Signature	Company	Date
Signature	Company	Date
Signature	Company	Date
Signature	Company	Date

Signature Company Date

11.0 General Health and Safety References

The references listed below provide information regarding the technical and regulatory standards and guidance for systems installation and operations and other activities related to operations at environmentally-contaminated sites.

ACGIH. Threshold Limit Values and Biological Exposure Indices (updated annually) (this is an excellent exposure reference with practical guidelines for exposure limits for many things which are either not addressed, or are addressed only in passing by OSHA);

American Petroleum Institute, API Publication 2015, 1985, "Cleaning Petroleum Storage Tanks"

American Petroleum Institute, Supplement to API Publications 2015A, 1982, "A Guide for Controlling the Lead Hazard Associated with Tank Entry and Cleaning"

American Petroleum Institute, Petroleum Safety Data 2202, 1982, "Dismantling and Disposing of Steel from Tanks Which Have Contained Leaded Gasoline"

CALIBRE 2006. Corporate Health and Safety Program Plan. January 1, 2006.

New York State Department of Environmental Conservation, 1/83, "Technology for the Storage of Hazardous Liquids: A State of the Art Review"

National Fire Protection Association, Flammable and Combustible Liquids Code, NFPA 30

NIOSH/OSHA/USCG/EPA. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities

NIOSH. Registry of Toxic Effects of Chemical Substances (RTECS) (this is a governmental publication which is an excellent repository of LD50-type data);

NIOSH. Pocket Guide to Chemical Hazards (June 1990 Edition)

NIOSH/OSHA/USCG/EPA. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (this is the "four agency" book and is an excellent overview of hazardous waste H&S and includes outstanding technical discussions of site control, decontamination, and drum handling);

Sax and Lewis. Hawley's Condensed Chemical Dictionary (quick reference book);

Sax and Lewis. Dangerous Properties of Industrial Materials (includes toxicological data in three volumes for many chemicals);

Sax and Lewis. Rapid Guide to Hazardous Chemicals in the Workplace

Title 49, CFR, Parts 171-177, Department of Transportation Hazardous Materials Regulations
Title 29, CFR, Part 1910.120, Hazardous Waste Operations and Emergency Response

Title 29, CFR, Part 1926, Construction Industry Standards

Verschueren. Handbook of Environmental Data on Organic Chemicals (information on odors, degradation in the environment, etc.).

TABLES

Table 1 Comparison of highest soil concentrations of chemicals of concern measured in the Bordeaux dump area with the MTCA Method B soil cleanup levels for unrestricted land use and MTCA Method C for industrial land use (both based on soil contact)

Chemicals Of Concern	Highest Concentration Measured, mg/kg	MTCA Soil Cleanup level, mg/kg
Lead	940	250(1)
Copper	110	577(2)
Selenium	9.5	5.2(2)
Arsenic	7.7	20
Cadmium	4.1	0.69(2)
Zinc	1,200	5,970(2)
Antimony	6.1	5.4(2)
Motor Oil (>C24-C36)	2,000	2,000(1)

(1) MTCA Methods A or B Soil Cleanup Levels for soil contact based unrestricted land use. Note that these values are for residential use of property and may or may not represent appreciable risk during site construction due to different/reduced exposure duration: MTCA values presented here are for relative comparison. Most compounds included in this table (except lead) exceed a leaching to groundwater or ecological standard but not a residential contact criteria.

(2) Soil-to-groundwater values calculated by equation 747-1 in the MTCA

	Soil, Method C, Carcinogen, Direct Contact (ingestion only), industrial land use (mg/kg)	Soil, Method C, Non carcinogen, Direct Contact (ingestion only), industrial land use (mg/kg)
Lead	Not Researched(3)	1,000(4)
Zinc	Not Researched(3)	NA- exceeds 100% (5)
Copper	Not Researched(3)	130,000

(3) “Not Researched” in these cases means that no cancer slope factor exists (for non carcinogens) and therefore the reference dose formula (Eq 745-1, from MTCA) is used to set standard (next column).

(4) A method A value for soil cleanup for industrial properties is presented (from Table 745-1).

(5)”NA-exceeds 100%” in these cases means the industrial cleanup standard using Eq 745-1 from MTCA is greater than 1 million mg/kg.

Table 2. Hazards Summary

Site Preparation Hazards	Electrical and Telephone Utility Installation
	Placement of Temporary Project Support Facilities
Well Construction and Direct-Push Hazards	Overhead hazards from drill rig
	Mechanical hazards of drilling and excavation
	Underground and overhead utilities
Facility Installation Hazards	Mobilization/setup of systems/trailers
	Electrical hazards
Heavy Equipment Operation	Load/unloading of equipment
	Safe operation and prevention of accidents with non-operators on ground
	Overhead and underground utilities
Excavations	Slumping of excavation sidewalls
	Egress from open excavations
	Vapor accumulation or low O_2 levels in low areas of excavation
Chemical Exposure Hazards	Contact with site contaminants in water, soil, and air
Slip, Trip and Fall Hazards	Surface pipes/hoses/other as tripping hazards
	Falling from ladders, steps or elevated platforms
	Work near open excavations
Weather Related/Heat Stress Hazards	Elevated body temperature due to work in hot conditions
	Working in impermeable clothing
	Hypothermia from exposure in cold conditions
	Dangerous weather conditions (electrical storms, ice)
	Dehydration due to loss of fluids

Table 3 Monitoring Equipment and Action Levels

Monitoring Equipment	Readings*	Action
Explosimeter	< 5 % Lower explosive limit (LEL)	Continue with caution
	5-15 % LEL	Implement mechanical control measures such as forced ventilation, continue with caution
	> 15 % LEL	Stop work and evacuate area until readings are below 10 %LEL
Oxygen (O_2) meter	19.5 - 21% O_2	Continue operations
	Needle deflects up ward then drops 0	Stop work and evacuate area until readings are approximately 20% O_2
	< 19.5% O_2	Stop work and evacuate area until readings are approximately 20% O_2
	> 21% O_2	Stop work and evacuate area until readings are approximately 20% O_2
PID	< 1 ppmv	Continue operations in level D PPE
	>1 & < 10 ppmv	Identify VOC type with colorimetric detector tube; continue operations in level D PPE, use engineered controls if necessary. If type and source of vapor are not identified use Level C PPE (respirator) and/or engineered controls.
	>10 & < 25 ppmv	Identify VOC type with colorimetric detector tube; if type and source of vapor are identified, evaluate MUL and use Level C PPE (respirator) & engineered controls if approved by SSO If type and source of vapor are not identified, stop work. Use engineered controls to reduce concentrations in breathing zone to levels below 10 ppmv.
Sound Level Meter	85 dBA	Continue operations
	> 85 dBA	Wear hearing protection to attenuate noise level below 85 dBA
	> 120 dBA	Continue operations if hearing protection attenuates noise levels below 85 dBA; continue to monitor, implement acoustical control measures (noise buffers)

*All readings are above background and taken in the breathing/hearing zone of field personnel

Attachment A

Chemical/Physical Properties for
Chemicals of Concern at Bordeaux Dump Site

(all data are from NIOSH website,
NIOSH Pocket Guide to Chemical Hazards [NPG]
http://www.cdc.gov/niosh/npg/npgsyn-a.html
dated 13 Sept 2010)

Lead

Synonyms & Trade Names

Lead metal, Plumbum

CAS No. 7439-92-1	RTECS No. OF7525000	DOT ID & Guide
Formula Pb	Conversion	IDLH 100 mg/m^3 (as Pb) See: 7439921

Exposure Limits

NIOSH REL

*: TWA (8-hour) 0.050 mg/m^3 See Appendix C [*Note: The REL also applies to other lead compounds (as Pb) -- see Appendix C.]

OSHA PEL

*: [1910.1025] TWA 0.050 mg/m^3 See Appendix C [*Note: The PEL also applies to other lead compounds (as Pb) -- see Appendix C.]

Measurement Methods

NIOSH 7082 , 7105 , 7300 , 7301 , 7303 , 7700 , 7701 , 7702 , 9100 , 9102 , 9105 ;
OSHA ID121 , ID125G , ID206
See: NMAM or OSHA Methods

Physical Description

A heavy, ductile, soft, gray solid.

MW: 207.2	BP: 3164°F	MLT: 621°F	Sol: Insoluble	VP: 0 mmHg (approx)	IP: NA
Sp.Gr: 11.34	Fl.P: NA	UEL: NA	LEL: NA		

Noncombustible Solid in bulk form.

Incompatibilities & Reactivities

Strong oxidizers, hydrogen peroxide, acids

Exposure Routes

inhalation, ingestion, skin and/or eye contact

Symptoms

lassitude (weakness, exhaustion), insomnia; facial pallor; anorexia, weight loss, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; paralysis wrist, ankles; encephalopathy; kidney disease; irritation eyes; hypertension

Target Organs

Eyes, gastrointestinal tract, central nervous system, kidneys, blood, gingival tissue

Personal Protection/Sanitation

(See protection codes)
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: Daily
Remove: When wet or contaminated
Change: Daily

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap flush promptly
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

(See Appendix E)
NIOSH/OSHA

Up to 0.5 mg/m^3:
(APF = 10) Any air-purifying respirator with an N100, R100, or P100 filter (including N100, R100, and P100 filtering facepieces) except quarter-mask respirators.
Click here for information on selection of N, R, or P filters.
(APF = 10) Any supplied-air respirator

Up to 1.25 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered, air-purifying respirator with a high-efficiency particulate filter.

Up to 2.5 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here for information on selection of N, R, or P filters.
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece

Up to 50 mg/m^3:
(APF = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

Up to 100 mg/m^3:
(APF = 2000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection

Zinc oxide

Synonyms & Trade Names Zinc peroxide	

CAS No. 1314-13-2	RTECS No. ZH4810000	DOT ID & Guide 1516 143
Formula ZnO	Conversion	IDLH 500 mg/m^3 See: 1314132
Exposure Limits NIOSH REL : Dust: TWA 5 mg/m^3 C 15 mg/m^3 Fume: TWA 5 mg/m^3 ST 10 mg/m^3 OSHA PEL †: TWA 5 mg/m^3 (fume) TWA 15 mg/m^3 (total dust) TWA 5 mg/m^3 (resp dust)		Measurement Methods NIOSH 7303 , 7502 ; OSHA ID121 , ID143 See: NMAM or OSHA Methods

Physical Description White, odorless solid.	

MW: 81.4	BP: ?	MLT: 3587°F	Sol(64°F): 0.0004%	VP: 0 mmHg (approx)	IP: NA
Sp.Gr: 5.61	Fl.P: NA	UEL: NA	LEL: NA		

Noncombustible Solid

Incompatibilities & Reactivities

Chlorinated rubber (at 419°F), water [Note: Slowly decomposed by water.]

Exposure Routes

inhalation

Symptoms

Metal fume fever: chills, muscle ache, nausea, fever, dry throat, cough; lassitude (weakness, exhaustion); metallic taste; headache; blurred vision; low back pain; vomiting; malaise (vague feeling of discomfort); chest tightness; dyspnea (breathing difficulty), rales, decreased pulmonary function

Target Organs

respiratory system

Personal Protection/Sanitation	First Aid
(See protection codes) Skin: No recommendation Eyes: No recommendation Wash skin: No recommendation Remove: No recommendation Change: No recommendation	(See procedures) Breathing: Respiratory support

Respirator Recommendations

NIOSH/OSHA

Up to 50 mg/m^3:
(APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100.
Click here for information on selection of N, R, or P filters.
(APF = 10) Any supplied-air respirator

Up to 125 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered, air-purifying respirator with a high-efficiency particulate filter.

Up to 250 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here for information on selection of N, R, or P filters.
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece

Up to 500 mg/m^3:
(APF = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection

Copper (dusts and mists, as Cu)

Synonyms & Trade Names

Copper metal dusts, Copper metal fumes

CAS No. 7440-50-8	RTECS No. GL5325000	DOT ID & Guide
Formula Cu	Conversion	IDLH 100 mg/m^3 (as Cu) See: 7440508

Exposure Limits NIOSH REL *: TWA 1 mg/m^3 [*Note: The REL also applies to other copper compounds (as Cu) except Copper fume.] OSHA PEL *: TWA 1 mg/m^3 [*Note: The PEL also applies to other copper compounds (as Cu) except copper fume.]	Measurement Methods NIOSH 7029 , 7300 , 7301 , 7303 , 9102 ; OSHA ID121 , ID125G See: NMAM or OSHA Methods

Physical Description

Reddish, lustrous, malleable, odorless solid.

MW: 63.5	BP: 4703°F	MLT: 1981°F	Sol: Insoluble	VP: 0 mmHg (approx)	IP: NA
Sp.Gr: 8.94	Fl.P: NA	UEL: NA	LEL: NA		

Noncombustible Solid in bulk form, but powdered form may ignite.

Incompatibilities & Reactivities

Oxidizers, alkalis, sodium azide, acetylene

Exposure Routes

inhalation, ingestion, skin and/or eye contact

Symptoms

irritation eyes, nose, pharynx; nasal septum perforation; metallic taste; dermatitis; in animals: lung, liver, kidney damage; anemia

Target Organs

Eyes, skin, respiratory system, liver, kidneys (increased risk with Wilson's disease)

Personal Protection/Sanitation

(See protection codes)
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated
Remove: When wet or contaminated
Change: Daily

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap wash promptly
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

NIOSH/OSHA

Up to 5 mg/m^3:
(APF = 5) Any quarter-mask respirator.
Click here for information on selection of N, R, or P filters.*

Up to 10 mg/m^3:
(APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100.
Click here for information on selection of N, R, or P filters.*
(APF = 10) Any supplied-air respirator*

Up to 25 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode*
(APF = 25) Any powered, air-purifying respirator with a high-efficiency particulate filter.*

Up to 50 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here for information on selection of N, R, or P filters.
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter*
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece

Up to 100 mg/m^3:
(APF = 2000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection

Attachment B
Technical Note TN 106 from RAE Systems

TN-106

TECHNICAL NOTE

CORRECTION FACTORS, IONIZATION ENERGIES*, AND CALIBRATION CHARACTERISTICS

Correction Factors and Ionization Energies

RAE Systems PIDs can be used for the detection of a wide variety of gases that exhibit different responses. In general, any compound with ionization energy (IE) lower than that of the lamp photons can be measured.* The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. In our PIDs, correction factors can be used in one of three ways:

1) Calibrate the monitor with isobutylene in the usual fashion to read in isobutylene equivalents. Manually multiply the reading by the correction factor (CF) to obtain the concentration of the gas being measured.
2) Calibrate the unit with isobutylene in the usual fashion to read in isobutylene equivalents. Call up the correction factor from the instrument memory or download it from a personal computer and then call it up. The monitor will then read directly in units of the gas of interest.
3) Calibrate the unit with isobutylene, but input an equivalent, "corrected" span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

** Some inorganic compounds like H_2O_2 and NO_2 give weak response at photon energies well above those of their ionization energies. The term "ionization energy" replaces the old term "ionization potential."*

Example 1:

With the unit calibrated to read isobutylene equivalents, the reading is 10 ppm with a 10.6 eV lamp. The gas being measured is butyl acetate, which has a correction factor of 2.6. Multiplying 10 by 2.6 gives an adjusted butyl acetate value of 26 ppm. Similarly, if the gas being measured were trichloroethylene (CF = 0.54), the adjusted value with a 10 ppm reading would be 5.4 ppm.

Example 2:

With the unit calibrated to read isobutylene equivalents, the reading is 100 ppm with a 10.6 eV lamp. The gas measured is m-xylene (CF = 0.43). After downloading this factor, the unit should read about 43 ppm when exposed to the same gas, and thus read directly in m-xylene values.

Example 3:

The desired gas to measure is ethylene dichloride (EDC). The CF is 0.6 with an 11.7 eV lamp. During calibration with 100 ppm isobutylene, insert 0.6 times 100, or 60 at the prompt for the calibration gas concentration. The unit then reads directly in EDC values.

Conversion to mg/m^3

To convert from ppm to mg/m^3, use the following formula:

$$\text{Conc. (mg/m}^3) = \frac{[\text{Conc.(ppmv) x mol. wt. (g/mole)}]}{\text{molar gas volume (L)}}$$

For air at 25 °C (77 °F), the molar gas volume is 24.4 L/mole and the formula reduces to:

$$\text{Conc.(mg/m}^3) = \text{Conc.(ppmv) x mol. wt. (g/mole) x } 0.041$$

For example, if the instrument is calibrated with a gas standard in ppmv, such as 100 ppm isobutylene, and the user wants to display to read in mg/m3 of hexane, whose m.w. is 86 and CF is 4.3, the overall correction factor would be 4.3 x 86 x 0.041 equals 15.2.

Correction Factors for Mixtures

The correction factor for a mixture is calculated from the sum of the mole fractions Xi of each component divided by their respective correction factors CFi:

$$\text{CFmix} = 1 / (X_1/\text{CF}_1 + X_2/\text{CF}_2 + X_3/\text{CF}_3 + \ldots X_i/\text{CF}_i)$$

Thus, for example, a vapor phase mixture of 5% benzene and 95% n-hexane would have a CFmix of CFmix = 1 / (0.05/0.53 + 0.95/4.3) = 3.2. A reading of 100 would then correspond to 320 ppm of the total mixture, comprised of 16 ppm benzene and 304 ppm hexane.

For a spreadsheet to compute the correction factor and TLV of a mixture see the appendix at the end of the CF table.

TLVs and Alarm Limits for Mixtures

The correction factor for mixtures can be used to set alarm limits for mixtures. To do this one first needs to calculate the exposure limit for the mixture. The Threshold Limit Value (TLV) often defines exposure limits. The TLV for the mixture is calculated in a manner similar to the CF calculation:

$$\text{TLV mix} = 1 / (X_1/\text{TLV}_1 + X_2/\text{TLV}_2 + X_3/\text{TLV}_3 + \ldots X_i/\text{TLV}_i)$$

In the above example, the 8-h TLV for benzene is 0.5 ppm and for n-hexane 50 ppm. Therefore the TLV of the mixture is TLVmix = 1 / (0.05/0.5 + 0.95/50) = 8.4 ppm, corresponding to 8.0 ppm hexane and 0.4 ppm benzene. For an instrument calibrated on isobutylene, the reading corrsponding to the TLV is:

$$\text{Alarm Reading} = \text{TLVmix} / \text{CFmix} = 8.4 / 3.2 = 2.6 \text{ ppm}$$

A common practice is to set the lower alarm limit to half the TLV, and the higher limit to the TLV. Thus, one would set the alarms to 1.3 and 2.6 ppm, respectively.

Calibration Characteristics

a) Flow Configuration. PID response is essentially independent of gas flow rate as long as it is sufficient to satisfy the pump demand. Four main flow configurations are used for calibrating a PID:

1) **A pressurized gas cylinder (Fixed-flow regulator):** The flow rate of the regulator should match the flow demand of the instrument pump or be slightly higher.
2) **A pressurized gas cylinder (Demand-flow regulator):** A demand-flow regulator better matches pump speed differences, but results in a slight vacuum during calibration and thus slightly high readings.
3) **A collapsible gas bag:** The instrument will draw the calibration gas from the bag at its normal flow rate, as long as the bag valve is large enough. The bag should be filled with enough gas to allow at least one minute of flow (~ 0.6 L for a MiniRAE, ~0.3 L for MultiRAE).
4) **The T (or open tube) method:** The T method uses a T-junction with gas flow higher than the pump draw. The gas supply is connected to one end of the T, the instrument inlet is connected to a second end of the T, and excess gas flow escapes through the third, open end of the T. To prevent ambient air mixing, a long tube should be connected to the open end, or a high excess rate should be used. Alternatively, the instrument probe can be inserted into an open tube slightly wider than the probe. Excess gas flows out around the probe.

The first two cylinder methods are the most efficient in terms of gas usage, while the bag and T methods give slightly more accurate results because they match the pump flow better.

b) Pressure. Pressures deviating from atmospheric pressure affect the readings by altering gas concentration and pump characteristics. It is best to calibrate with the instrument and calibration gas at the same pressure as each other and the sample gas. (Note that the cylinder pressure is not relevant because the regulator reduces the pressure to ambient.) If the instrument is calibrated at atmospheric pressure in one of the flow configurations described above, then 1) pressures slightly above ambient are acceptable but high pressures can damage the pump and 2) samples under vacuum may give low readings if air leaks into the sample train.

c) Temperature. Because temperature effects gas density and concentration, the temperature of the calibration gas and instrument should be as close as possible to the ambient temperature where the unit will be used. We recommend that the temperature of the calibration gas be within the instrument's temperature specification (typically 14°-113° F or -10°- 45° C). Also, during actual measurements, the instrument should be kept at the same or higher temperature than the sample temperature to avoid condensation in the unit.

d) Matrix. The matrix gas of the calibration compound and VOC sample is significant. Some common matrix components, such as methane and water vapor can affect the VOC signal. PIDs are most commonly used for monitoring VOCs in air, in which case the preferred calibration gas matrix is air. For a MiniRAE, methane, methanol, and water vapor reduce the response by about 20% when their concentration is 15,000 ppm and by about 40% at 30,000 ppm. Despite earlier reports of oxygen effects, RAE PID responses with 10.6 eV lamps are independent of oxygen concentration, and calibration gases in a pure nitrogen matrix can be used. H_2 and CO_2 up to 5 volume % also have no effect.

e) Concentration. Although RAE Systems PIDs have electronically linearized output, it is best to calibrate in a concentration range close to the actual measurement range. For example, 100 ppm standard gas for anticipated vapors of 0 - 250 ppm, and 500 ppm standard for expected concentrations of 250 - 1000 ppm.

f) Filters. Filters affect flow and pressure conditions and therefore all filters to be used during sampling should also be in place during calibration. Using a water trap (hydrophobic filter) greatly reduces the chances of drawing water aerosols or dirt particles into the instrument. Regular filter replacements are recommended because dirty filters can adsorb VOCs and cause slower response time and shifts in calibration.

Table Abbreviations:

CF =Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)
NR =No Response
IE =Ionization Energy (values in parentheses are not well established)
C =Confirmed Value; all others are preliminary or estimated values and are subject to change
ne =Not Established ACGIH 8-hr. TWA
C## =Ceiling value, given where 8-hr.TWA is not available

Disclaimer:

Actual readings may vary with age and cleanliness of lamp, relative humidity, and other factors. For accurate work, the instrument should be calibrated regularly under the operating conditions used. The correction factors in this table were measured in dry air at room temperature.

Updates:

The values that are indicated by a "plus" sign in the "C" columns are confirmed values; all others are preliminary and subject to change. Watch for updates of this table on the Internet at **http://www.raesystems.com**

IE data are taken from the CRC Handbook of Chemistry and Physics, 73rd Edition, D.R. Lide (Ed.), CRC Press (1993) and NIST Standard Ref. Database 19A, NIST Positive Ion Energetics, Vers. 2.0, Lias, et.al., U.S. Dept. Commerce (1993). Exposure limits (8-h TWA and Ceiling Values) are from the 1997 ACGIH TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 1997.

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C_2H_4O	NR	+	6	+	3.3	+	10.23	C25
Acetic Acid	Ethanoic Acid	64-19-7	$C_2H_4O_2$	NR	+	22	+	2.6	+	10.66	10
Acetic Anhydride	Ethanoic Acid Anhydride	108-24-7	$C_4H_6O_3$	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C_3H_6O	1.2	+	1.1	+	1.4	+	9.71	500
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C_2H_3N					100		12.19	40
Acetylene	Ethyne	74-86-2	C_2H_2					2		11.40	ne
Acrolein	Propenal	107-02-8	C_3H_4O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic Acid	Propenoic Acid	79-10-7	$C_3H_4O_2$			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C_3H_3N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C_3H_6O			2.4	+	1.7		9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C_3H_5Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	H_3N	NR	+	9.7	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	$C_7H_{14}O_2$	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	$C_5H_{12}O$			5				10.00	ne
Aniline	Aminobenzene	62-53-3	C_7H_7N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C_7H_8O			0.8				8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH_3			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C_7H_6O					1		9.49	ne
Benzene		71-43-2	C_6H_6	0.55	+	0.53	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C_7H_5N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C_7H_8O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C_7H_7Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	$C_8H_8O_2$	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF_3	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br_2	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C_6H_5Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C_3H_7OBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	$CHBr_3$	NR	+	2.5	+	0.5	+	10.48	0.5
Bromopropane,1-	n-Propyl bromide	106-94-5	C_3H_7Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C_4H_6	0.8		0.85	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	$C_4H_6O_2$	25	+	3.5	+	1.2		~10	ne
Butane		106-97-8	C_4H_{10}			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	$C_4H_{10}O$	70	+	4.7	+	1.4	+	9.99	20
Butanol, t-	tert-Butanol, t-Buty alcohol	75-65-0	$C_4H_{10}O$	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C_4H_8			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	$C_6H_{14}O_2$	1.8	+	1.2	+	0.6	+	<10	25
Butyl acetate, n-		123-86-4	$C_6H_{12}O_2$			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	$C_7H_{12}O_2$			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	$C_4H_{11}N$	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve	see 2-Butoxyethanol	111-76-2									
Butyl hydroperoxide, t-		75-91-2	$C_4H_{10}O_2$	2.0	+	1.6	+			<10	1
Butyl mercaptan	1-Butanethiol	109-79-5	$C_4H_{10}S$	0.55	+	0.52	+			9.14	0.5
Carbon disulfide		75-15-0	CS_2	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl_4	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve see 2-Ethoxyethanol											
CFC-14 see Tetrafluoromethane											
CFC-113 see 1,1,2-Trichloro-1,2,2-trifluoroethane											
Chlorine		7782-50-5	Cl_2					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO_2	NR	+	NR	+	NR	+	10.57	0.1
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C_4H_5Cl			3					10

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Chlorobenzene	Monochlorobenzene	108-90-7	C_6H_5Cl	0.44	+	0.40	+	0.39	+	9.06	10
Chloro-1,1-difluoroethane, 1-	(R-142B)	75-68-3	$C_2H_3ClF_2$			NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	$CHClF_2$	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C_2H_5Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlrohydrin	107-07-3	C_2H_5ClO							10.52	C1
Chloroethyl ether, 2-	bis(2-chloroethyl) ether	111-44-4	$C_4H_8Cl_2O$	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	C_3H_7ClO			3					ne
Chloroform	Trichloromethane	67-66-3	$CHCl_3$	NR	+	NR	+	3.5	+	11.37	10
Chloropicrin		76-06-2	CCl_3NO_2	NR	+	~400	+	7	+	?	0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C_7H_7Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C_7H_7Cl					0.6		8.69	ne
Chlorotrimethylsilane		75-77-4	C_3H_9ClSi	NR		NR		0.82	+	10.83	ne
Crotonaldehyde	*trans*-2-Butenal	123-73-9 4170-30-3	C_4H_6O	1.5	+	1.1	+	1.0	+	9.73	2
Cumene	Isopropylbenzene	98-82-8	C_9H_{12}	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C_6H_{12}	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	$C_6H_{12}O$					1.1		9.75	50
Cyclohexanone		108-94-1	$C_6H_{10}O$	1.0	+	0.9	+	0.7	+	9.14	25
Cyclohexene		110-83-8	C_6H_{10}			0.8	+			8.95	300
Cyclohexylamine		108-91-8	$C_6H_{13}N$			1.2				8.62	10
Cyclopentane 85% 2,2-dimethylbutane 15%		287-92-3	C_5H_{10}	NR	+	15	+	1.1		10.33	600
Cyclopropylamine	Aminocyclpropane	765-30-0	C_3H_7N	1.1	+	0.9	+	0.9	+		ne
Decane		124-18-5	$C_{10}H_{22}$	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	$C_6H_{12}O_2$			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	$CHBr_2Cl$	NR	+	5.3	+	0.7	+	10.59	ne
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	$C_2H_4Br_2$	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	$C_6H_4Cl_2$	0.54	+	0.47	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl_2F_2			NR	+	NR	+	11.75	1000
Dichlorodimethylsilane		75-78-5	$C_2H_6Cl_2Si$	NR		NR		1.1	+	>10.7	ne
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	$C_2H_4Cl_2$			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	$C_2H_2Cl_2$			0.82	+	0.8	+	9.79	5
Dichloroethene, c-1,2-	*c*-1,2-DCE, *cis*-Dichloroethylene	156-59-2	$C_2H_2Cl_2$			0.8				9.66	200
Dichloroethene, t-1,2-	*t*-1,2-DCE, *trans*-Dichloroethylene	156-60-5	$C_2H_2Cl_2$			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	$C_2H_3Cl_2F$	NR	+	NR	+	2.0	+		ne
Dichloromethane	see Methylene chloride										
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	442-56-0 507-55-1	$C_3HCl_2F_5$	NR	+	NR	+	25	+		ne
Dichloropropane, 1,2-		78-87-5	$C_3H_6Cl_2$					0.7		10.87	75
Dichloro-1-propene, 1,3-		542-75-6	$C_3H_4C_{12}$	1.3	+	0.96	+			<10	1
Dichloro-1-propene, 2,3-		78-88-6	$C_3H_4Cl_2$	1.9	+	1.3	+	0.7	+	<10	ne
Dichloro-1,1,1-trifluoroethane, 2,2-	R-123	306-83-2	$C_2HCl_2F_3$	NR	+	NR	+	10.1	+	11.5	ne
Dichloro-2,4,6-trifluoropyridine, 3,5-	DCTFP	1737-93-5	$C_5Cl_2F_3N$	1.1	+	0.9	+	0.8	+		ne
Dichlorvos	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	$C_4H_7Cl_2O_4P$			0.9	+			<9.4	0.1

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	$C_{10}H_{12}$	0.57	+	0.48	+	0.43	+	8.8	5
Diesel Fuel		68334-30-5	m.w. 226			0.9	+				11
Diesel Fuel #2 (Automotive)		68334-30-5	m.w. 216			0.7	+	0.4	+		11
Diethylamine		109-89-7	$C_4H_{11}N$			1	+			8.01	5
Diethylaminopropylamine, 3-		104-78-9	$C_7H_{18}N_2$			1.3					ne
Diethylbenzene	See Dowtherm J										
Diethylmaleate		141-05-9	$C_8H_{12}O_4$			4					ne
Diethyl sulfide	see Ethyl sulfide										
Diisopropylamine		108-18-9	$C_6H_{15}N$	0.84	+	0.74	+	0.5	+	7.73	5
Diketene	Ketene dimer	674-82-8	$C_4H_4O_2$	2.6	+	2.0	+	1.4	+	9.6	0.5
Dimethylacetamide, N,N-	DMA	127-19-5	C_4H_9NO	0.87	+	0.8	+	0.8	+	8.81	10
Dimethylamine		124-40-3	C_2H_7N			1.5				8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	$C_3H_6O_3$	NR	+	~70	+	1.7	+	~10.5	ne
Dimethyl disulfide	DMDS	624-92-0	$C_2H_6S_2$	0.2	+	0.20	+	0.21	+	7.4	ne
Dimethyl ether	see Methyl ether										
Dimethylethylamine	DMEA	598-56-1	$C_4H_{11}N$	1.1	+	1.0	+	0.9	+	7.74	~3
Dimethylformamide, N,N-	DMF	68-12-2	C_3H_7NO			0.8				9.13	10
Dimethylhydrazine, 1,1-	UDMH	57-14-7	$C_2H_8N_2$			0.8	+	0.8	+	7.28	0.01
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	$C_3H_9O_3P$	NR	+	4.3	+	0.74	+	10.0	ne
Dimethyl sulfate		77-78-1	$C_2H_6O_4S$	~23		~20	+	2.3	+		0.1
Dimethyl sulfide	see Methyl sulfide										
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C_2H_6OS			1.4	+			9.10	ne
Dioxane, 1,4-		123-91-1	$C_4H_8O_2$			1.3				9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	$C_3H_6O_2$	4.0	+	2.3	+	1.6	+	9.9	20
Dowtherm A see Therminol®											
Dowtherm J (97% Diethylbenzene)		25340-17-4	$C_{10}H_{14}$			0.5					
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/ Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+		ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro2,3-epoxypropane	106-89-8	C_2H_5ClO	~200	+	8.5	+	1.4	+	10.2	0.5
Ethane		74-84-0	C_2H_6			NR	+	15	+	11.52	ne
Ethanol	Ethyl alcohol	64-17-5	C_2H_6O			10	+	3.1	+	10.47	1000
Ethanolamine	MEA, Monoethanolamine	141-43-5	C_2H_7NO	5.6	+	1.6	+			8.96	3
Ethene	Ethylene	74-85-1	C_2H_4			9	+	4.5	+	10.51	ne
Ethoxyethanol, 2-	Ethyl cellosolve, Ethylene glycol monoethyl ether	110-80-5	$C_4H_{10}O_2$			1.3				9.6	5
Ethyl acetate		141-78-6	$C_4H_8O_2$			4.6	+			10.01	400
Ethyl acrylate		140-88-5	$C_5H_8O_2$			2.4	+	1.0	+	<10.3	5
Ethylamine		75-04-7	C_2H_7N			0.8				8.86	5
Ethylbenzene		100-41-4	C_8H_{10}	0.52	+	0.52	+	0.51	+	8.77	100
Ethylene glycol	1,2-Ethanediol	107-21-1	$C_2H_6O_2$			16	+	6	+	10.16	C100
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	$C_4H_{10}O_2$	1.1		0.86		0.7		9.2	ne
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C_2H_4O			13	+	3.5	+	10.57	1
Ethyl ether	Diethyl ether	60-29-7	$C_4H_{10}O$			1.1	+			9.51	400
Ethyl 3-ethoxypropionate	EEP	763-69-9	$C_7H_{14}O_3$	1.2	+	0.75	+				ne
Ethyl formate		109-94-4	$C_3H_6O_2$					1.9		10.61	100
Ethyl hexyl acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	$C_{11}H_{20}O_2$			1.1	+	0.5	+		ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	$C_5H_{10}O_3$	13	+	3.2	+	1.6	+	~10	ne
Ethyl mercaptan	Ethanethiol	75-08-1	C_2H_6S	0.60	+	0.56	+			9.29	0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	$C_4H_{10}S$			0.5	+			8.43	ne
Formaldehyde	Formalin	50-00-0	CH_2O	NR	+	NR	+	1.6	+	10.87	C0.3
Formamide		75-12-7	CH_3NO			6.9	+	4		10.16	10
Formic acid		64-18-6	CH_2O_2	NR	+	NR	+	9	+	11.33	5

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Furfural	2-Furaldehyde	98-01-1	$C_5H_4O_2$			0.92	+	0.8	+	9.21	2
Furfuryl alcohol		98-00-0	$C_5H_6O_2$			0.80	+			<9.5	10
Gasoline #1		8006-61-9	m.w. 72			0.9	+				300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+		300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	$C_5H_8O_2$	1.1	+	0.8	+	0.6	+		C0.05
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	$C_2HBrClF_3$					0.6		11.0	50
HCFC-22 see Chlorodifluoromethane											
HCFC-123 see 2,2-Dichloro-1,1,1-trifluoroethane											
HCFC-141B see 1,1-Dichloro-1-fluoroethane											
HCFC-142B see 1-Chloro-1,1-difluoroethane											
HCFC-134A see 1,1,1,2-Tetrafluoroethane											
HCFC-225 see Dichloropentafluoropropane											
Heptane, n-		142-82-5	C_7H_{16}	45	+	2.8	+	0.60	+	9.92	400
Hexamethyldisilazane, 1,1,1,3,3,3-	HMDS	999-97-3	$C_6H_{19}NSi_2$			0.2	+	0.2	+	~8.6	
Hexane, n-		110-54-3	C_6H_{14}	350	+	4.3	+	0.54	+	10.13	50
Hexanol, 1-	Hexyl alcohol	111-27-3	$C_6H_{14}O$	9	+	2.5	+	0.55	+	9.89	ne
Hexene, 1-		592-41-6	C_6H_{12}			0.8				9.44	30
Hydrazine		302-01-2	H_4N_2	>8	+	2.6	+	2.1	+	8.1	0.01
Hydrazoic acid	Hydrogen azide		HN_3							10.7	
Hydrogen	Synthesis gas	1333-74-0	H_2	NR	+	NR	+	NR	+	15.43	ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6	C4.7
Hydrogen peroxide		7722-84-1	H_2O_2	NR	+	NR	+	NR	+	10.54	1
Hydrogen sulfide		7783-06-4	H_2S	NR	+	3.3	+	1.5	+	10.45	10
Iodine		7553-56-2	I_2	0.1	+	0.1	+	0.1	+	9.40	C0.1
Iodomethane	Methyl iodide	74-88-4	CH_3I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	$C_7H_{14}O_2$	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C_4H_{10}			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	$C_4H_{10}O$	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C_4H_8	1.00	+	1.00	+	1.00	+	9.24	ne
Isobutyl acetate		110-19-0	$C_6H_{12}O_2$			2.6					150
Isobutyl acrylate	Isobutyl 2-propenoate, Acrylic acid Isobutyl ester	106-63-8	$C_7H_{12}O_2$			1.5	+	0.60	+		ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	$C_3H_2ClF_5O$							~11.7	ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C8H18			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w. 121	1.7	+	0.8	+				ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		ne
Isopentane	2-Methylbutane	78-78-4	C_5H_{12}			8.2					ne
Isophorone		78-59-1	$C_9H_{14}O$					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C_5H_8	0.69	+	0.63	+	0.60	+	8.85	ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C_3H_8O	500	+	6.0	+	2.7		10.12	400
Isopropyl acetate		108-21-4	$C_5H_{10}O_2$			2.6				9.99	250
Isopropyl ether	Diisopropyl ether	108-20-3	$C_6H_{14}O$			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, Wide cut type aviation fuel	8008-20-6 + 64741-42-0	m.w. 115			1.0	+	0.4	+		ne
Jet fuel JP-5	Jet 5, Kerosene type aviation fuel	8008-20-6 + 64747-77-1	m.w. 167			0.6	+	0.5	+		15
Jet fuel JP-8	Jet A-1, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 165			0.6	+	0.3	+		15
Jet fuel A-1 (JP-8)	Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 145			0.67					15

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Limonene, D-	(R)-(+)-Limonene	5989-27-5	$C_{10}H_{16}$			0.33	+			~8.2	ne
Kerosene C10-C16 petro.distillate – see Jet Fuels		8008-20-6									
MDI – see 4,4'-Methylenebis(phenylisocyanate)											
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C_9H_{12}	0.36	+	0.35	+	0.3	+	8.41	25
Methane	Natural gas	74-82-8	CH_4	NR	+	NR	+	NR	+	12.61	ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH_4O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	$C_3H_8O_2$	4.8	+	2.4	+	1.4	+	10.1	5
Methoxyethoxyethanol, 2-	2-(2-Methoxyethoxy)ethanol Diethylene glycol monomethyl ether	111-77-3	$C_7H_{16}O$	2.3	+	1.2	+	0.9	+	<10	ne
Methyl acetate		79-20-9	$C_3H_6O_2$	NR	+	6.6	+	1.4	+	10.27	200
Methyl acrylate	Methyl 2-propenoate, acrylic acid methyl ester	96-33-3	$C_4H_6O_2$			3.7	+	1.2	+	(9.9)	2
Methylamine	Aminomethane	74-89-5	CH_5N			1.2				8.97	5
Methyl bromide	Bromomethane	74-83-9	CH_3Br	110	+	1.7	+	1.3	+	10.54	1
Methyl t-butyl ether	MTBE, *tert*-Butyl methyl ether	1634-04-4	$C_5H_{12}O$			0.9	+			9.24	40
Methyl cellosolve	see 2-Methoxyethanol										
Methyl chloride	Chloromethane	74-87-3	CH_3Cl	NR	+	NR	+	0.74	+	11.22	50
Methylcyclohexane		107-87-2	C_7H_{14}	1.6	+	0.97	+	0.53	+	9.64	400
Methylene bis(phenyl-isocyanate), 4,4'-	MDI, Mondur M		$C_{15}H_{10}N_2O_2$	Very slow ppb level response							0.005
Methylene chloride	Dichloromethane	75-09-2	CH_2Cl_2	NR	+	NR	+	0.89	+	11.32	25
Methyl ether	Dimethyl ether	115-10-6	C_2H_6O	4.8	+	3.1	+	2.5	+	10.03	ne
Methyl ethyl ketone	MEK, 2-Butanone	78-93-3		0.86	+	0.9	+	1.1	+	9.51	200
Methylhydrazine	Monomethylhydrazine, Hydrazomethane	60-34-4	$C_2H_6N_2$	1.4	+	1.2	+	1.3	+	7.7	0.01
Methyl isobutyl ketone	MIBK, 4-Methyl-2-pentanone	108-10-1	$C_6H_{12}O$	0.9	+	0.8	+	0.6	+	9.30	50
Methyl isocyanate	CH3NCO	624-83-9	C_2H_3NO	NR	+	4.6	+	1.5		10.67	0.02
Methyl isothiocyanate	CH3NCS	551-61-6	C_2H_3NS	0.5	+	0.45	+	0.4	+	9.25	ne
Methyl mercaptan	Methanethiol	74-93-1	CH_4S	0.65		0.54		0.66		9.44	0.5
Methyl methacrylate		80-62-6	$C_5H_8O_2$	2.7	+	1.5	+	1.2	+	9.7	100
Methyl nonafluorobutyl ether	HFE-7100DL	163702-08-7, 163702-07-6	$C_5H_3F_9O$			NR	+	~35	+		ne
Methyl-1,5-pentane-diamine, 2- (coats lamp)	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	$C_6H_{16}N_2$			~0.6	+			<9.0	ne
Methyl propyl ketone	MPK, 2-Pentanone	107-87-9	$C_5H_{12}O$			0.93	+	0.79	+	9.38	200
Methyl-2-pyrrolidinone, N-	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C_5H_9NO	1.0	+	0.8	+	0.9	+	*9.17*	ne
Methyl salicylate	Methyl 2-hydroxybenzoate	119-36-8	C_8H_8O3	1.3	+	0.9	+	0.9	+	~9	ne
Methylstyrene, α-	2-Propenylbenzene	98-83-9	C_9H_{10}			0.5				8.18	50
Methyl sulfide	DMS, Dimethyl sulfide	75-18-3	C_2H_6S	0.49	+	0.44	+	0.46	+	8.69	ne
Mineral spirits	Stoddard Solvent, Varsol 1, White Spirits	8020-83-5 8052-41-3 68551-17-7	m.w. 144			0.7	+	0.39	+		100
Mineral Spirits - Viscor 120B Calibration Fluid, b.p. 156-207°C		8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100
Monoethanolamine - see Ethanolamine											
Mustard	HD, Bis(2-chloroethyl) sulfide	505-60-2 39472-40-7 68157-62-0	$C_4H_8Cl_2S$			0.6					0.0005
Naphtha - see VM & P Naptha											
Naphthalene	Mothballs	91-20-3	$C_{10}H_8$	0.45	+	0.42	+	0.40	+	8.13	10
Nickel carbonyl (in CO)	Nickel tetracarbonyl	13463-39-3	C_4NiO_4			0.18				<8.8	0.001
Nitric oxide		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
Nitrobenzene		98-95-3	$C_6H_5NO_2$	2.6	+	1.9	+	1.6	+	9.81	1
Nitroethane		79-24-3	$C_2H_5NO_2$					3		10.88	100
Nitrogen dioxide		10102-44-0	NO_2	23	+	16	+	6	+	9.75	3

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Nitrogen trifluoride		7783-54-2	NF_3	NR		NR		NR		13.0	10
Nitromethane		75-52-5	CH_3NO_2					4		11.02	20
Nitropropane, 2-		79-46-9	$C_3H_7NO_2$					2.6		10.71	10
Nonane		111-84-2	C_9H_{20}			1.4				9.72	200
Norpar 12	n-Paraffins, mostly C_{10}-C_{13}	64771-72-8	m.w. 161	3.2	+	1.1	+	0.28	+		ne
Norpar 13	n-Paraffins, mostly C_{13}-C_{14}	64771-72-8	m.w. 189	2.7	+	1.0	+	0.3	+		ne
Octane, n-		111-65-9	C_8H_{18}	13	+	1.8	+			9.82	300
Pentane		109-66-0	C_5H_{12}	80	+	8.4	+	0.7	+	10.35	600
Peracetic acid	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$	NR	+	NR	+	2.3	+		ne
Peracetic/Acetic acid mix	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	$C_2H_4O_3$			50	+	2.5	+		ne
Perchloroethene	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C_2Cl_4	0.69	+	0.57	+	0.31	+	9.32	25
PGME	Propylene glycol methyl ether, 1-Methoxy-2-propanol	107-98-2	$C_6H_{12}O_3$	2.4	+	1.5	+	1.1	+		100
PGMEA	Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate	108-65-6	$C_6H_{12}O_3$	1.65	+	1.0	+	0.8	+		ne
Phenol	Hydroxybenzene	108-95-2	C_6H_6O	1.0	+	1.0	+	0.9	+	8.51	5
Phosgene	Dichlorocarbonyl	75-44-5	CCl_2O	NR	+	NR	+	8.5	+	11.2	0.1
Phosgene in Nitrogen	Dichlorocarbonyl	75-44-5	CCl_2O	NR	+	NR	+	6.8	+	11.2	0.1
Phosphine		7803-51-2	PH_3	28		3.9	+	1.1	+	9.87	0.3
Photocopier Toner	Isoparaffin mix					0.5	+	0.3	+		ne
Picoline, 3-	3-Methylpyridine	108-99-6	C_6H_7N			0.9				9.04	ne
Pinene, α-		2437-95-8	$C_{10}H_{16}$			0.31	+	0.47		8.07	ne
Pinene, β-		18172-67-3	$C_{10}H_{16}$	0.38	+	0.37	+	0.37	+	~8	100
Piperylene, isomer mix	1,3-Pentadiene	504-60-9	C_5H_8	0.76	+	0.69	+	0.64	+	8.6	100
Propane		74-98-6	C_3H_8			NR	+	1.8	+	10.95	2500
Propanol, n-	Propyl alcohol	71-23-8	C_3H_8O			5		1.7		10.22	200
Propene	Propylene	115-07-1	C_3H_6	1.5	+	1.4	+	1.6	+	9.73	ne
Propionaldehyde	Propanal	123-38-6	C_3H_6O			1.9				9.95	ne
Propyl acetate, n-		109-60-4	$C_5H_{10}O_2$			3.5				10.04	200
Propylamine, n-	1-Propylamine, 1-Aminopropane	107-10-8	C_3H_9N	1.1	+	1.1	+	0.9	+	8.78	ne
Propylene carbonate		108-32-7	$C_4H_6O_3$			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	$C_3H_8O_2$	18		5.5	+	1.6	+	<10.2	ne
Propylene oxide	Methyloxirane	75-56-9 16088-62-3 15448-47-2	C_3H_6O	~240		6.6	+	2.9	+	10.22	20
Propyleneimine	2-Methylaziridine	75-55-8	C_3H_7N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C_3H_8S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C_5H_5N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C_4H_9N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol:1-Methoxy-2-acetoxypropane)	107-98-2	$C_4H_{10}O_2$ / $C_6H_{12}O_3$			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8 50642-23-4	$C_4H_{10}FO_2P$			~3					
Stoddard Solvent - see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C_8H_8	0.45	+	0.40	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO_2			NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF_6	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO_2F_2	NR		NR		NR		13.0	5
Tabun	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	$C_5H_{11}N_2O_2P$			0.8					15ppt

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Tetrachloroethane, 1,1,1,2-		630-20-6	$C_2H_2Cl_4$					1.3		~11.1	ne
Tetrachloroethane, 1,1,2,2-		79-34-5	$C_2H_2Cl_4$	NR	+	NR	+	0.60	+	~11.1	1
Tetrachlorosilane		10023-04-7	$SiCl_4$	NR		NR		15	+	11.79	ne
Tetraethyllead	TEL	78-00-2	$C_8H_{20}Pb$	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	$C_8H_{20}O_4Si$			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	$C_2H_2F_4$			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C_2F_4			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF_4			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C_4H_8O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	$C_4H_{12}O_4Si$	10	+	1.9	+			~10	1
Therminol VP-1®	Dowtherm,3:1 Diphenyl oxide: Biphenyl	101-84-8 92-52-4	$C_{12}H_{10}O$ $C_{12}H_{10}$			0.4	+				ne
Toluene	Methylbenzene	108-88-3	C_7H_8	0.54	+	0.50	+	0.51	+	8.82	50
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	$C_9H_6N_2O_2$	1.4	+	1.4	+	2.0	+		0.002
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	$C_6H_3Cl_3$	0.7	+	0.46	+			9.04	C5
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	$C_2H_3Cl_3$			NR	+	1	+	11	350
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	$C_2H_3Cl_3$	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichoroethylene	79-01-6	C_2HCl_3	0.62	+	0.54	+	0.43	+	9.47	50
Trichloromethylsilane	Methyltrichlorosilane	75-79-6	CH_3Cl_3Si	NR		NR		1.8	+	11.36	ne
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	$C_2Cl_3F_3$			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	$C_6H_{15}N$	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester, Boron ethoxide	150-46-9	$C_6H_{15}O_3B$			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	$C_6H_{15}O_4P$	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	$C_2H_3F_3$					34		*12.9*	ne
Trimethylamine		75-50-3	C_3H_9N			0.9				7.82	5
Trimethylbenzene, 1,3,5- - see Mesitylene		108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	$C_3H_9O_3B$			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	$C_3H_9O_4P$			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	$C_3H_9O_3P$			1.1	+		+	*8.5*	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	$C_{10}H_{16}$	0.4	+	0.3	+			~8	100
Undecane		1120-21-4	$C_{11}H_{24}$			2				9.56	ne
Varsol – see Mineral Spirits											
Vinyl actetate		108-05-4	$C_4H_6O_2$	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C_2H_3Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C_2H_3Cl			2.0	+	0.6	+	9.99	5
Vinyl-1-cyclohexene, 4-	Butadiene dimer, 4-Ethenylcyclohexene	100-40-3	C_8H_{12}	0.6	+	0.56	+			9.83	0.1
Vinylidene chloride - see 1,1-Dicholorethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C_6H_9NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B - see Mineral Spirits - Viscor 120B Calibration Fluid											
V. M. & P. Naphtha	Ligroin; Solvent naphtha; Varnish maker's & painter's naptha	64742-89-8	m.w. 111 (C_8-C_9)			~1					300
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C_8H_{10}	0.50	+	0.43	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C_8H_{10}	0.57	+	0.59	+	0.69		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C_8H_{10}			0.45	+	0.62	+	8.44	100
None				1		1		1			
Undetectable				1E+6		1E+6		1E+6			

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Appendix I:

Example of Automatic Calculation of Correction Factors, TLVs and Alarm Limits for Mixtures

(Calculations performed using Excel version of this database, available on request)

Compound	**CF 9.8 eV**	**CF 10.6 eV**	**CF 11.7eV**	**Mol. Frac**	**Conc ppm**	**TLV ppm**	**STEL Ppm**
Benzene	0.55	0.53	0.6	0.01	1	0.5	2.5
Toluene	0.54	0.5	0.51	0.06	10	50	150
Hexane, n-	300	4.3	0.54	0.06	10	50	150
Heptane, n-	45	2.8	0.6	0.28	50	400	500
Styrene	0.45	0.4	0.42	0.06	10	20	40
Acetone	1.2	1.1	1.4	0.28	50	750	1000
Isopropanol	500	6	2.7	0.28	50	400	500
None	1	1	1	0.00	0	1	
Mixture Value:	2.1	1.5	0.89	1.00	181 ppm	56 ppm	172 ppm
TLV Alarm Setpoint when Calibrated to Isobutylene:	26 ppm	37 ppm	62 ppm				
STEL Alarm Setpoint, same Calibration	86 ppm	115 ppm	193 ppm				