Work Plan for Investigation of Apron R Area, Rev 3
Boeing Renton Facility
Renton, Washington

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Table of Contents

List of Tables

List of Figures

Acronym List

AOC	Areas of concern
Bgs	Below ground surface
CAP	Cleanup Action Plan
CLARC	Cleanup Levels and Risk Calculation
DNR	Department of Natural Resources
DOT	Department of transportation
Ecology	Washington State Department of Ecology
EHS	Environmental, health and safety
Facility	Boeing Renton Facility
Ft	Feet
GAC	Granulated active carbon
GIS	Geographic information system
HWTR	Hazardous Waste & Toxics Reduction Program
IDW	Investigation-derived waste
MTCA	Model Toxics Control Act
NFA	No further action
PAH	Polycyclic aromatic hydrocarbons
PID	Photoionization detector
PPE	Personal protective equipment
PSE	Puget Sound Energy
QAPP	Quality Assurance Project Plan
SOP	Standard operating procedures
SP	Screen point
SWMUs	Solid waste management units
SVOCs	Semi- volatile organic compounds
TCP	Toxics Cleanup Program
Tech Memo	Technical memorandum
TPH	Total petroleum hydrocarbons
UNC	Utility Notification Center
USCS	Unified soil classification system
VOC	Volatile organic compounds
µg/L	Micrograms per liter
mg/L	Milligrams per liter

1.0 Introduction and Background

The Boeing Company (Boeing) has to address historic releases of hazardous substances at the Boeing Renton Facility (Facility) located in the City of Renton, Washington with Washington State Department of Ecology (Ecology) oversight. Boeing entered into Agreed Order No. DE 97HZ-N233 with Ecology, dated October 10, 1997 (1997 Agreed Order). Following completion of the Cleanup Action Plan (CAP), Boeing entered into Agreed Order No. 8191 with Ecology dated January 2, 2013 (2013 Agreed Order) to implement the CAP. Under the 2013 Agreed Order, Boeing is required to notify Ecology of any newly discovered release(s).

During 2021, Boeing's construction contractor (Skanska) worked on various construction projects at the north end of the Facility, including the installation of a new stormwater system in the area of Apron R (Figure 1). In mid- June 2021, Skanska observed a sheen in shallow water within a small area of an excavation trench (Apron R excavation trench) that appeared to be comprised of petroleum hydrocarbons (TPH). Work was stopped while Skanska coordinated the next steps with Boeing. During a July 9, 2021, teleconference, Boeing informed Ecology's Hazardous Waste & Toxics Reduction Program (HWTR) Project Manager (PM) of the observation of the TPH sheen in the Apron R excavation trench. Boeing stated that the potential TPH contamination appeared to originate from a thin zone about 4 feet below ground surface. Water was observed at approximately 3 feet bgs. The Ecology PM requested that Boeing evaluate whether any TPH sheen was observed in Lake Washington along the Boeing property shoreline in the vicinity of Apron R or at the nearest outfall to the Apron R construction area. CALIBRE (Boeing's contractor) performed a sweep of the area with a small watercraft and visually confirmed that no TPH sheen was observed. Also discussed during the July 9th call were Boeing's plan to mitigate further migration of the observed TPH in the Apron R excavation trench by installing a layered geotechnical membrane backfilled with granular activated carbon (GAC) above and below the observed TPH. This work was completed during the week of July 26, 2021.

On July 23, 2021, Boeing submitted to Ecology a technical memorandum (Tech Memo) which described the construction work in the Apron R vicinity, as well as initial characterization sampling results from the Apron R excavation trench (CALIBRE 2021). Ecology provided comments in a letter dated August 10, 2021. The July 2021 Tech Memo also documented that, while the potential TPH contamination was found on Boeing property, Boeing is not aware of any use, storage, or spills of TPH (or similar chemicals) in this area. The 2021 review did identify that this location is very close to a former fueling dock (now removed) used by the former Shuffleton Power plant, which was owned by Puget Sound Energy (PSE).

This report presents the following information:

1) The environmental data collected at the Apron R excavation trench in June 2021.
2) A summary of historical site use and related data from Ecology records and

3) Based on the 2021 environmental data, a work plan with sampling procedures to determine the extent of the potential TPH contaminated soil and groundwater in the vicinity of the Apron R excavation trench.

1.1 Summary of 2021 Sampling Data

Soil and water samples were collected from the Apron R excavation trench on June 21st, 2021. The sampling included two water samples and one soil stockpile sample. The water samples were collected in the excavation trench from the water surface (labeled as *OF-03-Surface)* and in the water column (approximately 1.5 feet (ft) below the water surface in the excavation (labeled as *OF-03-Mid)*).
A composite soil sample (labeled as *OF-03-Soil)* was collected from the segregated soil stockpile derived from the excavation trench (approximately 15 cubic yards). The samples were collected for two purposes; 1) to determine if the apparent hydrocarbon material observed represented a release; and 2) to characterize the material for waste management/disposal.

All three samples were analyzed for volatile organic compounds (VOCs), semi- volatile organic compounds (SVOCs), metals, and TPH as gasoline range, diesel range and motor oil range. Complete sample results are included in Attachment 1. A short summary of sample results with the analytes detected are presented in Tables 1, 2, and 3.

Cleanup levels have not yet been established for Apron R. All three samples had relatively low detections for all analytes and most were below the MTCA Method A and B criteria for all analytes, except for the *OF-03-Surface s*ample; this sample had chrysene exceeding Ecology's recommended surface water quality criteria (from WAC 173-201A-240), weathered TPH diesel range above Ecology freshwater protective value (Ecology 2021), TPH motor oil range above MTCA Method A, and one metal (lead) which exceeded MTCA Method A (see Table 1). It is important to note that the *OF-03-Surface* sample intentionally included a few small blobs (1 to 2 centimeter) of black material that was floating on the surface of the water in the Apron R excavation trench. The TPH observed in the Apron R excavation trench appears to be a weathered fuel from a discrete horizon located on the north side of the excavation.

In sample *OF-03-Surface,* pyrene was detected at 29.4 micrograms per liter (µg/L) compared to the Ecology surface water quality criteria of 310 µg/L (WAC 173-201A-240). Chrysene was detected at 19.3 µg/L compared to the Ecology surface water quality criteria of 1.4 µg/L (WAC 173-201A-240). The TPH diesel range and motor oil range results from this sample exceeded the MTCA Method A criteria of 0.5 milligrams per liter (mg/L) at 7.4 mg/L and 13.2 mg/L, respectively. Low level detections of acetone and toluene were detected in sample *OF-03-Surface* which were below Ecology surface water quality criteria and MTCA B criteria. Arsenic was detected at 2.89 µg/L and lead was detected at 15.7 µg/L in sample *OF-03-Surface*. The arsenic level detected is within the naturally occurring range published by Ecology

(Ecology 2022) and lead exceeds the MTCA Method A criteria of 15 µg/L. No other VOCs, SVOCs, metals or TPH compounds exceeded MTCA criteria (see Table 1).

In sample *OF-03-Mid*, chrysene was detected at 0.60 µg/L, below the Ecology surface water quality criteria (WAC 173-201A-240). Results for TPH motor oil range exceeded MTCA Method A criteria at 0.52 mg/L (versus MTCA Method A at 0.5 mg/L) and diesel range, at 0.382 mg/L that is below MTCA Method A criteria of 0.5 mg/L. Arsenic, detected at 3.07 µg/L is within the naturally occurring range published by Ecology. No other VOCs, SVOCS, metals or TPH compounds exceeded MTCA criteria presented in Cleanup Levels and Risk Calculation (CLARC see Table 2).

In the soil sample *OF-03-Soil*, benzo(a)pyrene was detected at 0.94 milligrams per kilogram (mg/kg), which exceeded MTCA Method B criteria of 0.19 mg/kg but is below the Method C criteria of 130 mg/kg. Mercury, detected at 0.067 mg/kg, was below the MTCA Method B standard for protection of potable groundwater (0.1 mg/kg) and selenium was detected at 0.57 mg/kg this is below the 90th percentile of natural background range published by Ecology (Ecology 1994)(see Table 3).

All waste materials generated were managed in accordance with the existing construction waste management plan (based on the analytical results received). As discussed with Ecology upon completion of the excavation work at Apron R, Boeing/Skanska implemented mitigation measures to prevent any contaminants in the excavation trench from reaching Lake Washington. The mitigation measures included utilizing backfill material consisting of 30% granulated active carbon (GAC) above and below the potential contamination zone to substantially adsorb any dissolved hydrocarbons [TPH and any related compounds] present in the immediate area.

1.2 Prior Site Use and Potential Source of Contamination

The source of the TPH in the Apron R excavation trench is unknown and, as noted previously, Boeing is not aware of any use, storage, or spills of related chemicals in this area. Relevant maps and historical aerial photos from the area of the recent excavation are included in Attachment 2. The historical information documents that the Apron R excavation area is near the former fueling dock used to supply tanks for the former Shuffleton Power plant. The Shuffleton Power plant was built in 1929 and is visible in a 1936 aerial photo (including the fueling dock, pump house, two large storage tanks, and power plant). The fueling dock extended approximately 350 feet into Lake Washington.

Historical design/as-built drawings maintained by Boeing for the 4-81 and 4-82 buildings from 1967 include pre-existing conditions before Boeing's construction and show two large storage tanks, pump house, pipelines to the fueling dock, the fueling dock, and pipelines to the Shuffleton Plant. All these structures, except the power plant, were removed prior to the Boeing 4-81 and 4-82 construction in the mid -1960s. The 1967 Boeing drawing indicates the prior Shuffleton fueling dock was removed and a new cooling water discharge canal (associated with the Shuffleton plant) was to be constructed on land and in-water on Department of Natural Resources (DNR) property in Lake Washington.

Ecology records from the Toxics Cleanup Program (TCP) (included in Attachment 2) describe this area as the Puget Sound Energy (PSE) Shuffleton, DNR Lease Area, Parcel: 723059105, Facility Site ID: 82611157, Cleanup Site ID: 14484. Ecology records indicate that in 1966-1967, while PSE held the DNR lease, PSE created the upland portion of the lease area with dredged material from Lake Washington. A no further action (NFA) letter for the upland portion of the DNR lease area was issued on June 26, 2000. The same Ecology records also note cleanup actions for Bunker C contamination on some part of the larger PSE/ Shuffleton Parcels. A 2014 aerial photo shows construction in the DNR parcel north of the Apron R excavation (construction by other parties other than Boeing) to remove the Shuffleton cooling water discharge canal on the DNR lease land and in-water work. A 2015 aerial photo shows the completed construction work where the trenching for stormwater discharge lines is visible on the PSE DNR Lease Parcel (highlighted with a yellow line added to the aerial photo). The construction shown in these two photos includes excavations across the area where the prior Shuffleton fuel line ran.

2.0 Planned Sampling Approach

The sampling results collected in 2021, and prior historical records identifying Bunker C use in the area (prior to Boeing's operations), indicate a historical release may have occurred near the area of the Apron R excavation trench during the time that PSE operated the Shuffleton power plant.

Additional investigation is needed to delineate the extent of TPH contaminated soil and groundwater in the area near the Apron R excavation trench.

The proposed sampling approach is to collect grab samples using a direct-push rig to advance borings located in a radial pattern extending out from the excavation trench where the TPH was detected. Figure 2 shows the proposed sampling locations and the sampling approach is discussed in detail below. This location on Apron R is a critical aircraft tow-path in front of the 737 final assembly buildings (4-81 and 4-82 buildings). A two-phase approach to sampling and characterization is planned based on the Facility's critical use of this area. The first phase will include collection of soil and groundwater samples from the area where the 2021 sampling identified hydrocarbons and include sampling extending radially outward from this spot. All of these samples will be temporary one-time grab samples collected with a direct push probe rig. Following review of the Phase 1 analytical results, a second Phase 2 sampling may be implemented that would include well installation. This work plan describes the Phase 1 sampling.

2.1 Site Preparation

A site walk will be coordinated with a representative from CASCADE drilling company, CALIBRE and Boeing to discuss the work requirements and scope including logistics, safety considerations, and staging areas. Following the site walk, notification will be provided to Boeing's Renton Site facility management in order to relocate any stored material, identify any subsurface utilities, and block off the planned work area. A traffic control plan will be implemented if needed and would require approval from Renton Site facility management.

Following these initial inspection and planning steps, the Renton Site environmental, health and safety (EHS) plan will be updated to include the planned work. All work will need to be planned and coordinated with Renton Site facility management, including determining access and availability once the drilling/sample collection dates have been finalized.

2.2 Utility Clearance

Underground utility clearance (gas, water, sewer, power, communication lines, and other utilities) will be completed prior to starting any intrusive work. The Utility Notification Center (UNC) will be notified at least 48 hours prior to initiation of intrusive work so that utilities can be marked. In addition, prior to sampling, a private utility locating service will be used to identify buried utilities in the area. Current utility maps for the area will be provided to the private utility locating service. Using a combination of electric resistivity and ground penetrating radar, any located utilities will be marked on the surface with spray paint. The current scope of work includes probing to a maximum depth of 8 feet below ground surface (ft bgs) and depth to water has historically been measured at approximately 3 to 4 ft bgs in this area. Known utilities in the area are active water lines and storm drains, see Figure 2. Added utility drawings are included in Attachment 3.

2.3 FOD Control

Foreign Object Debris (FOD) awareness and prevention is a critical aspect of the proposed scope of work due to the proximity of stored aircraft and equipment. CALIBRE has developed an active FOD awareness/prevention program that is applicable to work performed on or near airports. This program is based on the procedures, training, and disciplines practiced with regard to tool accountability and control and safe housekeeping practices reflecting a “clean as you go” work environment. All activities performed in the vicinity of Apron R will be completed in accordance with the CALIBRE SOP for FOD Awareness/Prevention Program.

2.4 Permitting

All probe work will be performed by a licensed driller and the driller will obtain the necessary start-cards from the Department of Ecology.

2.5 Coring and Sampling

After utilities have been cleared at the proposed sampling locations, the surface concrete will be cored to enable soil and groundwater sampling with a direct push rig. A total of 10 sampling locations are planned in the area of the prior Apron R excavation trench, see Table 4. Each probe location will be sampled to a depth of 8 ft bgs which is estimated to be at least 4 feet below the water table. From the prior 2021 data, the zone of potential TPH contamination was found around 4 ft bgs based on the observations within the trench excavation in 2021.

The soil cores will be logged by the CALIBRE field geologist/engineer using the Unified Soil Classification System (USCS) methodology. The soil cores will be field tested using a sheen test and a calibrated photoionization detector (PID) will also be used to field screen the soil cores over the extent of the depth drilled. Soil samples will be collected for laboratory analysis from each soil boring at approximately 3 to 4 and 6 to 8 ft bgs. In the event the sheen testing or PID screening indicate elevated levels at other depths, added soil samples may be collected based on those field screening results. The number of samples collected may change (increase) depending on field observations with the PID instrument and any petroleum odor, e.g., if the field personnel observe high PID readings from the soil cores and especially if this is combined with petroleum odors. The same field screening criteria, i.e., PID readings and odor, will be used to select the field duplicates.

The pre-planning logistics for intrusive work in this active area of the Renton Facility are critical and this field investigation needs to be constrained to the probe points as planned. Due to the reinforced concrete in the tarmac and proximity to the flightline/towpath, this investigation cannot expand beyond the scope this workplan without prior coordination. The data from this sampling will be evaluated to determine if they are sufficient to define the nature and extent of the release. If added data are needed, that subsequent scope would be planned in consultation with Ecology and with the Renton Facility Operations.

Two groundwater samples will be collected from each point using a Geoprobe Screen Point, with the sample collected using a peristaltic pump. One sample will be collected near the depth of the water table (likely around 3 to 4 ft bgs) and the second sample will be collected near the base of the probe point (approximately 8 ft bgs). The samples will be submitted for laboratory analysis following the analytes listed in Table 4 (both soil and groundwater samples). The samples will be submitted with one trip blank per cooler, and at least one field duplicate sample of the soil and groundwater samples at a minimum of one duplicate sample for every 20 primary samples per the QAPP (AMEC-Foster-Wheeler, 2016) .

2.6 Investigation-Derived Waste and Debris

The soil and water sampling described in this project may generate the following construction debris and investigation-derived waste (IDW):

- Groundwater
- Decontamination water
- Personal protective equipment (PPE)
- Soil cores from the probe investigation

Based on the Site history and results of the prior sampling in 2021, potential contaminants in the IDW may contain semi-volatile organic compounds and petroleum products. All IDW generated will be handled and disposed of according to local, state, and federal laws and applicable Boeing procedures. The waste management procedures will follow standard operating procedures (SOPs) and will be coordinated with designated Boeing personnel.

IDW generated during field activities will be stored in Department of Transportation (DOT)-approved 55-gallon drums or 5-gallon containers and temporarily stored on-site. Drum labels will be placed on the side of each drum and will include information on the type of IDW stored in the drum, the probe identification number, the date of waste generation, and a contact phone number. Disposable PPE will be placed in a plastic bag and disposed of in an industrial dumpster.

2.7 Laboratory Analysis

The water and soil samples from the Site will be analyzed for: Diesel/Heavy Oil Range Organics by Method NW-TPHDx, SVOCs by EPA Method SW8270E, and volatiles by EPA Method SW8260D. Samples collected will be kept in a cooler on ice in the custody of the field sampler(s) from the time of sample collection until the samples are transferred or shipped to Analytical Resources, LLC. CALIBRE's project manager will evaluate whether proper sampling and custody procedures were followed during the fieldwork by reviewing the documentation and prior discussions/procedures with sampling personnel.

A chain-of-custody record will accompany samples. When transferring custody of the samples, the individual relinquishing and receiving the samples will sign, date, and note the time of transfer on the chain-of-custody record.

2.8 Field Documentation

The field procedures for documentation, control, and transport of environmental samples are described below.

Field notes will be recorded in bound field logbooks or field sampling sheets. Entries will be made with indelible ink. Field logbook entries will include factual information (free of conjecture and subjective language) and include sufficient detail such that another person (not the field sampling team) reading the logbook entries is able to understand the sampling situation based on the recorded information. Logbook pages will not be removed from the logbook. Incorrect entries will be noted by striking the incorrect entry with a single line, adding the correct entry, dating, and initialing the change. Sampling information that should be entered into the field logbook includes the following:

- Date and time of sampling.
- Names or initials of sampling personnel.
- Sample location (including sketch and photograph)
- Odor and visual descriptions
- Water quality data

2.9 Data Quality Objectives

The characterization data collected will be used to answer three key questions.

1) Does the new data sufficiently define the nature and extent of potential TPH contamination in both soil and groundwater?
2) Does the prior Apron R excavation area require remediation beyond the GAC material installed during construction in July 2021?
3) Does the area require future monitoring of groundwater and, if so, how many monitoring wells would be needed?

2.10 Reporting

Effective data management is required to provide consistent, accurate, and defensible environmental data to support subsequent project decisions/determinations. Within 90 days after receipt of the final quality control/quality assurance (QA/QC) report, the results from the characterization sampling will be submitted in a Tech Memo to Ecology. The project plans for data management and reporting are discussed in the following sections.

2.10.1 Field Data

Daily field records (a combination of field logbooks and task-specific data sheets) will comprise the main documentation for field activities. As soon after collection as possible, field notes, data sheets, boring logs, field-duplicates and chain-of-custody forms will be scanned to create an electronic record for use in creating field summary reports.

2.10.2 Laboratory Data

The contracted laboratory will provide sampling results electronically, as a PDF laboratory data package as well as an electronic data deliverable. Field documentation will also be used to record field and laboratory duplicates. The data management task will include keeping accurate records of trip blanks, field duplicates and laboratory QA/QC samples, so that project managers and technical staff who use the data will have appropriate documentation. The laboratory will assign a unique code to each batch of samples called a sample delivery group or SDG.

2.10.3 Data Validation and Management

In order to ensure that data is of a known and acceptable quality, a data quality review will be performed independent of the laboratory and will include a review of laboratory performance criteria and sample-specific criteria. The reviewer will determine whether the project objectives have been met and whether the data are suitable for the intended purpose. The data review/validation procedure includes a review of these project QC measures. The primary data quality review will consist of the following elements:

- Verification that sample numbers and analyses match the chain-of-custody request.
- Verification that sample holding times are met.

- Verification that field and laboratory blanks were performed at the proper frequency and that no analytes were present in the blanks.
- Verification that field and laboratory duplicates, matrix spikes (MS), and laboratory control samples (LCS) were run at the proper frequency and that control limits were met.
- Verification that surrogate compound analyses have been performed and that results met the criteria.
- Verification that established reporting limits have been achieved.

The data quality review will also include a review of the precision, bias, and completeness of analytical data. Precision will be assessed based on the relative percent difference (RPD) of MS/MSD and/or duplicate pairs. Calculated RPDs will be compared to the control limits and if the RPD is within these limits, the precision of the analysis will be assumed to meet the data quality objectives (DQOs) of the project. Bias will be reviewed by comparing the percent recoveries of surrogates, and LCS to the appropriate control limits. Data will be reviewed in accordance with the analytical methods, laboratory's SOPs, the project SOPs and QAPP and following industry guidance documents for data validation.

All characterization data will be entered into and managed in the Site data management system for use in conjunction with mapping tools [AutoCAD or geographic information system (GIS)] to manage, summarize, and report the sampling data generated.

2.10.4 Data Review and Reporting

Data validation reports will be completed following receipt of the complete laboratory data package for each round of analytical results. A summary data report will be prepared and submitted to Ecology.

The summary data report will include a description of the field sampling effort (e.g., procedures, sample and locations, field sample observations), descriptions and rationale for any deviations from this work plan; a discussion of any data quality issues; and tabulated field and laboratory data. Electronic data will be provided to Ecology once all analyses and data validation have been completed.

3.0 References

AMEC-Foster-Wheeler, 2016, Quality Assurance Project Plan (QAPP), Boeing Renton Facility, Renton, Washington, February 2016.

CALIBRE, 2021. Boeing Renton - Summary of Recent Excavation Work and Sampling at Apron R Construction Site. Prepared for the Boeing Company. July 22, 2021.

Ecology, 1994. Natural Background Soil Metals Concentrations in Washington State. Publication No. 94-115 October 1994.

Ecology, 2021. Concentrations of Gasoline and Diesel Range Organics Predicted to be Protective of Aquatic Receptors in Surface Waters, Implementation Memorandum No. 23, August 25, 2021

Washington State Department of Ecology (Ecology), 2022, Natural Background Groundwater Arsenic Concentrations in WA State, Study Results, Publication No. 14-09-044, January.

Tables

Table 1: Sample OF-03-Surface (see Data Tables in Attachment 1 for complete results)

Lab Results				WAC 173-201A-240 Consumption of Water & Organisms		CLARC TEF adjusted based on Benzo(a)pyrene equivalent		Notes & other
Analysis								
SVOCs - EPA 8270E							units	
Phenanthrene	ug/L	17.4	J,D	No Value				
Pyrene	ug/L	29.4	J,D	310		480	ug/L	
Chrysene	ug/L	19.3	J,D	1.4		2.3	ug/L	based on MTCA B for BaP at 0.023 ug/L and TEF of 0.01 BaP is benzoapyrene
NWTPH-Dx								
Diesel Range Organics (C12-C24)	mg/L	7.40	D	No Value		NA	mg/L	MTCA A/B 500 ug/L converted to mg/L
Motor Oil Range Organics (C24-C38)	mg/L	13.2	D	No Value		NA	mg/L	
VOCs - EPA 8260D								
Acetone	ug/L	6.42	Q	No Value		NA	ug/L	MTCA B 7.20E+03 ug/L
Toluene	ug/L	0.12	J	180		NA	ug/L	
NWTPHg								
Gasoline Range Organics	ug/L	<100	U	No Value		1,000	ug/L	MTCA A as ug/L

The CPAH compounds consider Toxicity Equivalent Factors (TEFs), per Ecology policy, and comparison as benzoapyrene (BaP) equivalent

J = Estimated concentration value detected below the reporting limit.

D = The reported value is from a dilution

Q = Indicates a detected analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20% RSD, <20% drift or minimum RRF)

U = This analyte is not detected above the reporting limit (RL) or if noted, not detected above the limit of detection (LOD).

Table 1: Sample OF-03-Surface (continued)

Metal	OF-3-Surface (µg/L)	Ground Water WA State Maximum Contaminant Level 246-290 WAC (µg/L)	WAC 173-201A-240 Water & Organisms (µg/L)
Arsenic	2.89	10	10
Barium	178	2000	NE
Cadmium	1.15	5	NE
Chromium	23.2	100	NE
Lead	15.7	15	NE
Mercury	0.67	2	NE
Selenium	< 0.5	50	120
Silver	< 0.1	NE	100

NE none exist (no criteria published)

Table 2: Sample OF-03-Mid (see Data Tables in Attachment 1 for complete results)

Lab Results **Analytes**	units	result	flag	WAC 173-201A-240 Consumption of Water & Organisms	CLARC Method B	Notes
SVOCs - EPA 8270E						
Pyrene	ug/L	0.7	J	310	480	
Chrysene	ug/L	0.6	J	1.4	2.3	based on MTCA B for BaP at 0.023 ug/L and TEF of 0.01 BaP is benzoapyrene
NWTPH-Dx						
Diesel Range Organics (C12-C24)	mg/L	0.382		No Value	0.5	MTCA A 500 ug/L converted to mg/L
Motor Oil Range Organics (C24-C38)	mg/L	0.524		No Value	0.5	MTCA A 500 ug/L converted to mg/L
VOCs - EPA 8260D						
NO DETECTIONS		NA				
NWTPHg						
Gasoline Range Organics	ug/L	<100	U	No Value	1,000	MTCA A as ug/L

The CPAH compounds consider Toxicity Equivalent Factors (TEFs) per Ecology policy, and comparison as benzoapyrene (BaP) equivalent
J = Estimated concentration value detected below the reporting limit.
U = This analyte is not detected above the reporting limit (RL) or if noted, not detected above the limit of detection (LOD).

Table 2: Sample OF-03-Mid (continued)

Metal	OF-3-Mid (µg/L)	Ground Water WA State Maximum Contaminant Level 246-290 WAC (µg/L)	WAC 173-201A-240 Water & Organisms (µg/L)
Arsenic	3.07	10	10
Barium	13.2	2000	NE
Cadmium	0.091	5	NE
Chromium	1.2	100	NE
Lead	1.36	15	NE
Mercury	0.14	2	NE
Selenium	1.79	50	120
Silver	< 0.1	NE	100

NE none exist (no criteria published)

Table 3: OF-03-Soil (see Data Tables in Attachment 1 for complete results)

Analysis	**Result**	**Flag**	**MTCA Method B criteria**
VOCs - EPA 8260D	mg/kg		mg/kg
Acetone	0.0969		72000
Carbon Disulfide	0.00168		8000
2-Butanone	0.00643	J	No value
Benzene	0.00059	J	320
Toluene	0.00061	J	6400
1,2,4-Trimethylbenzene	0.00047	J	800
4-Isopropyl Toluene	0.00071	J	No value
2-Pentanone	0.00	J	No value
SVOCs - EPA 8270E	mg/kg	**Flag**	**MTCA Method B criteria**
2-Methylnaphthalene	8.21	D	320
Acenaphthene	1.01	J,D	98
Fluorene	1.40	D,J	100
Phenanthrene	4.26	D	No value
Anthracene	1.55	J,D	2,300
Pyrene	5.64	Q,D	650
Benzo(a)anthracene	1.79	J,D	1.9
Chrysene	3.28	D	19
Benzo(a)pyrene	0.94	J,D	0.190
1-Methylnaphthalene	6.26	D	34

J = Estimated concentration value detected below the reporting limit.

D = The reported value is from a dilution

Q = Indicates a detected analyte with an initial or continuing calibration t
does not meet established acceptance criteria (<20% RSD, <20% drift or minimum RRF)

Table 3: OF-03-Soil (continued)

Metal	OF-3-Soil (mg/kg)	Soil Method A Industrial Properties (mg/kg)	Soil Method C Direct Contact (mg/kg)
Arsenic	4.48	20	88
Barium	69.5	NE	700000
Cadmium	0.516	2	3500
Chromium	25.3	NE	NE
Lead	15.96	1000	1000
Mercury	0.0666	2	NE
Selenium	0.568	NE	18000
Silver	0.0358	NE	18000

NE none exist (no criteria published)

Table 4: Planned Soil and Water Samples

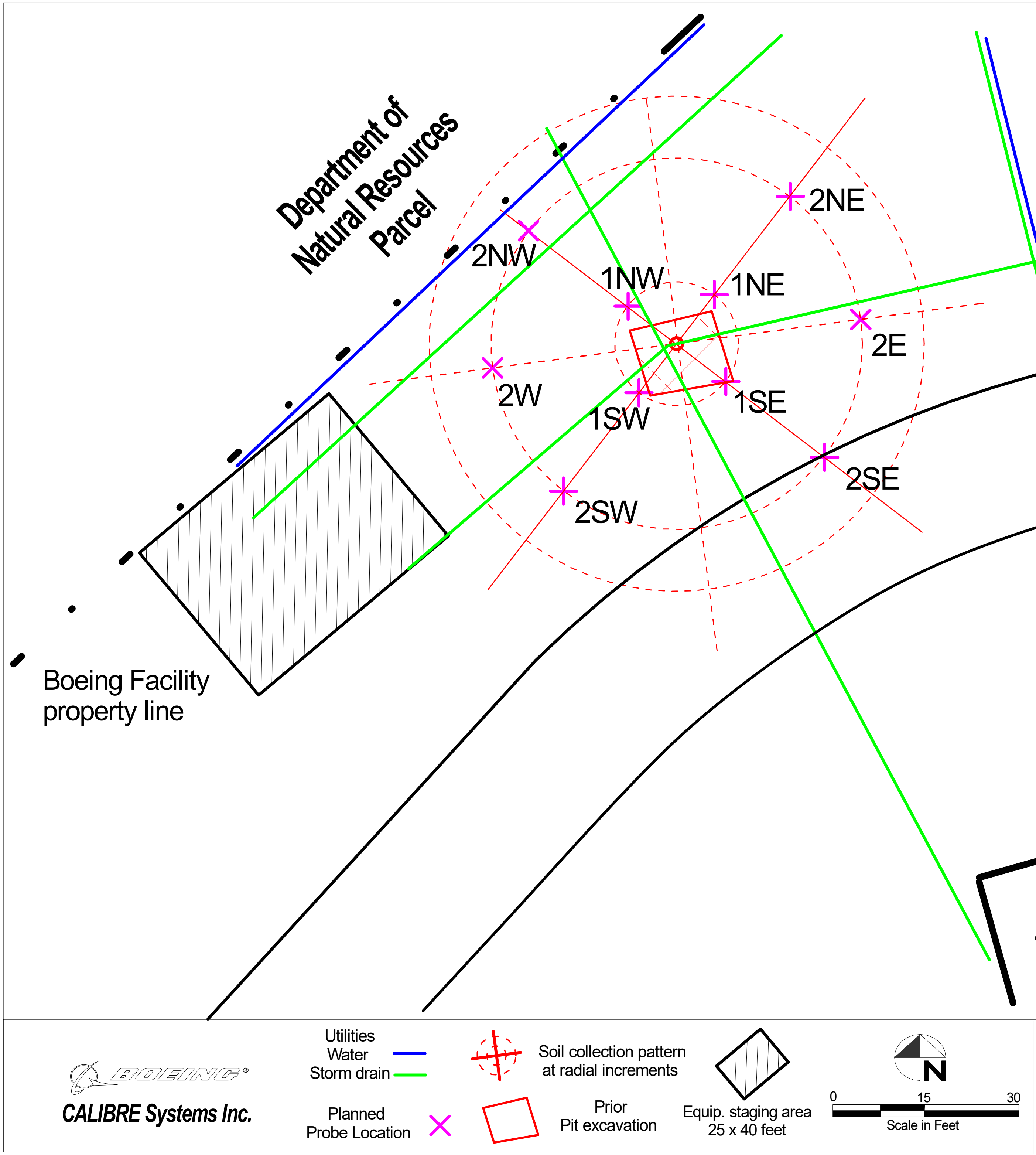
Soil samples					
Probe Location	**Depth Feet**		**Diesel/Heavy Oil Range Organics NW-TPHDx**	**SVOCs EPA 8270E**	**VOCs EPA 8260D**
1NE	4	8	2	2	2
1SE	4	8	2	2	2
1SW	4	8	2	2	2
1NW	4	8	2	2	2
2NE	4	8	2	2	2
2E	4	8	2	2	2
2SE	4	8	2	2	2
2SW	4	8	2	2	2
2W	4	8	2	2	2
2NW	4	8	2	2	2
Total soil including duplicate			21	21	21
Water samples					
Probe Location	**Depth Feet**		**Diesel/Heavy Oil Range Organics NW-TPHDx**	**SVOCs EPA 8270E**	**VOCs EPA 8260D**
1NE	4	8	2	2	2
1SE	4	8	2	2	2
1SW	4	8	2	2	2
1NW	4	8	2	2	2
2NE	4	8	2	2	2
2E	4	8	2	2	2
2SE	4	8	2	2	2
2SW	4	8	2	2	2
2W	4	8	2	2	2
2NW	4	8	2	2	2

Total water including duplicate			21	21	21

Trip blanks to be included, per QA/QC plans, are not listed in the table above (field samples)
The choice of field duplicate will be based on field observations (PID and Odor)
See Figure 2 for probe positions with each probe location

Figures

Figure 1 Site Location with the Renton Facility (near the Northeast corner of the property)



Boeing Renton
Apron R
Investigation Area

Figure 2
Apron R
Probe Locations

Attachment 1 – Data Validation with Tables of Sampling Data from June 2021

Data Validation Checklist
Renton Apron R Excavation Sampling, Data Package 21F0234,
Report Dated 7/2/2021

Organic data for water and solids by ARI, Metals data for water and solids by AmTest
2 groundwater samples and 1 soil sample analyzed by one or more of the following Methods:
VOC by 8260D, SVOCs by 8270E, metals by 200.8 (ICP/MS), Diesel/Heavy Oil Range Organics - WA-Ecology Method NW-TPHDx, Gasoline Range Organics - WA-Ecology Method NW-TPHG, Method 1664B (oil and grease). Reviewed by Justin Neste 7/15/2021

Criteria	**Notes**	**Result**
COC complete	Check COC plus other notes	COC is complete, lab noted extra sample bottles included in ice chest, not used, not on COC, intended for disposal
Holding times	Check Case Narrative	Holding times met. Samples collected on 6/21/2021, delivered to lab on same day, organics analyzed on 6/22/2021 Samples for metals received by AmTest (transferred from ARI) on 6/22/2021 and analyses by 7/1/2021
Temperature	Check Case Narrative	Ice chest received with ice at 24.7 C, above criteria of 4-6 degrees C. Samples were delivered to lab in less than 3 hours from sample collection (with 36 samples bottles) and had not yet cooled down. Received by lab and placed in lab cooler. No further qualification needed
Blanks	Check Case Narrative, review blanks data	No detections in method blanks.
Field duplicate sample analysis	Calculate relative percent difference for all field dupes.	No field duplicates collected; plan was for one-time waste characterization, further investigation to be considered if a release is identified. The MSD and LCSD duplicates were within acceptable limits.
Calibration	Check Case Narrative, review calibration data.	No anomalies listed in the case narrative.
Surrogate recovery	Check Case Narrative, review surrogate data	Surrogates met criteria.
Matrix spike and matrix spike duplicate recovery	Check Case Narrative, review MS/MSDs	The MS/MSD samples for metals within control limits. No MS/MSD for organics, only LCS/LCSD
Laboratory control sample or blank spike	Check Case Narrative, review LCS and or blank spikes	LCS/LCSD met acceptance criteria
Internal standard performance	Check Case Narrative	Internal standards met criteria.
Overall assessment of data for SDG	Any reason to reject data or perform full validation?	The data are acceptable for intended purpose (identification of a release, and plans for waste disposal with existing permits)

OF-3-Soil samples all analytes

Volatiles by EPA 82060D			
Date	Parameter	Concentration (µg/kg)	Flag
6/21/2021	Carbon Disulfide	1.68	
6/21/2021	Acetone	96.9	
6/21/2021	1,2,4-Trimethylbenzene	0.47J	J
6/21/2021	Benzene	0.59J	J
6/21/2021	Toluene	0.61J	J
6/21/2021	4-Isopropyl Toluene	0.71J	J
6/21/2021	2-Pentanone	3.10J	J
6/21/2021	2-Butanone	6.43J	J
6/21/2021	Tetrachloroethene	<0.26	U
6/21/2021	Chlorobenzene	<0.28	U
6/21/2021	2-Chlorotoluene	<0.29	U
6/21/2021	Ethylbenzene	<0.3	U
6/21/2021	1,2-Dichloroethane	<0.31	U
6/21/2021	1,3-Dichloropropane	<0.31	U
6/21/2021	n-Propylbenzene	<0.31	U
6/21/2021	o-Xylene	<0.32	U
6/21/2021	s-Butylbenzene	<0.32	U
6/21/2021	1,3-Dichlorobenzene	<0.33	U
6/21/2021	Bromobenzene	<0.33	U
6/21/2021	Styrene	<0.33	U
6/21/2021	t-Butylbenzene	<0.33	U
6/21/2021	1,3,5-Trimethylbenzene	<0.34	U
6/21/2021	Bromodichloromethane	<0.34	U
6/21/2021	cis-1,2-Dichloroethene	<0.34	U
6/21/2021	Methyl tert-butyl Ether	<0.34	U
6/21/2021	Trichloroethene	<0.34	U
6/21/2021	cis-1,3-Dichloropropene	<0.35	U
6/21/2021	Isopropyl Benzene	<0.35	U
6/21/2021	1,1,2-Trichloroethane	<0.36	U
6/21/2021	Dibromochloromethane	<0.36	U
6/21/2021	1,1,2,2-Tetrachloroethane	<0.37	U
6/21/2021	n-Butylbenzene	<0.37	U
6/21/2021	1,1-Dichloroethane	<0.38	U
6/21/2021	1,1-Dichloropropene	<0.38	U
6/21/2021	Chloroform	<0.38	U
6/21/2021	4-Chlorotoluene	<0.39	U
6/21/2021	1,2-Dibromoethane	<0.41	U
6/21/2021	2,2-Dichloropropane	<0.41	U
6/21/2021	Carbon tetrachloride	<0.42	U
6/21/2021	1,2-Dichloropropane	<0.44	U
6/21/2021	Vinyl Chloride	<0.45	U
6/21/2021	1,1,1,2-Tetrachloroethane	<0.47	U
6/21/2021	Dibromomethane	<0.47	U
6/21/2021	1,1-Dichloroethene	<0.49	U
6/21/2021	Chloromethane	<0.51	U
6/21/2021	Bromomethane	<0.52	U
6/21/2021	Bromochloromethane	<0.53	U
6/21/2021	Dichlorodifluoromethane	<0.54	U
6/21/2021	trans-1,3-Dichloropropene	<0.55	U
6/21/2021	1,4-Dichlorobenzene	<0.57	U
6/21/2021	Bromoform	<0.62	U
6/21/2021	m,p-Xylene	<0.66	U
6/21/2021	trans-1,2-Dichloroethene	<0.7	U
6/21/2021	1,1,1-Trichloroethane	<0.8	U
6/21/2021	1,2-Dichlorobenzene	<0.87	U
6/21/2021	Xylenes, total	<0.93	U
6/21/2021	1,1,2-Trichloro-1,2,2-Trifluoroethane	<1.13	U
6/21/2021	Iodomethane	<1.21	U
6/21/2021	Trichlorofluoromethane	<1.3	U
6/21/2021	Chloroethane	<1.66	U
6/21/2021	2-Hexanone	<1.7	U
6/21/2021	4-Methyl-2-Pentanone	<1.82	U
6/21/2021	1,2,3-Trichloropropane	<2	U
6/21/2021	Acrolein	<2.34	U
6/21/2021	Hexachloro-1,3-Butadiene	<2.4	U
6/21/2021	1,2,4-Trichlorobenzene	<2.42	U
6/21/2021	Acrylonitrile	<2.64	U
6/21/2021	1,2,3-Trichlorobenzene	<3.1	U
6/21/2021	1,2-Dibromo-3-chloropropane	<3.15	U
6/21/2021	Naphthalene	<3.28	U
6/21/2021	trans-1,4-Dichloro 2-Butene	<3.67	U
6/21/2021	2-Chloroethyl vinyl ether	<4.02	U
6/21/2021	Vinyl Acetate	<4.34	U
6/21/2021	Methylene Chloride	<5.82	U

OF-3-Soil samples all analytes

Semi volatiles by EPA 8270E			
Date	Parameter	Concentration (µg/kg)	Flag
6/21/2021	Chrysene	3280	
6/21/2021	Phenanthrene	4260	
6/21/2021	Pyrene	5640	
6/21/2021	1-Methylnaphthalene	6260	
6/21/2021	2-Methylnaphthalene	8210	
6/21/2021	Acenaphthene	1010J	J
6/21/2021	Fluorene	1400J	J
6/21/2021	Anthracene	1550J	J
6/21/2021	Benzo(a)anthracene	1790J	J
6/21/2021	Benzo(a)pyrene	935J	J
6/21/2021	Isophorone	<400	U
6/21/2021	2-Chlorophenol	<427	U
6/21/2021	Carbazole	<439	U
6/21/2021	Naphthalene	<445	U
6/21/2021	1,4-Dichlorobenzene	<465	U
6/21/2021	1,3-Dichlorobenzene	<468	U
6/21/2021	1,2,4-Trichlorobenzene	<474	U
6/21/2021	Phenol	<480	U
6/21/2021	2,4-Dimethylphenol	<483	U
6/21/2021	bis(2-chloroethyl) ether	<504	U
6/21/2021	N-Nitrosodiphenylamine	<504	U
6/21/2021	Bis(2-Chloroethoxy)methane	<516	U
6/21/2021	Dibenzofuran	<543	U
6/21/2021	1,2-Dichlorobenzene	<549	U
6/21/2021	2,2'-Oxybis(1-chloropropane)	<558	U
6/21/2021	Hexachlorobutadiene	<561	U
6/21/2021	Hexachloroethane	<561	U
6/21/2021	Hexachlorobenzene	<564	U
6/21/2021	Di-n-Octylphthalate	<570	U
6/21/2021	4-Bromophenyl phenyl ether	<576	U
6/21/2021	4-Chlorophenylphenyl ether	<612	U
6/21/2021	N-Nitroso-di-n-Propylamine	<621	U
6/21/2021	Diethyl phthalate	<624	U
6/21/2021	Acenaphthylene	<629	U
6/21/2021	2-Chloronaphthalene	<635	U
6/21/2021	4-Methylphenol	<668	U
6/21/2021	2-Methylphenol	<695	U
6/21/2021	bis(2-Ethylhexyl)phthalate	<713	U
6/21/2021	Butylbenzylphthalate	<734	U
6/21/2021	Dibenzo(a,h)anthracene	<734	U
6/21/2021	Nitrobenzene	<764	U
6/21/2021	Benzo(g,h,i)perylene	<773	U
6/21/2021	Dimethylphthalate	<791	U
6/21/2021	Indeno(1,2,3-cd)pyrene	<805	U
6/21/2021	Benzofluoranthenes, Total	<970	U
6/21/2021	Di-n-Butylphthalate	<987	U
6/21/2021	Fluoranthene	<1240	U
6/21/2021	4-Nitrophenol	<1440	U
6/21/2021	Hexachlorocyclopentadiene	<1860	U
6/21/2021	2-Nitrophenol	<1890	U
6/21/2021	2,4-Dichlorophenol	<2230	U
6/21/2021	2,4-Dinitrophenol	<2310	U
6/21/2021	Benzyl Alcohol	<2590	U
6/21/2021	3,3'-Dichlorobenzidine	<2660	U
6/21/2021	2,4-Dinitrotoluene	<2860	U
6/21/2021	2,6-Dinitrotoluene	<2860	U
6/21/2021	Pentachlorophenol	<2880	U
6/21/2021	4-Chloroaniline	<2980	U
6/21/2021	4-Nitroaniline	<3040	U
6/21/2021	3-Nitroaniline	<3100	U
6/21/2021	4-Chloro-3-Methylphenol	<3430	U
6/21/2021	2-Nitroaniline	<3580	U
6/21/2021	4,6-Dinitro-2-methylphenol	<3640	U
6/21/2021	2,4,6-Trichlorophenol	<4240	U
6/21/2021	2,4,5-Trichlorophenol	<4470	U
6/21/2021	Benzoic acid	<7490	U

OF-3-Soil samples all analytes

Metals by EPA 6020B			
SampleDate	Parameter	Concentration (mg/kg)	Flag
6/21/2021	Silver	0.0358	
6/21/2021	Arsenic	4.48	
6/21/2021	Barium	69.5	
6/21/2021	Cadmium	0.516	
6/21/2021	Chromium	25.3	
6/21/2021	Lead	15.96	
6/21/2021	Selenium	0.568	
6/21/2021	Mercury	0.0666	

OF-3- surface of water column sample - all analytes

Hydrocarbons by EPA 1664B

Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	HEM Polar Oil & Grease	55	
6/21/2021	SGT-HEM NP Oil & Grease	55	
6/21/2021	HEM Oil & Grease	110	

Hydrocarbons by NWTPH

Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Diesel Range Organics (C12-C24)	7.4	
6/21/2021	Motor Oil Range Organics (C24-C38)	13.2	
6/21/2021	Gasoline Range Organics (Tol-Nap)	ND	U

Metals by EPA 200.8

Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Arsenic	2.89	
6/21/2021	Barium	178	
6/21/2021	Cadmium	1.15	
6/21/2021	Chromium	23.2	
6/21/2021	Lead	15.7	
6/21/2021	Selenium	<0.5	U
6/21/2021	Silver	<0.1	U
6/21/2021	Mercury	0.67	

Other SM 2540 F-97

Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Settleable Solids	2.7	

Other SM 4500-H+ B-00

Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	pH	7.14	

OF-3- surface of water column sample - all analytes

Volatiles by EPA 82060D			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Acetone	6.42	
6/21/2021	Toluene	0.12J	J
6/21/2021	1,1,1,2-Tetrachloroethane	<0.09	U
6/21/2021	1,1,1-Trichloroethane	<0.08	U
6/21/2021	1,1,2,2-Tetrachloroethane	<0.1	U
6/21/2021	1,1,2-Trichloro-1,2,2-Trifluoroethane	<0.11	U
6/21/2021	1,1,2-Trichloroethane	<0.1	U
6/21/2021	1,1-Dichloroethane	<0.09	U
6/21/2021	1,1-Dichloroethene	<0.08	U
6/21/2021	1,1-Dichloropropene	<0.09	U
6/21/2021	1,2,3-Trichlorobenzene	<0.25	U
6/21/2021	1,2,3-Trichloropropane	<0.16	U
6/21/2021	1,2,4-Trichlorobenzene	<0.21	U
6/21/2021	1,2,4-Trimethylbenzene	<0.1	U
6/21/2021	1,2-Dibromo-3-chloropropane	<0.39	U
6/21/2021	1,2-Dibromoethane	<0.09	U
6/21/2021	1,2-Dichlorobenzene	<0.08	U
6/21/2021	1,2-Dichloroethane	<0.08	U
6/21/2021	1,2-Dichloropropane	<0.07	U
6/21/2021	1,3,5-Trimethylbenzene	<0.07	U
6/21/2021	1,3-Dichlorobenzene	<0.08	U
6/21/2021	1,3-Dichloropropane	<0.07	U
6/21/2021	1,4-Dichlorobenzene	<0.1	U
6/21/2021	2,2-Dichloropropane	<0.11	U
6/21/2021	2-Butanone	<1.77	U
6/21/2021	2-Chloroethyl vinyl ether	<0.55	U
6/21/2021	2-Chlorotoluene	<0.06	U
6/21/2021	2-Hexanone	<2.06	U
6/21/2021	2-Pentanone	<2.34	U
6/21/2021	4-Chlorotoluene	<0.06	U
6/21/2021	4-Isopropyl Toluene	<0.08	U
6/21/2021	4-Methyl-2-Pentanone	<1.9	U
6/21/2021	Acrolein	<2.7	U
6/21/2021	Acrylonitrile	<0.4	U
6/21/2021	Benzene	<0.05	U
6/21/2021	Bromobenzene	<0.07	U
6/21/2021	Bromochloromethane	<0.09	U
6/21/2021	Bromodichloromethane	<0.09	U
6/21/2021	Bromoform	<0.15	U
6/21/2021	Bromomethane	<0.74	U
6/21/2021	Carbon Disulfide	<0.12	U
6/21/2021	Carbon tetrachloride	<0.09	U
6/21/2021	Chlorobenzene	<0.06	U
6/21/2021	Chloroethane	<0.18	U
6/21/2021	Chloroform	<0.05	U
6/21/2021	Chloromethane	<0.27	U
6/21/2021	cis-1,2-Dichloroethene	<0.08	U
6/21/2021	cis-1,3-Dichloropropene	<0.09	U
6/21/2021	Dibromochloromethane	<0.09	U
6/21/2021	Dibromomethane	<0.06	U
6/21/2021	Dichlorodifluoromethane	<0.13	U
6/21/2021	Ethylbenzene	<0.05	U
6/21/2021	Hexachloro-1,3-Butadiene	<0.41	U
6/21/2021	Iodomethane	<0.43	U
6/21/2021	Isopropyl Benzene	<0.07	U
6/21/2021	m,p-Xylene	<0.14	U
6/21/2021	Methyl tert-butyl Ether	<0.14	U
6/21/2021	Methylene Chloride	<0.53	U
6/21/2021	Naphthalene	<0.27	U
6/21/2021	n-Butylbenzene	<0.18	U
6/21/2021	n-Propylbenzene	<0.07	U
6/21/2021	o-Xylene	<0.08	U
6/21/2021	s-Butylbenzene	<0.06	U
6/21/2021	Styrene	<0.09	U
6/21/2021	t-Butylbenzene	<0.07	U
6/21/2021	Tetrachloroethene	<0.09	U
6/21/2021	trans-1,2-Dichloroethene	<0.07	U
6/21/2021	trans-1,3-Dichloropropene	<0.09	U
6/21/2021	trans-1,4-Dichloro 2-Butene	<0.6	U
6/21/2021	Trichloroethene	<0.07	U
6/21/2021	Trichlorofluoromethane	<0.13	U
6/21/2021	Vinyl Acetate	<0.12	U
6/21/2021	Vinyl Chloride	<0.08	U
6/21/2021	Xylenes, total	<0.22	U

OF-3- surface of water column sample - all analytes

Semi volatiles by EPA 8270E			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Phenanthrene	17.4J	J
6/21/2021	Chrysene	19.3J	J
6/21/2021	Pyrene	29.4J	J
6/21/2021	1,2,4-Trichlorobenzene	<9.5	U
6/21/2021	1,2-Dichlorobenzene	<9.3	U
6/21/2021	1,3-Dichlorobenzene	<8.4	U
6/21/2021	1,4-Dichlorobenzene	<8.6	U
6/21/2021	1-Methylnaphthalene	<8.1	U
6/21/2021	2,2'-Oxybis(1-chloropropane)	<15.9	U
6/21/2021	2,4,5-Trichlorophenol	<54.1	U
6/21/2021	2,4,6-Trichlorophenol	<58.4	U
6/21/2021	2,4-Dichlorophenol	<55.8	U
6/21/2021	2,4-Dimethylphenol	<31.1	U
6/21/2021	2,4-Dinitrophenol	<146	U
6/21/2021	2,4-Dinitrotoluene	<58.6	U
6/21/2021	2,6-Dinitrotoluene	<63.7	U
6/21/2021	2-Chloronaphthalene	<14.2	U
6/21/2021	2-Chlorophenol	<11	U
6/21/2021	2-Methylnaphthalene	<7.1	U
6/21/2021	2-Methylphenol	<10	U
6/21/2021	2-Nitroaniline	<59.8	U
6/21/2021	2-Nitrophenol	<15.1	U
6/21/2021	3,3'-Dichlorobenzidine	<48.6	U
6/21/2021	3-Nitroaniline	<65.1	U
6/21/2021	4,6-Dinitro-2-methylphenol	<150	U
6/21/2021	4-Bromophenyl phenyl ether	<10.4	U
6/21/2021	4-Chloro-3-Methylphenol	<60	U
6/21/2021	4-Chloroaniline	<58.1	U
6/21/2021	4-Chlorophenylphenyl ether	<11.3	U
6/21/2021	4-Methylphenol	<13.2	U
6/21/2021	4-Nitroaniline	<58.2	U
6/21/2021	4-Nitrophenol	<30.2	U
6/21/2021	Acenaphthene	<8.9	U
6/21/2021	Acenaphthylene	<10.3	U
6/21/2021	Anthracene	<12	U
6/21/2021	Benzo(a)anthracene	<12	U
6/21/2021	Benzo(a)pyrene	<14.6	U
6/21/2021	Benzo(g,h,i)perylene	<13.8	U
6/21/2021	Benzofluoranthenes, Total	<24.9	U
6/21/2021	Benzoic acid	<103	U
6/21/2021	Benzyl Alcohol	<29.1	U
6/21/2021	Bis(2-Chloroethoxy)methane	<17.8	U
6/21/2021	bis(2-chloroethyl) ether	<10.7	U
6/21/2021	bis(2-Ethylhexyl)phthalate	<15.8	U
6/21/2021	Butylbenzylphthalate	<11.9	U
6/21/2021	Carbazole	<17.9	U
6/21/2021	Dibenzo(a,h)anthracene	<12.9	U
6/21/2021	Dibenzofuran	<8	U
6/21/2021	Diethyl phthalate	<12.7	U
6/21/2021	Dimethylphthalate	<11.8	U
6/21/2021	Di-n-Butylphthalate	<15	U
6/21/2021	Di-n-Octylphthalate	<10.9	U
6/21/2021	Fluoranthene	<12.5	U
6/21/2021	Fluorene	<10.3	U
6/21/2021	Hexachlorobenzene	<12.5	U
6/21/2021	Hexachlorobutadiene	<4.2	U
6/21/2021	Hexachlorocyclopentadiene	<75.9	U
6/21/2021	Hexachloroethane	<8.7	U
6/21/2021	Indeno(1,2,3-cd)pyrene	<11.9	U
6/21/2021	Isophorone	<14.3	U
6/21/2021	Naphthalene	<7.4	U
6/21/2021	Nitrobenzene	<12.5	U
6/21/2021	N-Nitroso-di-n-Propylamine	<6.4	U
6/21/2021	N-Nitrosodiphenylamine	<12.2	U
6/21/2021	Pentachlorophenol	<77.3	U
6/21/2021	Phenol	<6.4	U

OF-3- middle of water column sample - all analytes

Hydrocarbons by EPA 1664B			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	HEM Oil & Grease	<5	U
6/21/2021	HEM Polar Oil & Grease	<5	U
6/21/2021	SGT-HEM NP Oil & Grease	<5	U

Hydrocarbons by NWTPH			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Diesel Range Organics (C12-C24)	0.382	
6/21/2021	Motor Oil Range Organics (C24-C38)	0.524	
6/21/2021	Gasoline Range Organics (Tol-Nap)	<100	U

Metals by EPA 200.8			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Arsenic	3.07	
6/21/2021	Barium	13.2	
6/21/2021	Cadmium	0.091	
6/21/2021	Chromium	1.2	
6/21/2021	Lead	1.36	
6/21/2021	Selenium	1.79	
6/21/2021	Silver	<0.1	U
6/21/2021	Mercury	0.14	

Other SM 2540 F-97			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Settleable Solids	<0.1	U

Other SM 4500-H+ B-00			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	pH	6.96	

OF-3- middle of water column sample - all analytes

Volatiles by EPA 82060D			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Benzene	<0.05	U
6/21/2021	Chloroform	<0.05	U
6/21/2021	Ethylbenzene	<0.05	U
6/21/2021	Toluene	<0.05	U
6/21/2021	2-Chlorotoluene	<0.06	U
6/21/2021	4-Chlorotoluene	<0.06	U
6/21/2021	Chlorobenzene	<0.06	U
6/21/2021	Dibromomethane	<0.06	U
6/21/2021	s-Butylbenzene	<0.06	U
6/21/2021	1,2-Dichloropropane	<0.07	U
6/21/2021	1,3,5-Trimethylbenzene	<0.07	U
6/21/2021	1,3-Dichloropropane	<0.07	U
6/21/2021	Bromobenzene	<0.07	U
6/21/2021	Isopropyl Benzene	<0.07	U
6/21/2021	n-Propylbenzene	<0.07	U
6/21/2021	t-Butylbenzene	<0.07	U
6/21/2021	trans-1,2-Dichloroethene	<0.07	U
6/21/2021	Trichloroethene	<0.07	U
6/21/2021	1,1,1-Trichloroethane	<0.08	U
6/21/2021	1,1-Dichloroethene	<0.08	U
6/21/2021	1,2-Dichlorobenzene	<0.08	U
6/21/2021	1,2-Dichloroethane	<0.08	U
6/21/2021	1,3-Dichlorobenzene	<0.08	U
6/21/2021	4-Isopropyl Toluene	<0.08	U
6/21/2021	cis-1,2-Dichloroethene	<0.08	U
6/21/2021	o-Xylene	<0.08	U
6/21/2021	Vinyl Chloride	<0.08	U
6/21/2021	1,1,1,2-Tetrachloroethane	<0.09	U
6/21/2021	1,1-Dichloroethane	<0.09	U
6/21/2021	1,1-Dichloropropene	<0.09	U
6/21/2021	1,2-Dibromoethane	<0.09	U
6/21/2021	Bromochloromethane	<0.09	U
6/21/2021	Bromodichloromethane	<0.09	U
6/21/2021	Carbon tetrachloride	<0.09	U
6/21/2021	cis-1,3-Dichloropropene	<0.09	U
6/21/2021	Dibromochloromethane	<0.09	U
6/21/2021	Styrene	<0.09	U
6/21/2021	Tetrachloroethene	<0.09	U
6/21/2021	trans-1,3-Dichloropropene	<0.09	U
6/21/2021	1,1,2,2-Tetrachloroethane	<0.1	U
6/21/2021	1,1,2-Trichloroethane	<0.1	U
6/21/2021	1,2,4-Trimethylbenzene	<0.1	U
6/21/2021	1,4-Dichlorobenzene	<0.1	U
6/21/2021	1,1,2-Trichloro-1,2,2-Trifluoroethane	<0.11	U
6/21/2021	2,2-Dichloropropane	<0.11	U
6/21/2021	Carbon Disulfide	<0.12	U
6/21/2021	Vinyl Acetate	<0.12	U
6/21/2021	Dichlorodifluoromethane	<0.13	U
6/21/2021	Trichlorofluoromethane	<0.13	U
6/21/2021	m,p-Xylene	<0.14	U
6/21/2021	Methyl tert-butyl Ether	<0.14	U
6/21/2021	Bromoform	<0.15	U
6/21/2021	1,2,3-Trichloropropane	<0.16	U
6/21/2021	Chloroethane	<0.18	U
6/21/2021	n-Butylbenzene	<0.18	U
6/21/2021	1,2,4-Trichlorobenzene	<0.21	U
6/21/2021	Xylenes, total	<0.22	U
6/21/2021	1,2,3-Trichlorobenzene	<0.25	U
6/21/2021	Chloromethane	<0.27	U
6/21/2021	Naphthalene	<0.27	U
6/21/2021	1,2-Dibromo-3-chloropropane	<0.39	U
6/21/2021	Acrylonitrile	<0.4	U
6/21/2021	Hexachloro-1,3-Butadiene	<0.41	U
6/21/2021	Iodomethane	<0.43	U
6/21/2021	Methylene Chloride	<0.53	U
6/21/2021	2-Chloroethyl vinyl ether	<0.55	U
6/21/2021	trans-1,4-Dichloro 2-Butene	<0.6	U
6/21/2021	Bromomethane	<0.74	U
6/21/2021	2-Butanone	<1.77	U
6/21/2021	4-Methyl-2-Pentanone	<1.9	U
6/21/2021	2-Hexanone	<2.06	U
6/21/2021	2-Pentanone	<2.34	U
6/21/2021	Acrolein	<2.7	U
6/21/2021	Acetone	<4.33	U

OF-3- middle of water column sample - all analytes

Semi volatiles by EPA 8270E			
Date	Parameter	Concentration (µg/L)	Flag
6/21/2021	Chrysene	0.6J	J
6/21/2021	Pyrene	0.7J	J
6/21/2021	Hexachlorobutadiene	<0.1	U
6/21/2021	2-Methylnaphthalene	<0.2	U
6/21/2021	Naphthalene	<0.2	U
6/21/2021	N-Nitroso-di-n-Propylamine	<0.2	U
6/21/2021	Phenanthrene	<0.2	U
6/21/2021	Phenol	<0.2	U
6/21/2021	1,2,4-Trichlorobenzene	<0.3	U
6/21/2021	1,2-Dichlorobenzene	<0.3	U
6/21/2021	1,3-Dichlorobenzene	<0.3	U
6/21/2021	1,4-Dichlorobenzene	<0.3	U
6/21/2021	1-Methylnaphthalene	<0.3	U
6/21/2021	2-Methylphenol	<0.3	U
6/21/2021	4-Bromophenyl phenyl ether	<0.3	U
6/21/2021	Acenaphthene	<0.3	U
6/21/2021	Acenaphthylene	<0.3	U
6/21/2021	Dibenzofuran	<0.3	U
6/21/2021	Fluorene	<0.3	U
6/21/2021	Hexachloroethane	<0.3	U
6/21/2021	2-Chlorophenol	<0.4	U
6/21/2021	4-Chlorophenylphenyl ether	<0.4	U
6/21/2021	4-Methylphenol	<0.4	U
6/21/2021	Anthracene	<0.4	U
6/21/2021	Benzo(a)anthracene	<0.4	U
6/21/2021	bis(2-chloroethyl) ether	<0.4	U
6/21/2021	Butylbenzylphthalate	<0.4	U
6/21/2021	Dibenzo(a,h)anthracene	<0.4	U
6/21/2021	Diethyl phthalate	<0.4	U
6/21/2021	Dimethylphthalate	<0.4	U
6/21/2021	Di-n-Octylphthalate	<0.4	U
6/21/2021	Fluoranthene	<0.4	U
6/21/2021	Hexachlorobenzene	<0.4	U
6/21/2021	Indeno(1,2,3-cd)pyrene	<0.4	U
6/21/2021	Nitrobenzene	<0.4	U
6/21/2021	N-Nitrosodiphenylamine	<0.4	U
6/21/2021	2,2'-Oxybis(1-chloropropane)	<0.5	U
6/21/2021	2-Chloronaphthalene	<0.5	U
6/21/2021	2-Nitrophenol	<0.5	U
6/21/2021	Benzo(a)pyrene	<0.5	U
6/21/2021	Benzo(g,h,i)perylene	<0.5	U
6/21/2021	bis(2-Ethylhexyl)phthalate	<0.5	U
6/21/2021	Di-n-Butylphthalate	<0.5	U
6/21/2021	Isophorone	<0.5	U
6/21/2021	Bis(2-Chloroethoxy)methane	<0.6	U
6/21/2021	Carbazole	<0.6	U
6/21/2021	Benzofluoranthenes, Total	<0.8	U
6/21/2021	2,4-Dimethylphenol	<1	U
6/21/2021	4-Nitrophenol	<1	U
6/21/2021	Benzyl Alcohol	<1	U
6/21/2021	3,3'-Dichlorobenzidine	<1.6	U
6/21/2021	2,4,5-Trichlorophenol	<1.8	U
6/21/2021	2,4,6-Trichlorophenol	<1.9	U
6/21/2021	2,4-Dichlorophenol	<1.9	U
6/21/2021	4-Chloroaniline	<1.9	U
6/21/2021	4-Nitroaniline	<1.9	U
6/21/2021	2,4-Dinitrotoluene	<2	U
6/21/2021	2-Nitroaniline	<2	U
6/21/2021	4-Chloro-3-Methylphenol	<2	U
6/21/2021	2,6-Dinitrotoluene	<2.1	U
6/21/2021	3-Nitroaniline	<2.2	U
6/21/2021	Hexachlorocyclopentadiene	<2.5	U
6/21/2021	Pentachlorophenol	<2.6	U
6/21/2021	Benzoic acid	<3.4	U
6/21/2021	2,4-Dinitrophenol	<4.9	U
6/21/2021	4,6-Dinitro-2-methylphenol	<5	U

Attachment 2 - Historical Photos and Maps in the Area of Apron R and Other Relevant Information

Photo 1. Aerial photo from 1936 of the area, this pre-dates Boeing and is all as farmland. Important structures in the photo are the Shuffleton power plant with the associated fueling dock and two large oil tanks.

Photo 2. Aerial photo from approximately 1960 of the area containing a portion of the current Boeing Renton Facility. Important structures in the photo include the presence of the fueling dock (bottom left) and two large oil tanks for Shuffleton power plant, with associated pump house and containment berms. The pipelines are above ground by the tanks as they bend over the berms and 2 fuel lines appear to be above ground to the fueling dock. Some type of structure exists on land at end of the fueling dock and is included on 1967 drawings. This 1960 aerial photo is before Boeing Buildings 4-81/82 and Apron R were constructed in 1967.

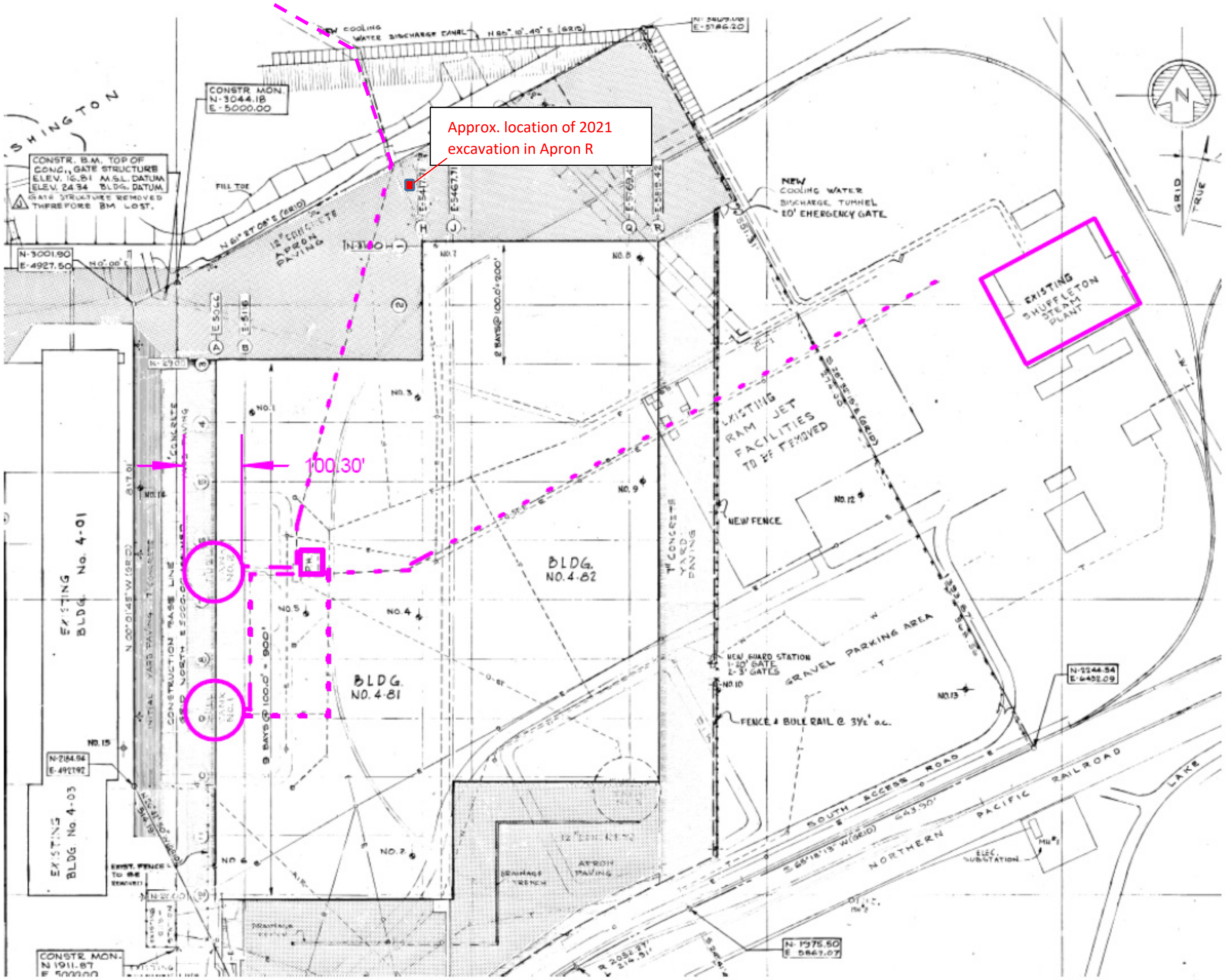


Photo 3. 1967 Boeing 'As-Built' construction drawing of Building 4-81/82 area. The drawing background includes of the prior Shuffleton Power plant and the associated infrastructure highlighted in purple.

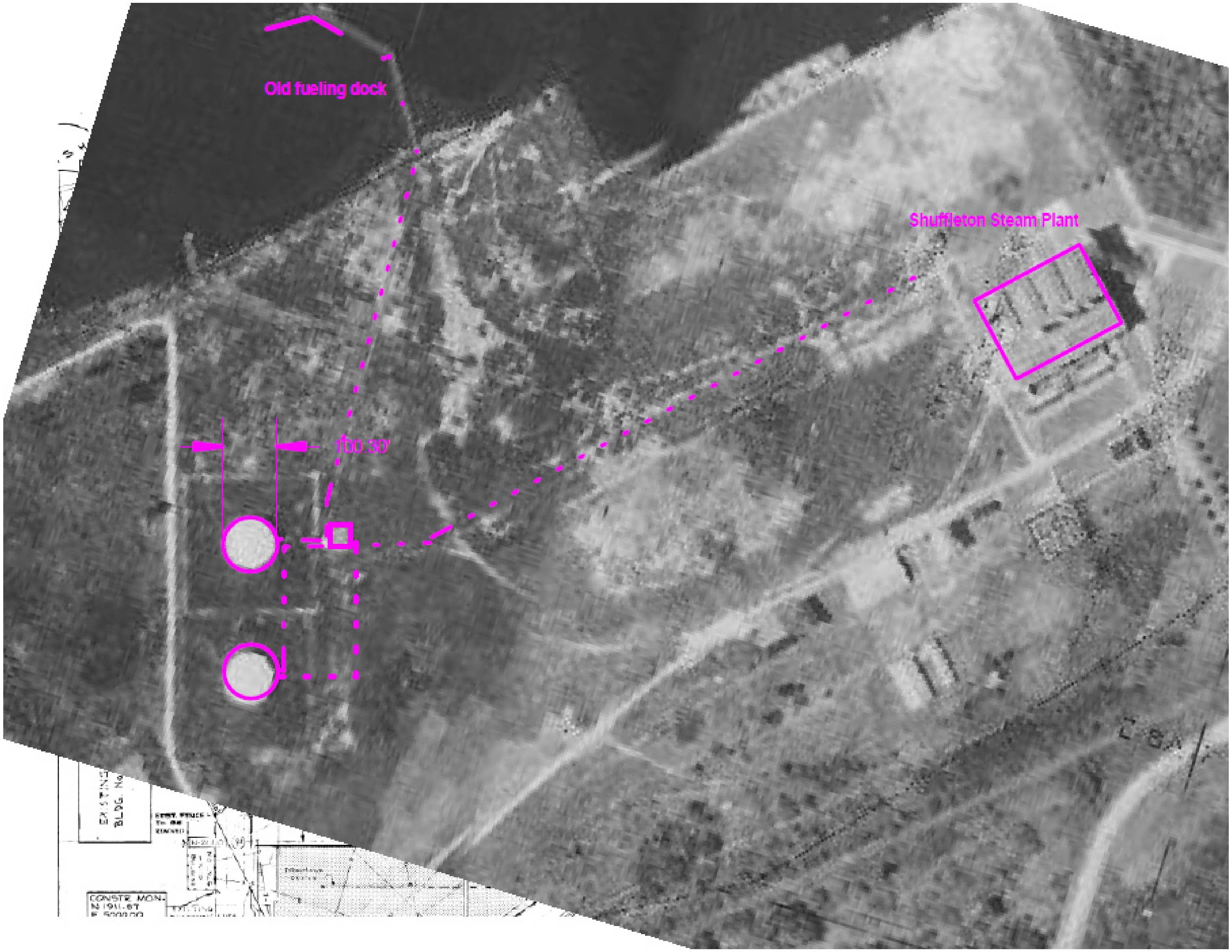


Photo 4. 1967 details from Boeing Construction drawing of Building 4-81/82 with overlay on the 1936 aerial photo of the Shuffleton Power plant and associated infrastructure, highlighted in purple.

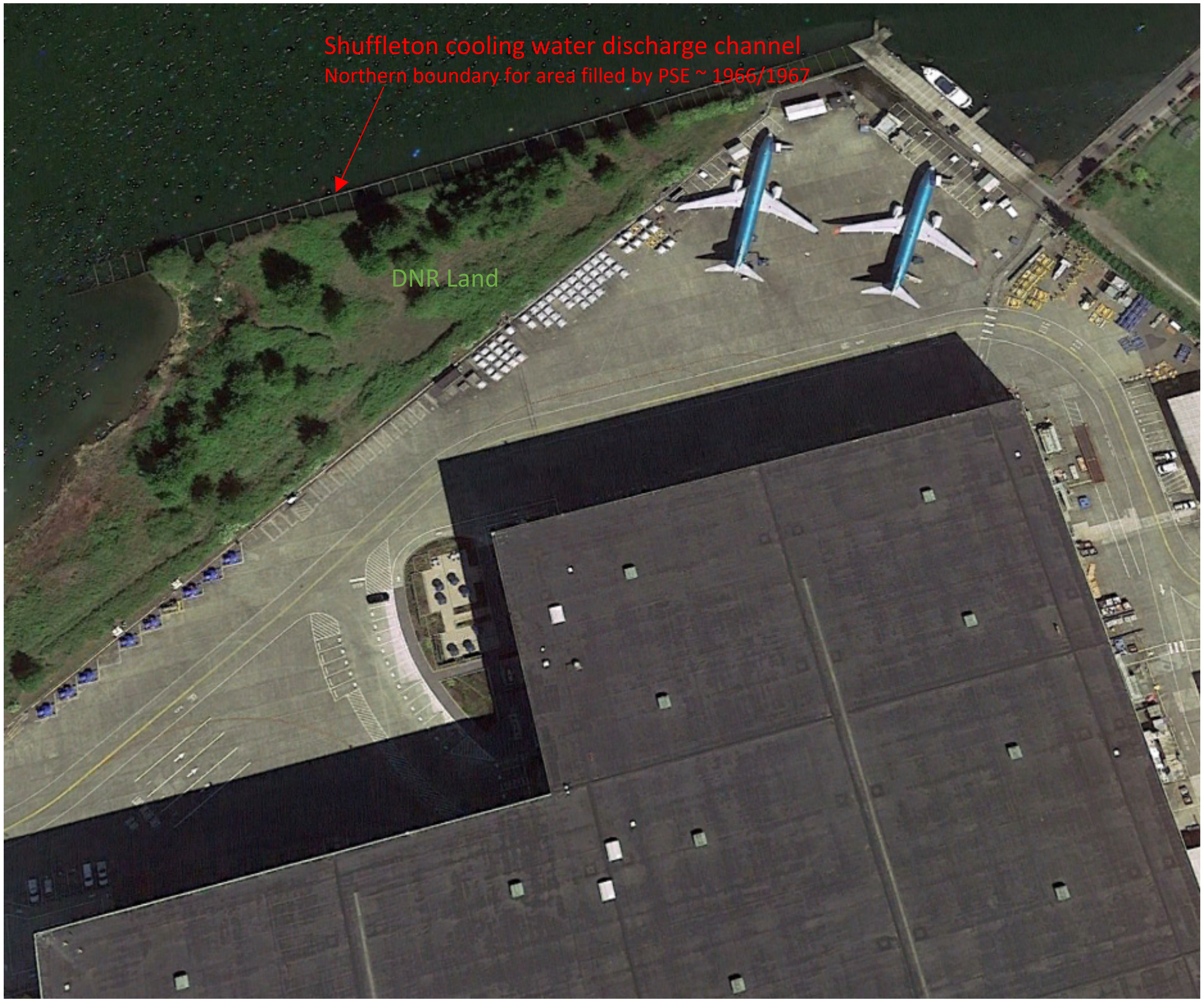


Photo 5. 2013 Aerial photo of Apron R and Building 4-81/82. The Shuffleton cooling water discharge canal is visible in the image. The prior cooling water discharge canal is important as its construction was part of the dismantling of the fueling dock and filling the DNR lease land in 1967 (completed by PSE).

Photo 6. 2014 Aerial photo of Apron R and Building 4-81/82. The storm drain outfall is visible during the removal of the cooling water discharge channel from the Shuffleton Power plant (this work was completed by others at the start of the Southport redevelopment)

Photo 7. 2015 Aerial photo of Apron R and Building 4-81/82. With a visible excavation line in the DNR lease parcel (leased to PSE) where the storm water drain has been buried. The location of the storm water lines to outfall would have crossed path with any historical lines from the prior Shuffleton refueling dock.

DEPARTMENT OF ECOLOGY

Toxics Cleanup Program

Memorandum

March 12, 2018

TO: TCP Files for PSE Shuffleton Steam Plant, Shuffleton Substation, and DNR Lease Area

FROM: Donna Musa, Toxics Cleanup Program, Northwest Regional Office

SUBJECT: Recommendation for Site and File Reorganization

Ecology's Integrated Site Information System (ISIS) database indicates only one "site" for the multiple parcel property known as PSE Shuffleton Substation. After a review of the site files (see attached PSE Shuffleton Summary: Site History), it has been determined that there are three separate areas of contamination, not one, as previously reflected in ISIS and Ecology site files.

Ecology will be updating the ISIS database and site files to reflect the following:

1) PSE Shuffleton Substation
   Also known as: PSE Shuffleton Complex, Puget Sound Power & Light
   Address: 1095 Lake Washington Blvd N, Renton
   Parcels: 0823059178, 0823059191
   Facility Site ID: 14655
   Cleanup Site ID: 6716
   UST ID: 8530
   Historic LUST Release ID: 301394
   Site Status: Cleanup Started

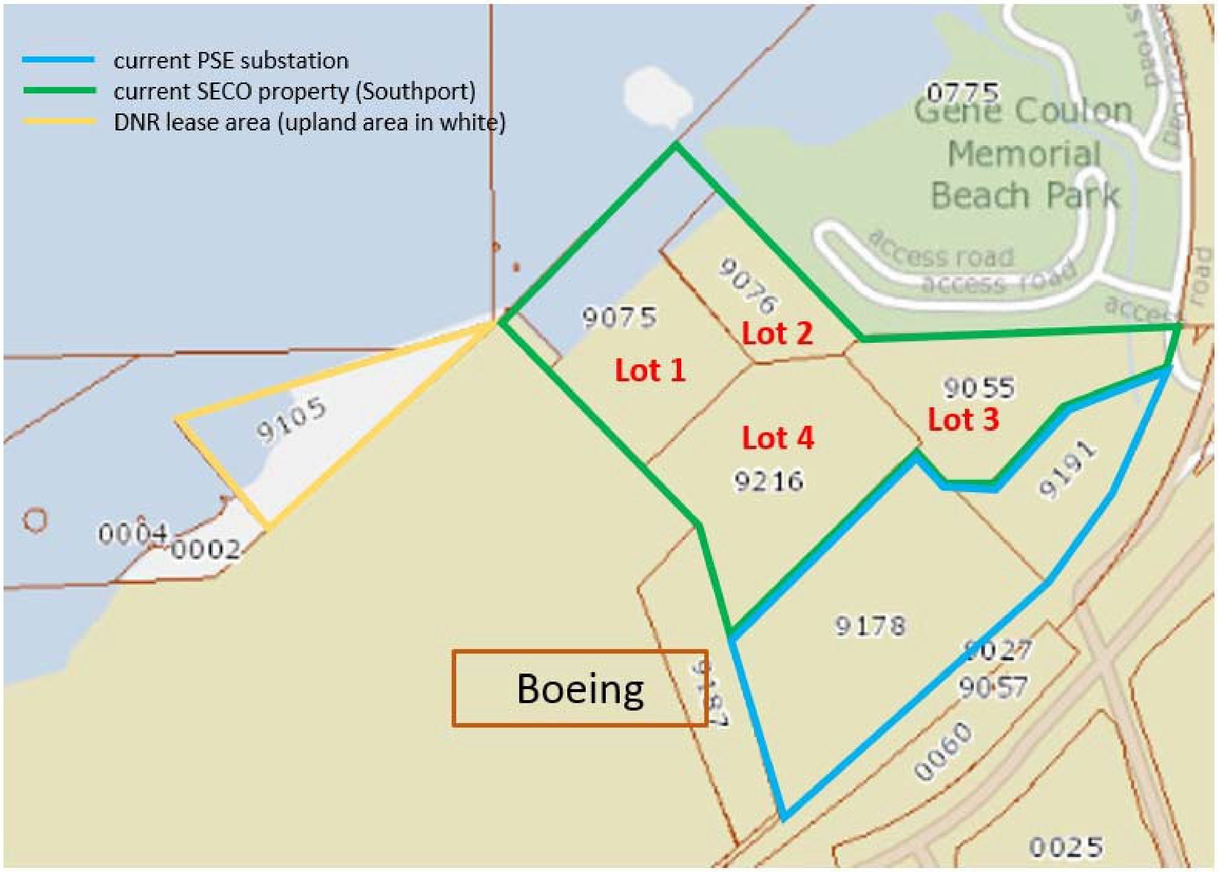
2) PSE Shuffleton Steam Plant
   Also known as: PSE Shuffleton Complex, Southport, SECO
   Address: 1101 Lake Washington Blvd N, Renton
   Parcels: 0523059075, 0523059076, 0823059055, 0823059216
   Facility Site ID: 82611157
   Cleanup Site ID: 14483
   Unit 1: Lots 1-3, NW0149, NFA on 9/20/99
   Unit 2: Lot 4, NW0461, NFA on 12/23/00
   Site Status: No Further Action

3) PSE Shuffleton DNR Lease Area
   Address: N/A
   Parcel: 0723059105
   Facility Site ID: 82611157
   Cleanup Site ID: 14484
   Site Status: No Further Action (6/26/00)

SITE HISTORY

The Puget Sound Energy Shuffleton site housed two main facilities: a steam plant on the northern portion of the site and a substation on the southern portion of the site. The steam plant portion of the property also contained other associated buildings, including a pump house, analytical laboratory, and storage buildings. The steam plant was functional daily until the mid-1950s, and remained functional in a standby status until 1989. The steam plant and associated buildings were demolished in the mid-1990s, at which point remediation of this portion of the site began prior to sale of the property. The substation portion of the site remains a functioning PSE property to the present.

The former steam plant portion of the property was divided into four regions, referred to as Lots 1-4. These regions correspond to current parcel numbers 0523059075, 0523059076, 0823059055, and 0823059216. The current Shuffleton substation property includes parcel numbers 0823059178 and 0823059191. A DNR lease area along Lake Washington was historically held by PSE. The DNR area primarily borders the Boeing property to the west of the site, and is approximately designated by current parcel 0723059105. Lots 1-4 were sold to SECO Development in 1999. Current property boundaries are indicated in the figure below.



CLEANUP ACTIVITIES PRIOR TO NFA LETTERS

The upland site first entered VCP in 1998 (VCP # NW0149). Multiple meetings are documented as being attended by PSE, consulting, and Ecology staff to discuss cleanup while remedial actions were being performed. The focus of the cleanup was Lots 1-4, and not the section of the property that was to remain PSE property. Chemicals of concern in this area included TPH, PAH, PCB, arsenic, and lead in soil, with areas of contamination located near areas of former plant activity. Groundwater was also characterized during remedial activities, and the only chemical present at elevated concentrations was arsenic. Based on information from other sites in the area, this was attributed to high natural background concentrations of arsenic in the region and not attributed to site activities.

Primary remediation activities were completed in 1999 (VCP # NW0149). Following this, an NFA letter was issued by Ecology on September 20, 1999 for soil and groundwater on Lots 1, 2, and 3. One remaining area of petroleum contaminated soil remained on Lot 4, and it was decided that this area would be addressed during construction activities when the soil would be accessible. Remediation was completed on Lot 4 in 2000 (VCP # NW0461), and an NFA letter for Lot 4 soil was issued on December 23, 2000. Groundwater conditions on Lot 4 had not been reported to differ from Lots 1-3, so it is unclear why different media were included in the two NFA letters.

The portion of the site to be retained by PSE was not well characterized during remedial activities. One soil sampling area on Lot 3 (EZ-11) extended across boundaries into the substation property. Soil on the SECO property were cleaned up, and contaminated soil on the PSE property were left in place due to difficulties in accessibility. Multiple reports were submitted documenting the removal of USTs near the former pump island, including LUST #3865 (UST #8530), and the cleanup of contaminated soil in this area. The DNR lease area was addressed separately from the steam plant and substation property. In 1966-1967, while they held the DNR lease, PSE created the upland portion of the lease area with dredged Lake Washington fill, and were therefore responsible for cleaning up any contamination prior to ending their lease. An NFA letter for the upland portion of the DNR lease area was issued on June 26, 2000.

CLEANUP ACTIVITES SINCE NFA LETTERS

The only cleanup activity reported to Ecology on Lots 1-4 since 2000 was the discovery and cleanup of a small area of Bunker C fuel oil contaminated soil. This was discovered on Lot 4 during construction activities in 2001 and removed. On the PSE substation, multiple remediated spills have been reported. Details on these spills are in the table below.

DATE OF REPORT	TYPE OF SPILL	ERTS#
October 2001	mineral oil	520270
February 2002	mineral oil	
March 2002	mineral oil	525102
May 2007	mineral oil	
January 2014	mineral oil	645655
April 2014	diesel	647602
October 2014	mineral oil	651666
November 2016	mineral oil	665783
April 2017	mineral oil	670760

CURRENT QUERY REGARDING NFA FOR LOTS 1-4

On December 20, 2017, FloydSnider submitted a letter to Ecology on behalf of SECO Development inquiring about a change in site status from NFA to Cleanup Started. They believe that this change in designation was related to a mineral oil spill reported on the PSE substation property in February 2017. This spill was designated NFA during the Initial Investigation. For this spill, a new site ID (CSID 14410) was created for the substation property; all cleanup activities from both the SECO property and the substation prior to this had been recorded in the original PSE Shuffleton cleanup site (CSID 6716). They inquired both about reestablishing the NFA for the site, and the possibility of splitting the sites to designate incidents on SECO property from those on the PSE substation property.

From notes from meetings attended by Ecology and PSE as part of the VCP cleanup process, it appears that separation of the sites was considered before cleanup began. To expedite cleanup, it was decided to leave it as one site with the option to separate the sites at a later date. Historically, there has been a clear difference in the level of cleanup activities on the SECO vs substation properties. Contamination on the SECO property has, to date, all been attributable to historic PSE contamination. In contrast, the substation property is still active and has reported a number of spills and cleanups that are unrelated to activities on the SECO property. Current tax parcel boundaries capture the designation between the two sites well, and would provide a good basis for site delineation.

Attachment 3 – Existing Utility Drawings in Apron R Area

TED-40-4013

C-18003506

LUA:18-00293

PR:18-000208

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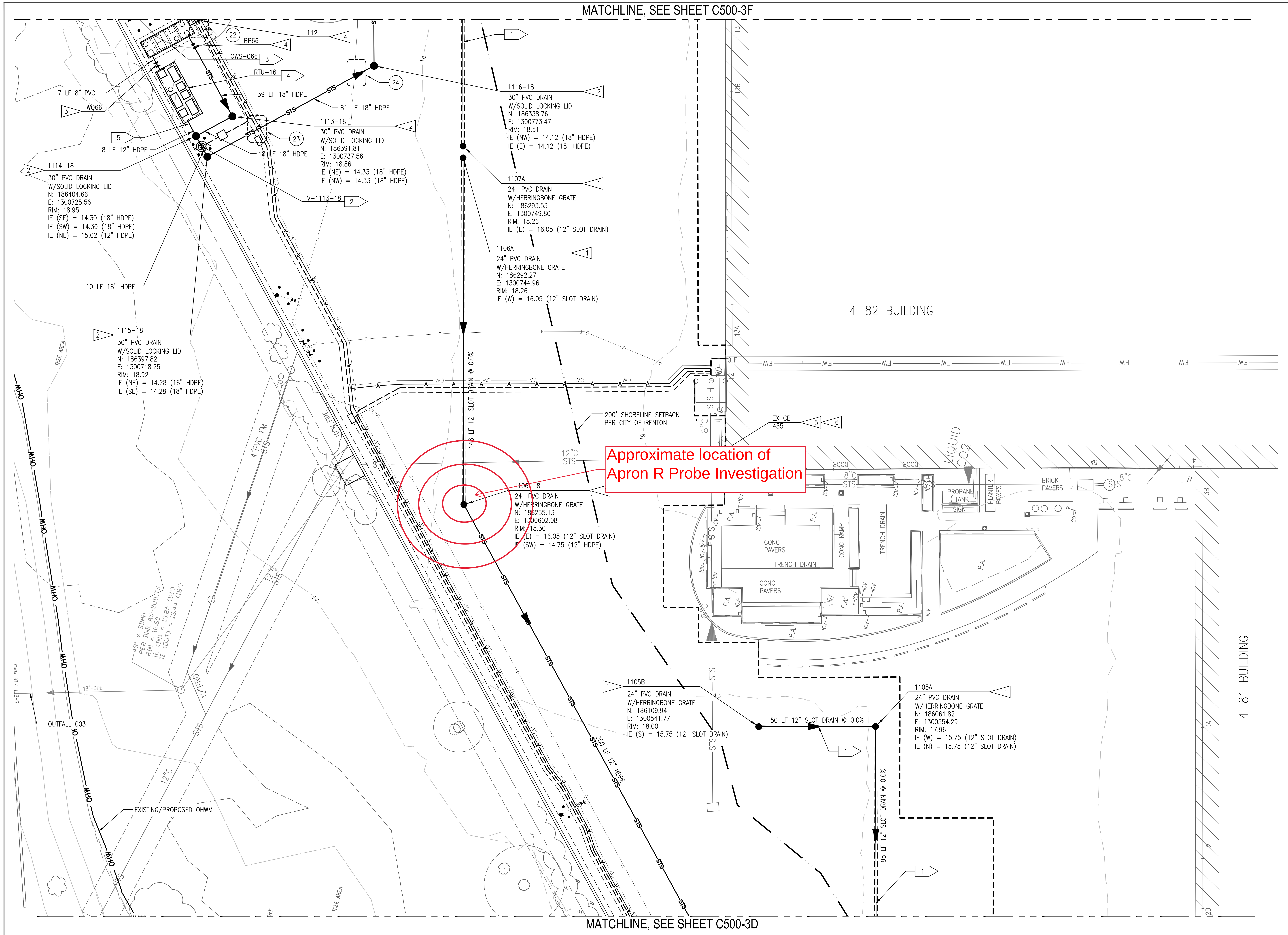


GENERAL NOTES

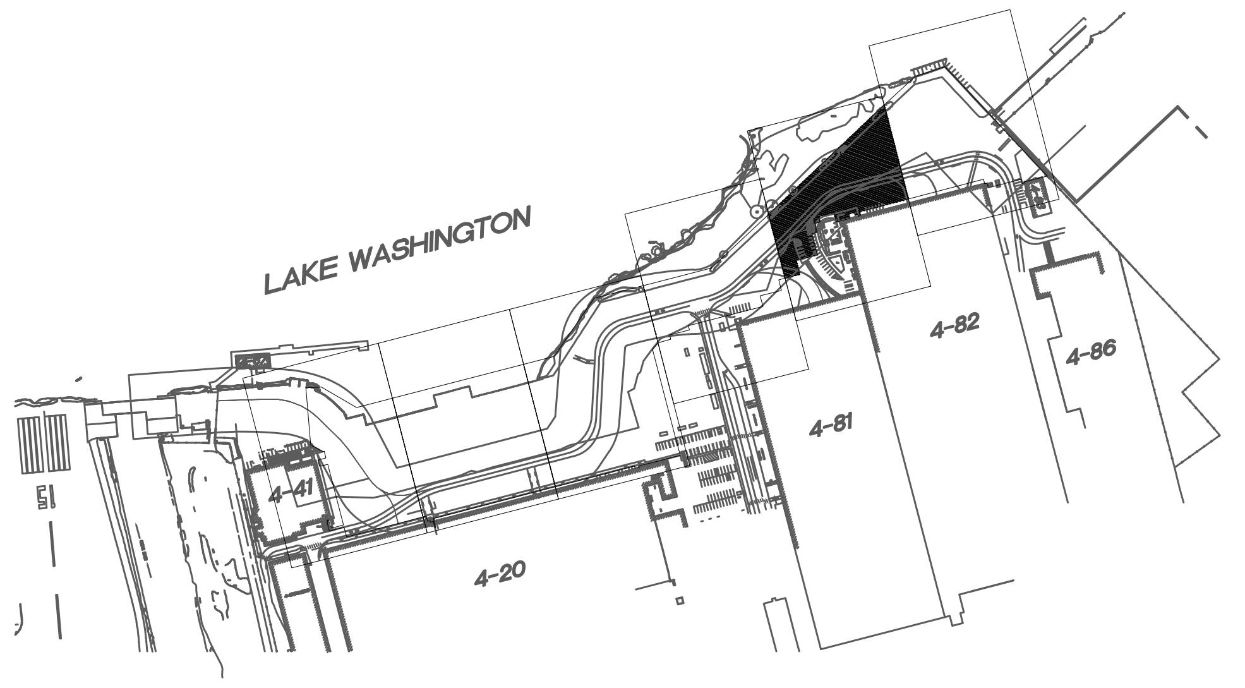
1. HORIZONTAL DATUM: WASHINGTON STATE COORDINATE SYSTEM, NORTH ZONE, NORTH AMERICA DATUM 1983(91). VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29). VERTICAL DATUM CONVERSION: NGVD29 TO THE NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88) = NGVD29 + 3.60 FEET.
2. THERE SHALL BE NO EXPOSED GALVANIZED MATERIALS, COATINGS OR ZINC APPLIED SURFACE TREATMENTS ON ANY EXTERIOR OR UNDERGROUND MATERIALS OR SURFACES. ALL GALVANIZED OR ZINC APPLIED MATERIALS OR COATINGS SHALL BE PERMANENTLY PAINTED OR COATED TO PREVENT EXPOSURE OF THE GALVANIZED/ZINC MATERIALS PRIOR TO INSTALLATION OR COMPLETION OF CONSTRUCTION.
3. PROVIDE 6" MINIMUM VERTICAL CLEARANCE FROM O.D. AT STORM CROSSINGS
4. PROVIDE ETHAFOAM BETWEEN PIPES WHERE 6" MINIMUM CLEARANCE CANNOT BE ACHIEVED
5. LOCATIONS OF DRAINAGE STRUCTURES SHOWN ON THIS DRAWING ARE TO THE CENTER OF THE STRUCTURE UNLESS NOTED OTHERWISE.
6. SEE STORM DRAINAGE PROFILES ON SHEETS C500-3G TO C500-3K FOR PIPE AND STRUCTURE ELEVATIONS AND UTILITY CROSSING INFORMATION.
7. SEE GENERAL NOTES ON SHEET G2.
8. PROVIDE MODIFIED CATCH BASIN COLLARS PER DETAILS ON SHEET C500-3L AT ALL EXISTING, NEW, AND REPLACED DRAINAGE STRUCTURES.
9. PERMANENT WATER QUALITY TREATMENT FACILITIES SHALL NOT BE USED TO CONVEY OR CONTAIN CONSTRUCTION STORM WATER. NEW FACILITIES SHALL BE KEPT OFFLINE UNTIL PROJECT IS COMPLETE.

(#) UTILITY CROSSING. SEE SHEET C500-3K FOR UTILITY CROSSING.

1 SLOTTED DRAIN WITH 12" SLOT PER DETAILS ON SHEET C500-3M
2 ACTUATED VALVE PER DETAILS ON SHEET C500-3N
3 COMBINED BYPASS AND OIL/WATER SEPARATOR VAULT PER DETAIL 1 ON C500-3R
4 MODULAR WETLAND PER DETAILS ON SHEET C500-3X
5 PROVIDE 12" TIDEFLEX CHECKMATE INLINE VALVE PER DETAIL 2 ON C500-3R

CONSTRUCTION NOTES

1 PROVIDE 24" PVC DRAIN BASIN WITH HERRINGBONE GRATE
2 PROVIDE 30" PVC DRAIN BASIN WITH SOLID LOCKING LID
3 PROVIDE 8" GATE VALVE AND VALVE BOX, LID LETTERING SHALL READ "SD"
4 PROVIDE 18" GATE VALVE AND VALVE BOX, LID LETTERING SHALL READ "SD"
5 ADJUST EXISTING STRUCTURE RIM TO FINISH GRADE
6 PROVIDE SPRING ASSISTED HATCH, NEENAH FOUNDRY PRODUCT R-3498-K2S OR APPROVED EQUAL



KEY PLAN
SCALE: N.T.S.

20 0 20 40
scale feet

N

— W4700331
ISSUED FOR CONSTRUCTION
11/15/19

CALL 48 HOURS
BEFORE YOU DIG
1-800-424-5555

WSP USA Inc.
33301 9th Avenue South
Suite 300
Federal Way, WA 98003-2600
TEL: (206) 431-2300
FAX: (206) 431-2250

SYM	REVISION	BY	APPROVED	DATE	SYM	REVISION	BY	APPROVED	DATE
–	APRON R INFRASTRUCTURE – IFC W4700331	WSP	SPT	11/15/19					

BOEING®

STEVEN P. TRUE
31271
11/15/2019

ACCEPTABILITY
THIS DESIGN AND/OR SPECIFICATION IS APPROVED

APPROVED BY	DEPT.	DATE

		DATE
DRAWN	JDM	06/08/18
CHECKED	SPT	06/08/18
ENGINEER	BEE	06/08/18
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APPROVED		
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SUBTITLE
STORM DRAINAGE PLAN - SHEET 5

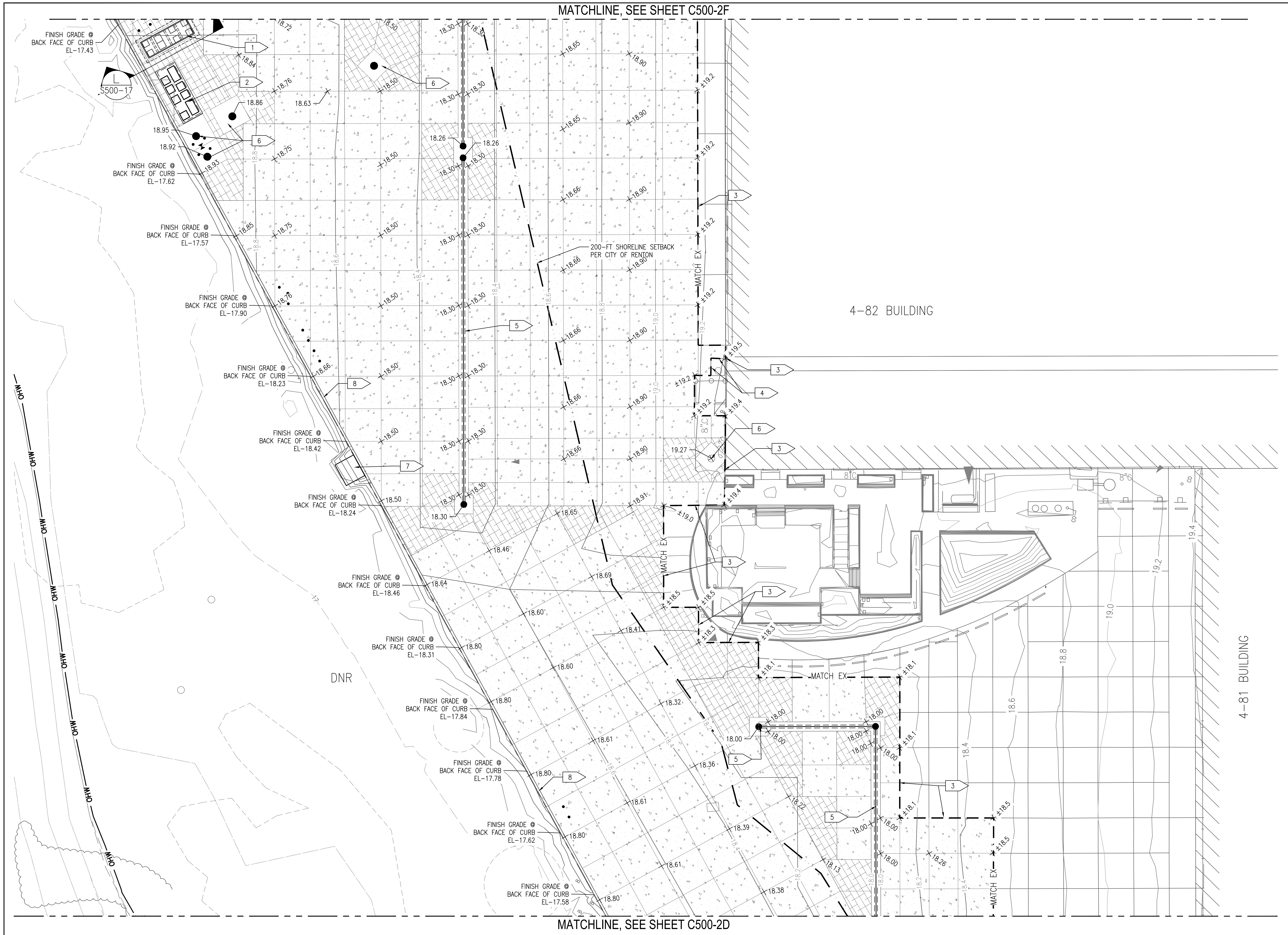
TITLE
APRON R INFRASTRUCTURE
RENTON SITE
CIVIL MASTER SITE RENTON, WA

CURRENT REVISION	SYMBOL	DATE
W4700331	—	11/15/19

SHEET C500-3E C44

JOB NO. W4700331
COMP NO.
DWG NO. 4-APRON-R-C500-3E

TED-40-4013



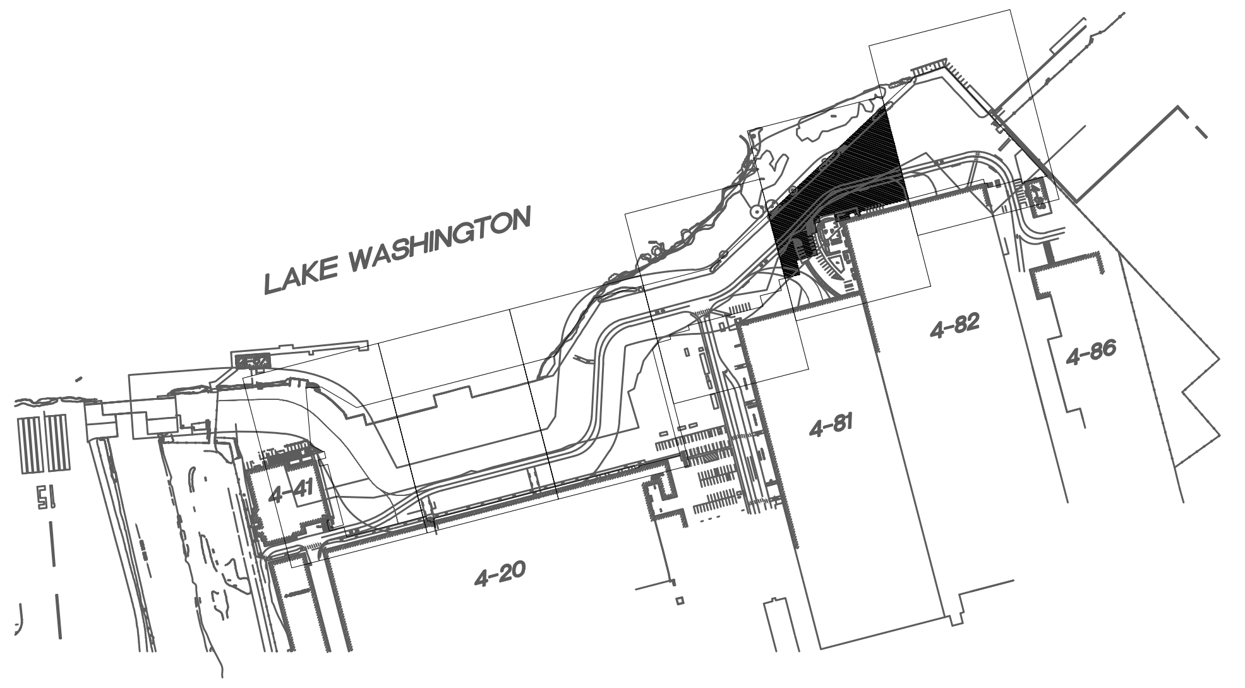
LEGEND

▨	12" THICK REINFORCED CONCRETE PAVEMENT
▨	12" THICK REINFORCED CONCRETE RELIEVING SLAB
▨	14.5" THICK REINFORCED CONCRETE RELIEVING SLAB
▨	14.5" THICK REINFORCED CONCRETE PAVEMENT
☐	14.5" THICK CEMENT CONCRETE PAVEMENT

GENERAL NOTES

1. HORIZONTAL DATUM: WASHINGTON STATE COORDINATE SYSTEM, NORTH ZONE, NORTH AMERICA DATUM 1983(91). VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29). VERTICAL DATUM CONVERSION: NGVD29 TO THE NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88) = NGVD29 + 3.60 FEET.
2. THERE SHALL BE NO EXPOSED GALVANIZED MATERIALS, COATINGS OR ZINC APPLIED SURFACE TREATMENTS ON ANY EXTERIOR OR UNDERGROUND MATERIALS OR SURFACES. ALL GALVANIZED OR ZINC APPLIED MATERIALS OR COATINGS SHALL BE PERMANENTLY PAINTED OR COATED TO PREVENT EXPOSURE OF THE GALVANIZED/ZINC MATERIALS PRIOR TO INSTALLATION OR COMPLETION OF CONSTRUCTION.
3. SEE SHEETS C500-2G THROUGH C500-2Z FOR PAVEMENT, GRADING, AND SUBGRADE DETAILS.
4. SEE STRUCTURAL SHEET S500-15 THROUGH S500-17 FOR REINFORCED PAVEMENT, RELIEVING SLAB AND TRANSITION DETAILS.
5. ALL ELEVATIONS ARE GIVEN AT THE TOP OF PAVEMENT/FACE OF CURB UNLESS OTHERWISE NOTED.
6. PROVIDE EMERGENCY DRAINAGE SPILLWAY AT ALL 4" RAISED CURBS UNLESS OTHERWISE NOTED. SEE DETAIL 5 ON SHEET C500-2H.
7. SEE CIVIL SITE PLANS ON SHEETS C80 THROUGH C85 FOR HORIZONTAL CONTROL.

1	COMBINED BYPASS AND OIL/WATER SEPARATOR WITH REINFORCED SLAB LID PER DETAILS ON SHEET S500-18 THROUGH S500-23 AND LID ELEVATIONS PER	1 / C300-3R
2	MODULAR WETLAND VAULT LID, SEE DETAILS ON SHEET C500-3W FOR LID ELEVATIONS.	
3	PROVIDE TIE IN TO EXISTING REINFORCED CONCRETE SLAB PER DETAIL	5 / C500-2G
4	PROVIDE ISOLATION JOINT AT EXISTING UTILITY VAULT	6 / C500-2G
5	PROVIDE REINFORCED CONCRETE AT SLOT DRAINS AND PVC DRAIN CONNECTIONS PER DETAILS ON SHEET C500-3M.	
6	PROVIDE REINFORCED CONCRETE COLLAR AT DRAINAGE STRUCTURES PER DETAILS ON SHEET C500-3L.	
7	PROVIDE FLUSH CURB AND ACCESS PER DETAIL	4 / C500-2H
8	PROVIDE INTEGRAL CURB AND REINFORCED THICKENED EDGE	3 / C500-2H



KEY PLAN

SCALE: N.T.S.

C-18003506

LUA:18-00293

PR:18-000208

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APPROVED	

SUBTITLE
GRADING/PAVEMENT PLAN - SHEET 5

TITLE
APRON R INFRASTRUCTURE
RENTON SITE

CIVIL MASTER SITE RENTON, WA

CURRENT REVISION	SYMBOL	DATE
W4700331	—	11/15/19

SHEET C500-2E C21

JOB NO. W4700331

COMP NO.

DWG NO. 4-APRON-R-C500-2E

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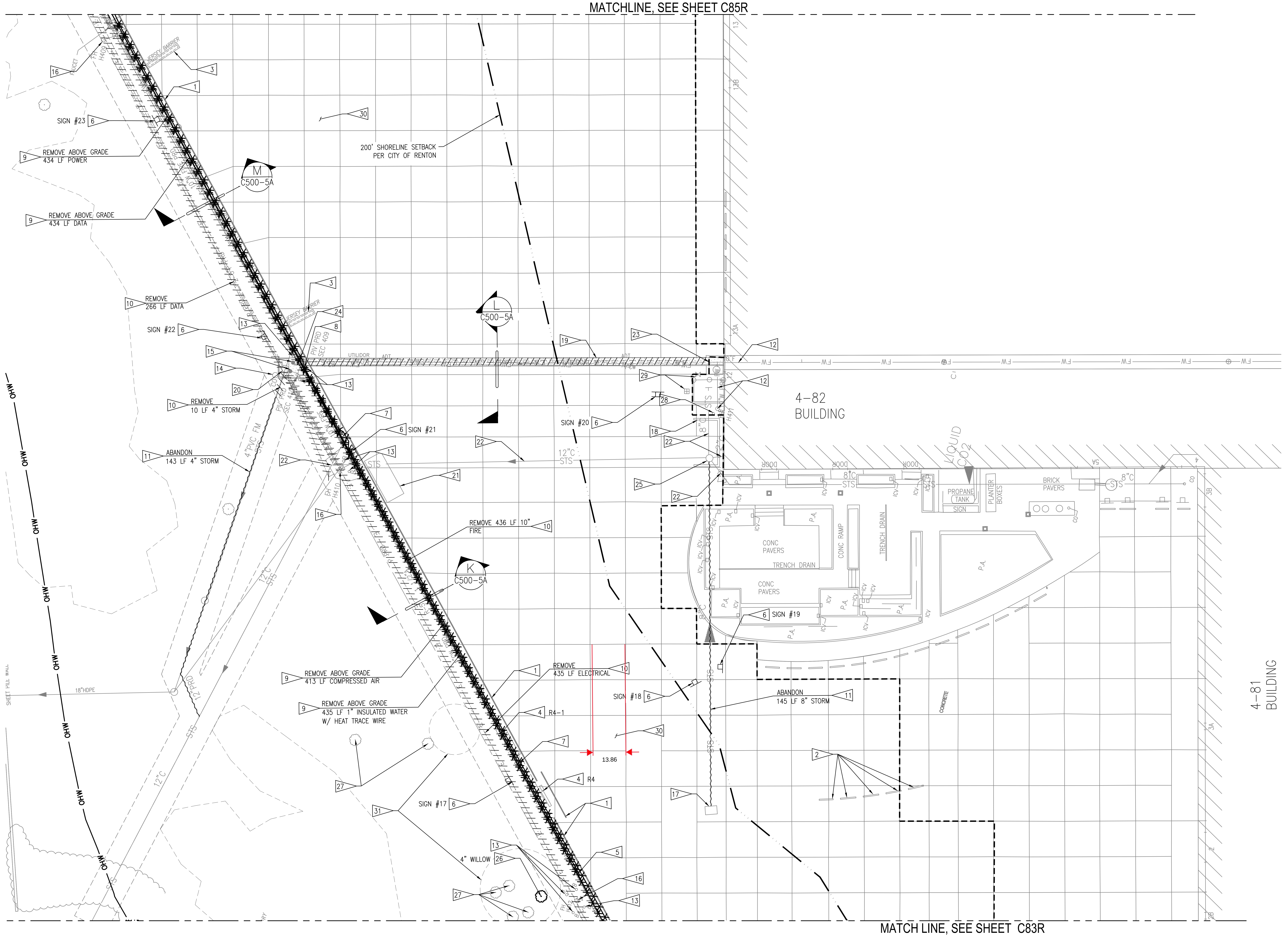

LEGEND

〰〰〰 ABANDON UNDERGROUND UTILITY

- - - - - - PROJECT LIMITS

·/·/·/·/·/·/· REMOVE UNDERGROUND UTILITY

GENERAL NOTES

1. ALL UTILITIES IDENTIFIED TO BE ABANDONED WITH A DIAMETER 8" OR LARGER, SHALL BE FILLED WITH CDF. SEE NOTES ON SHEET G02.
2. REMOVE EXISTING ALL CONCRETE PAVEMENT WITHIN PROJECT LIMITS AS APPLICABLE. PAVEMENT REMOVAL SHALL BE TO NEAREST PANEL JOINT AT BOUNDARIES, SAWCUT AS NECESSARY. SEE SHEET G08 FOR OVERALL EXISTING PAVEMENT THICKNESS PLAN.
3. SEE LANDSCAPE PLANS FOR LIMITS OF INVASIVE SPECIES REMOVAL AND LIMITS OF PLANTING AND IRRIGATION REMOVAL/REPLACEMENT.
4. HORIZONTAL DATUM: WASHINGTON STATE COORDINATE SYSTEM, NORTH ZONE, NORTH AMERICA DATUM 1983(91). VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM 1929 (NGVD29). VERTICAL DATUM CONVERSION: NGVD29 TO THE NORTH AMERICAN VERTICAL DATUM 1988 (NAVD88) = NGVD29 + 3.60 FEET.
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6. REFER TO CHANNELIZATION PLANS FOR SIGN REMOVAL AND RELOCATION.

CONSTRUCTION NOTES

1 REMOVE EXISTING SURFACE MOUNTED WOOD BULLRAIL – 439 LF

2 SALVAGE AND RE-USE EXISTING WHEELSTOP. TO REMAIN PROPERTY OF BOEING – 5 EA

3 REMOVE CONCRETE BARRIER. TO REMAIN PROPERTY OF BOEING CONTRACTOR TO COORDINATE WITH BOEING FOR NEW LOCATION – 28 LF

4 REMOVE EXISTING HARDSTAND – 2 EA

5 REMOVE EXISTING AIR MANIFOLD AND STAND – 1 EA

6 REMOVE EXISTING SIGN, SEE GENERAL NOTE 6

7 REMOVE EXISTING SURFACE MOUNTED COMM J BOX – 2 EA

8 REMOVE EXISTING SURFACE MOUNTED COMM CABINET AND STAND – 1 EA

9 REMOVE EXISTING SURFACE MOUNTED UTILITY

10 REMOVE UNDERGROUND UTILITY

11 ABANDON UNDERGROUND UTILITY

12 PROTECT EXISTING FIRE

13 REMOVE EXISTING BOLLARD – 9 EA

14 PROTECT EXISTING IRRIGATION BOX DURING TEMPORARY DISCONNECTION. RETAIN AND COORDINATE WITH BOEING FOR LOCATION OF RECONNECTION. SEE LANDSCAPE PLANS.

15 REMOVE EXISTING PIV – 2 EA

16 REMOVE EXISTING FIRE HYDRANT – 3 EA

17 REMOVE EXISTING CATCH BASIN – 1 EA

18 REMOVE AND SALVAGE STEEL BULLRAIL AT TRASH ENCLOSURE. TO REMAIN PROPERTY OF BOEING – 40 LF

19 REMOVE EXISTING CONCRETE UTILIDOR AND UTILITIES – 170 LF

20 REMOVE EXISTING VAULT AND SUMP PUMP – 1 EA

21 RELOCATE DISASTER SUPPLY CONNEX. COORDINATE WITH BOEING FOR LOCATION AND REQUIREMENTS. – 1 EA

22 PROTECT EXISTING STORM

23 PROTECT EXISTING VAULT. PROVIDE GROUT SEAL AT UTILITY PENETRATIONS

24 REMOVE EXISTING SURFACE MOUNTED POWER CABINET AND STAND – 2 EA

25 PROTECT EXISTING CATCH BASIN AND ADJUST TO GRADE – 1 EA

26 REMOVE EXISTING TREE

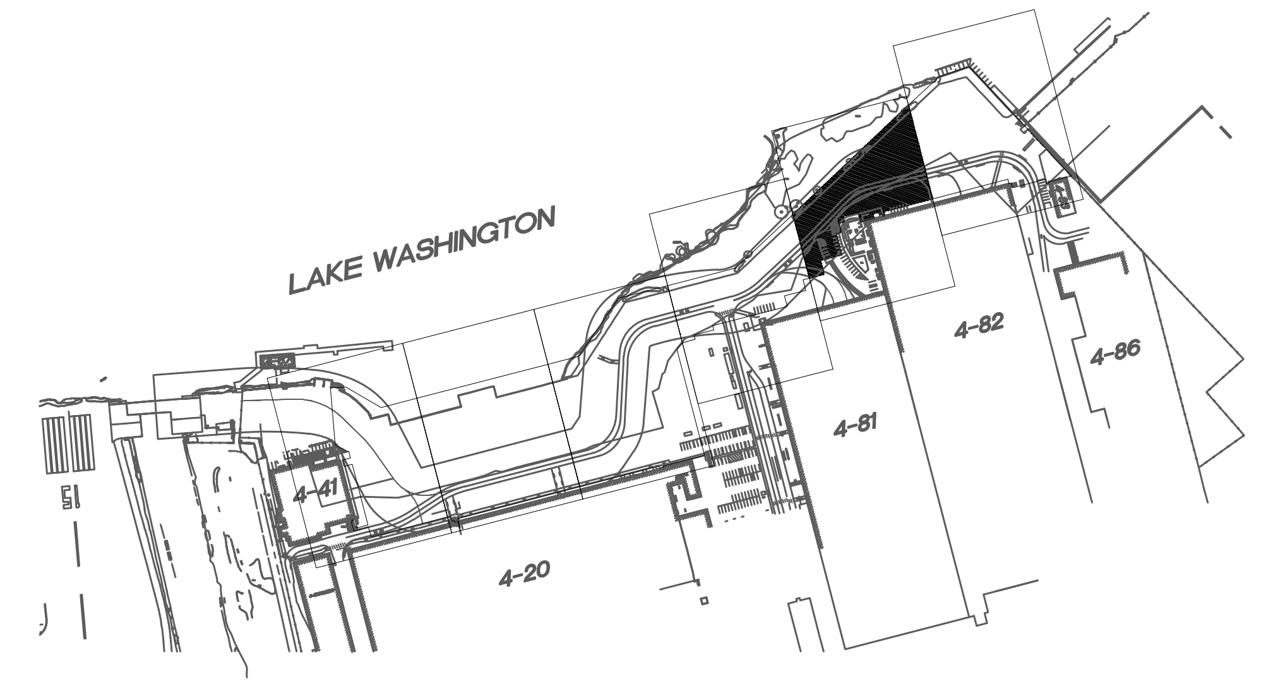
27 PROTECT EXISTING TREE

28 PROTECT EXISTING BOLLARD

29 PROTECT EXISTING VALVE AND ADJUST TO GRADE

30 REMOVE EXISTING CONCRETE PAVEMENT, SEE GENERAL NOTE 2

31 PROTECT VEGETATION UNLESS OTHERWISE NOTED



KEY PLAN
SCALE: N.T.S.

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APPROVED		

SUBTITLE
CIVIL SITE REMOVAL PLAN

TITLE
APRON R INFRASTRUCTURE
RENTON SITE

CIVIL MASTER SITE RENTON, WA

CURRENT REVISION	SYMBOL	DATE
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SHEET C84R C05

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COMP NO.
DWG NO. 4-APRON-R-C84R

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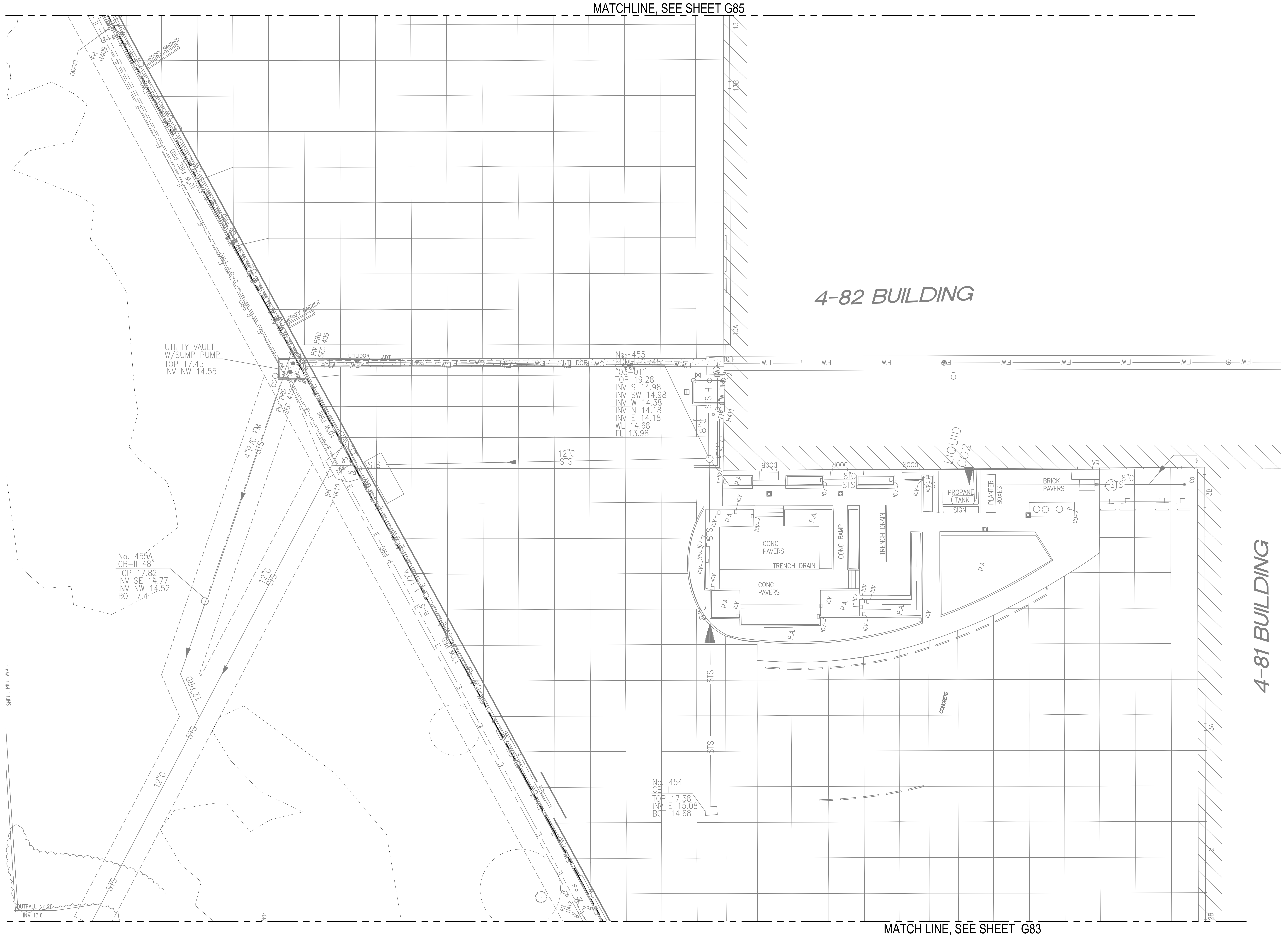

GENERAL NOTES

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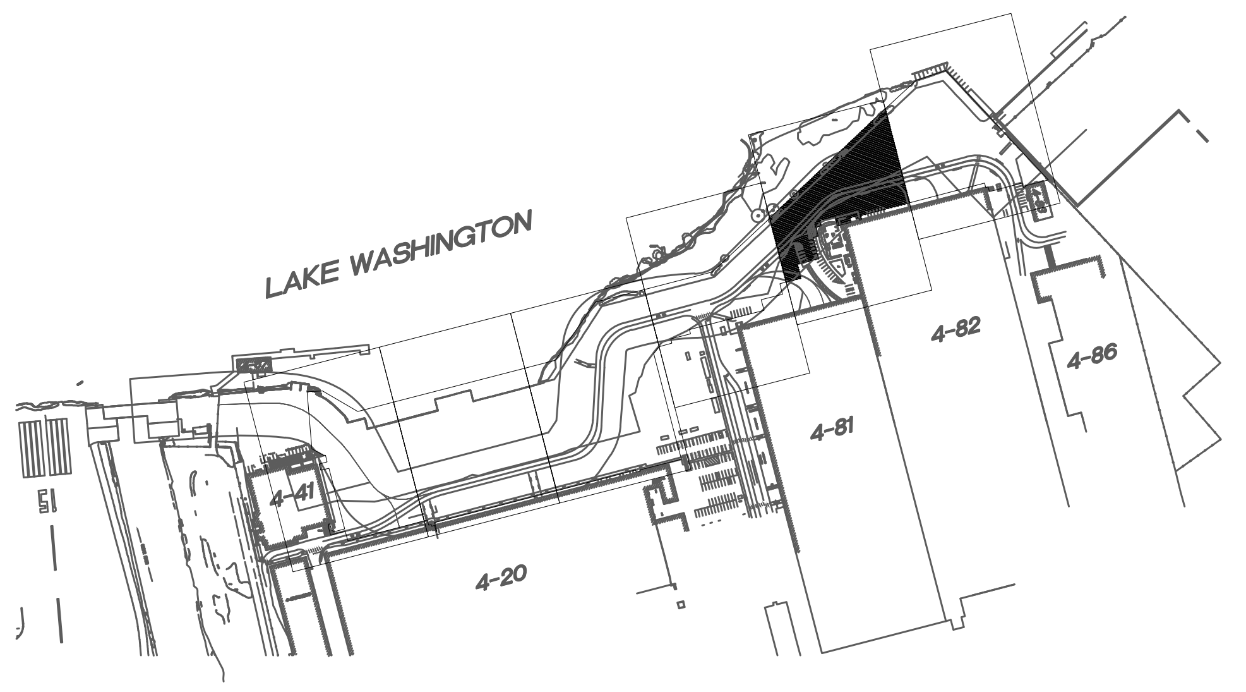
2. ALL LOCATIONS OF EXISTING UTILITIES SHOWN HEREIN HAVE BEEN ESTABLISHED BY FIELD SURVEY OR OBTAINED FROM AVAILABLE RECORDS, AND THEREFORE, SHOULD BE CONSIDERED APPROXIMATE ONLY AND NOT NECESSARILY COMPLETE. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO INDEPENDENTLY VERIFY THE ACCURACY OF ALL UTILITY LOCATIONS SHOWN AND TO FURTHER DISCOVER AND AVOID OTHER UTILITIES NOT SHOWN HEREIN WHICH MAY BE AFFECTED BY THE IMPLEMENTATION OF THIS PLAN. CONTRACTOR SHALL CONTACT THE "UTILITIES UNDERGROUND LOCATION CENTER" AT (1-800-424-5555) AND THE APPROPRIATE BOEING OFFICIAL 48 HOURS MINIMUM BEFORE DIGGING FOR LOCATION OF UTILITIES.



KEY PLAN

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SUBTITLE
EXISTING CONDITIONS

TITLE
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RENTON SITE

CIVIL MASTER SITE RENTON, WA

CURRENT REVISION W4700331	SYMBOL –	DATE 11/15/19
SHEET G84		G15
JOB NO. W4700331		COMP NO.
DWG NO. 4-APRON-R-G84		

Attachment 4
Standard Operating Procedures

STANDARD OPERATING PROCEDURES (SOPS)

The following SOPs are included in this attachment:

- Contingency Plan and Emergency Procedures
- Data Validation
- Decontamination of Sampling Equipment
- Foreign Object Debris/Damage (FOD) Awareness/Prevention Program
- Groundwater Sampling
- Low-Flow Groundwater Sample Collection
- Passive Diffusion Bag Samplers
- Photoionization Detector (PID) Calibration and Use
- Sample Packaging and Shipment
- Soil Sampling
- Soil Sampling – Encore Sampler
- Well Drilling, Construction, and Sampling in Roadways
- Traffic Control
- Investigation Derived Waste (IDW) Waste Management Plan
- Utility Clearance
- Well Construction and Development

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
______________________________	__________________
______________________________	__________________
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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.

Foreign Object Debris (FOD)
Awareness/Prevention/Management Plan

1.0 INTRODUCTION

CALIBRE has developed this Foreign Object Debris (FOD) Awareness, Prevention, and Management Plan (FOD Plan) to assist employees engaging in conducting field work on job sites at or near a flight line, taxiway, parking stall or aircraft towpath. This plan is applicable to all work performed by CALIBRE in areas where implementation of a FOD awareness/prevention program is required. FOD awareness and prevention is a critical aspect of work conducted by and for companies working on or near airport runways and taxiways. This Plan is based on the procedures, training, and disciplines practiced with regard to tool and equipment accountability and control as well as safe housekeeping practices reflecting a "clean as you go" work environment. Standard operating procedures (SOPs) related to tool accountability and FOD management are included as attachments to this FOD Plan and will be followed while working in an area requiring FOD safety. These procedures in this Plan are designed to meet or exceed the FAA FOD management requirements[1].

2.0 SCOPE

The objective of this Plan is to eliminate accidents and incidents, and loss of life or equipment, due to FOD associated with environmental remediation activities (e.g. well installation, sampling, and substrate injections) in FOD management areas. This FOD plan applies to Boeing Facilities, located at or near a flight line, where airplanes, aircraft, and miscellaneous aircraft equipment are fabricated, assembled, transported, stored and/or tested.

2.1 Definitions

(1) Foreign Object Debris (FOD). A substance, debris or article alien to the flight line, aircraft, or assembly that has been allowed to invade the product. On the flight line, a foreign object is also any object on the ground that might come aboard the assembly or be ingested by the engines.

(2) Foreign Object Damage. Any damage attributed to a foreign object that can be expressed in physical or economic terms which may or may not degrade the product's required safety and/or performance characteristics.

(3) Air Operations Area (AOA). All airport areas where aircraft can operate, either under their own power or while in tow. The AOA includes runways, taxiways, apron areas, and all unpaved surfaces within the airport's perimeter fence.

(4) Airport Apron (or Ramp). A surface in the AOA where aircraft park and are serviced (refueled, loaded with cargo, and/or boarded by passengers).

(5) Clean-as-you-go. The practice of cleaning one's surroundings before, during, and after a shift, especially when working with items that may become FOD.

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[1] FAA Advisory Circular (AC) No: 150/5210-24, Airport Foreign Object Debris (FOD) Management, Dated: 9/30/2010

(6) Hazard. A condition, object or activity with the potential for causing damage, loss, or injury.

(7) Manufacturer. The distributor, lessor, or supplier of automated FOD detection equipment. This includes any operator of a FOD removal program that incorporates FOD detection equipment and removal equipment.

2.2 Other Acronyms and Terms

ACM	Airport Certification Manual
AOA	Air Operations Area
FAA	Federal Aviation Administration
FOD	Foreign Object Debris
GSE	Ground Support Equipment
ICAO	International Civil Aviation Organization

2.3 Specific Applicability to Planned Work

The complete FAA FOD management plans in AC 150_5210_24 cover all phases of airport operations. CALIBRE's planned scope of work within FOD controlled areas is limited to environmental sampling and construction related activities. This plan is focused on (and limited to) those specific elements of the FAA requirements and may be generally summarized as:

- FOD prevention procedures established and employed for each construction project.
- Airport preconstruction planning should include a means for controlling and containing FOD generated by the construction.
- Designated routes of construction vehicles on the AOA should be examined, so as to avoid or minimize crossings of critical areas of aircraft operations.
- Contractor training to fully understand the requirements.

3.0 GENERAL REQUIREMENTS

3.1 FOD Prevention Training

All CALIBRE personnel, including subcontractors and suppliers, performing work in areas subject to FOD awareness and prevention requirements will be FOD trained and will be responsible for understanding and adhering to the FOD awareness/prevention program described in this Plan. All CALIBRE personnel, including subcontractors and suppliers, requiring access to the flightline are required to receive FOD training prior to entry or be escorted. Elimination of FOD is the responsibility of all persons while on the flightline and any individual working on a job is responsible for FOD control in that area. The completion of each job is an acknowledgment that this area is free of FOD.

3.2 Housekeeping

Utilize normal "Clean-As-You-Go" routines to provide an organized and professional working environment. FOD walks of the work area should be performed routinely during and after completion of work to inspect the area cleanliness and remove loose or unwanted items. Intrusive drilling work will necessarily require coring of the airport tarmac and asphalt and concrete pavements are the most common source of FOD on an airport.

"Clean-As-You-Go" is an aerospace industry standard routine for cleaning up work areas prior to, during and after work efforts. It is the continuous practice of debris removal and surface cleanliness during manufacturing, maintenance or any operation involving sensitive hardware, equipment or tools. The routine prevents accumulation of FOD, and thus greatly decreases the potential for FOD migrating into or damaging equipment.

The following are good clean-as-you-go practices, and should be applied when working on or near a flightline:

- Clean up the immediate and surrounding areas when work cannot continue.
- Clean up the area when work effort is complete.
- Clean up any generated debris that has the potential to migrate to an out of sight or inaccessible area.
- Clean up debris that has the potential to cause damage to hardware and/or would give the appearance of poor workmanship or housekeeping to a visitor.

Airports are often windy locations. Wind around airports is often stronger due to several factors including large open spaces (runways and taxiways) which are not obstructed by buildings or trees. This lack of obstruction allows the wind to flow more freely, potentially increasing its speed. “Closed-type” containers for refuse are preferable, given the opportunity for wind to dislodge the container contents and blow dry debris, including paper or plastic bags, onto the flight area. Work should ensure that refuse containers do not blow over during periods of high winds. This can be accomplished by using trash cans/lids secured the ground with a tether or a weight.

3.3 Incident Reporting

All FOD related incidents should be immediately reported and investigated. When FOD occurs outside of a planned, fenced work area, operations should immediately cease, and an investigation should be initiated to determine the cause. Corrective action will be immediately implemented to preclude similar occurrences from happening in the future.

4.0 ADDITIONAL FOD PREVENTION PRACTICES

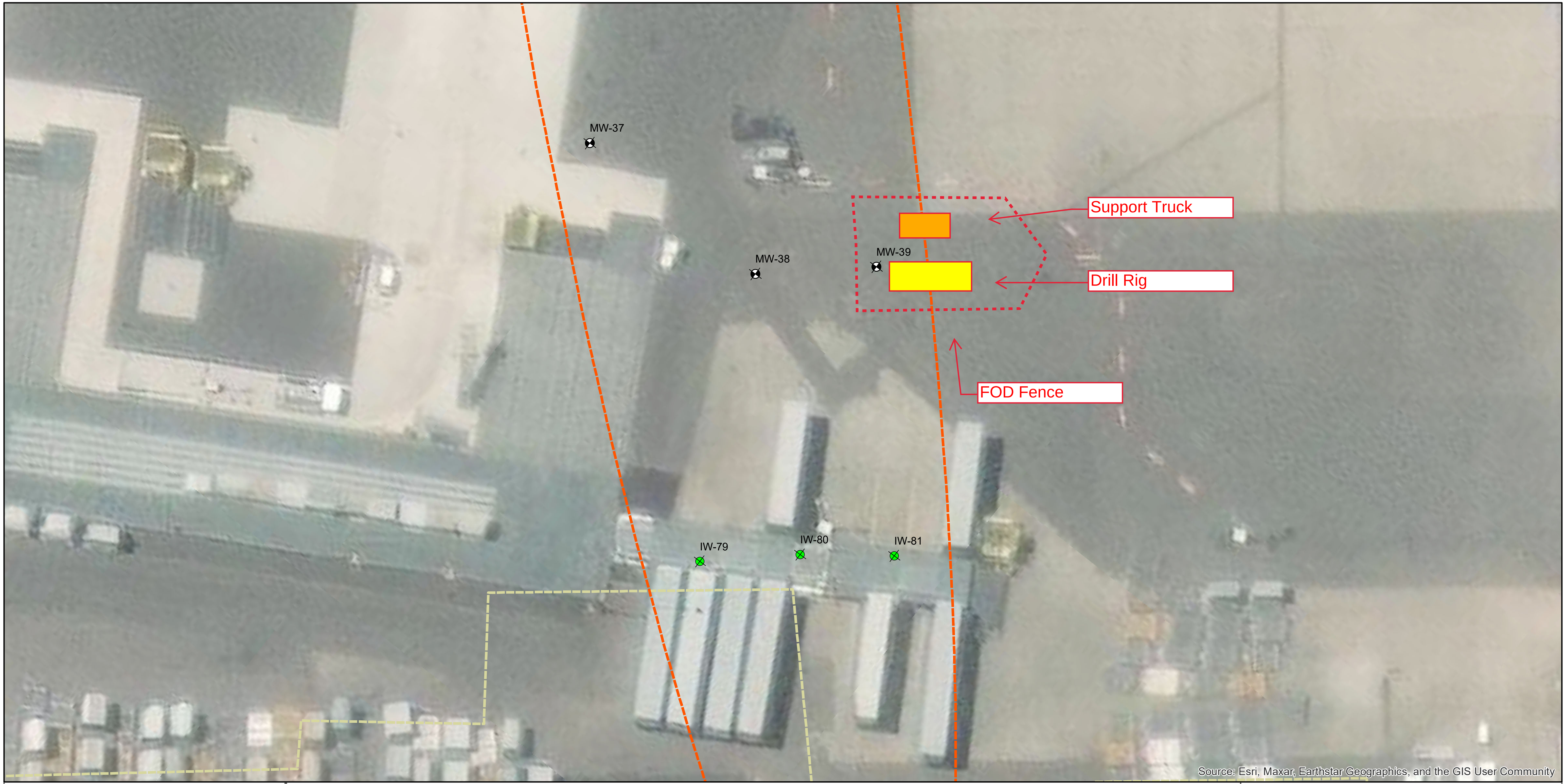
All equipment used in a FOD awareness area, including sampling and injection equipment, vehicles, tools, and support equipment (e.g., drill rigs), must be thoroughly inspected to ensure they are in proper working condition, and that no foreign object can migrate and/or damage FOD sensitive equipment. This will also include vehicle wheel inspection prior to entering the work area; personnel will check tires and remove rocks and other debris that may be lodged in the tire treads before driving on site. Maintenance of equipment shall be performed as required as to preclude the risk of FOD incidents. Vehicle routes will avoid or minimize crossings of critical areas of aircraft operation.

Field personnel must maintain an inventory of all tools and equipment present in the FOD awareness area through the tool accountability SOP (attached) and be continually accountable for each tool that is introduced into the FOD awareness area. A tool checklist is the primary means used to ensure tool accountability for the typical work CALIBRE conducts on client sites. All loose tools and material necessary to complete the field activities will be carried and stored in a tote tray, soft tool bag, bucket or other suitable container and not be placed in a manner that would cause damage to other flight line hardware or injury to personnel.

When required CALIBRE, or its subcontractors, will utilize a FOD fence to minimize any FOD hazard. A typical FOD fence will include 42” cones, delineator boards, plastic sheeting and clamps (see attached photos). Any FOD within this zone will be cleaned up immediately.

Attachments:

- EMF – FOD Fence example layout
- Renton – FOD Fence example layout
- Typical FOD Fence Layout Detail – Photos
- Foreign Object Debris/Damage (FOD) Awareness/Prevention Program – CALIBRE SOP
- Tool Accountability Program to Support FOD Prevention Program – CALIBRE SOP



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

BOEING

CALIBRE

Legend

Proposed Well

⊕ Injection Well

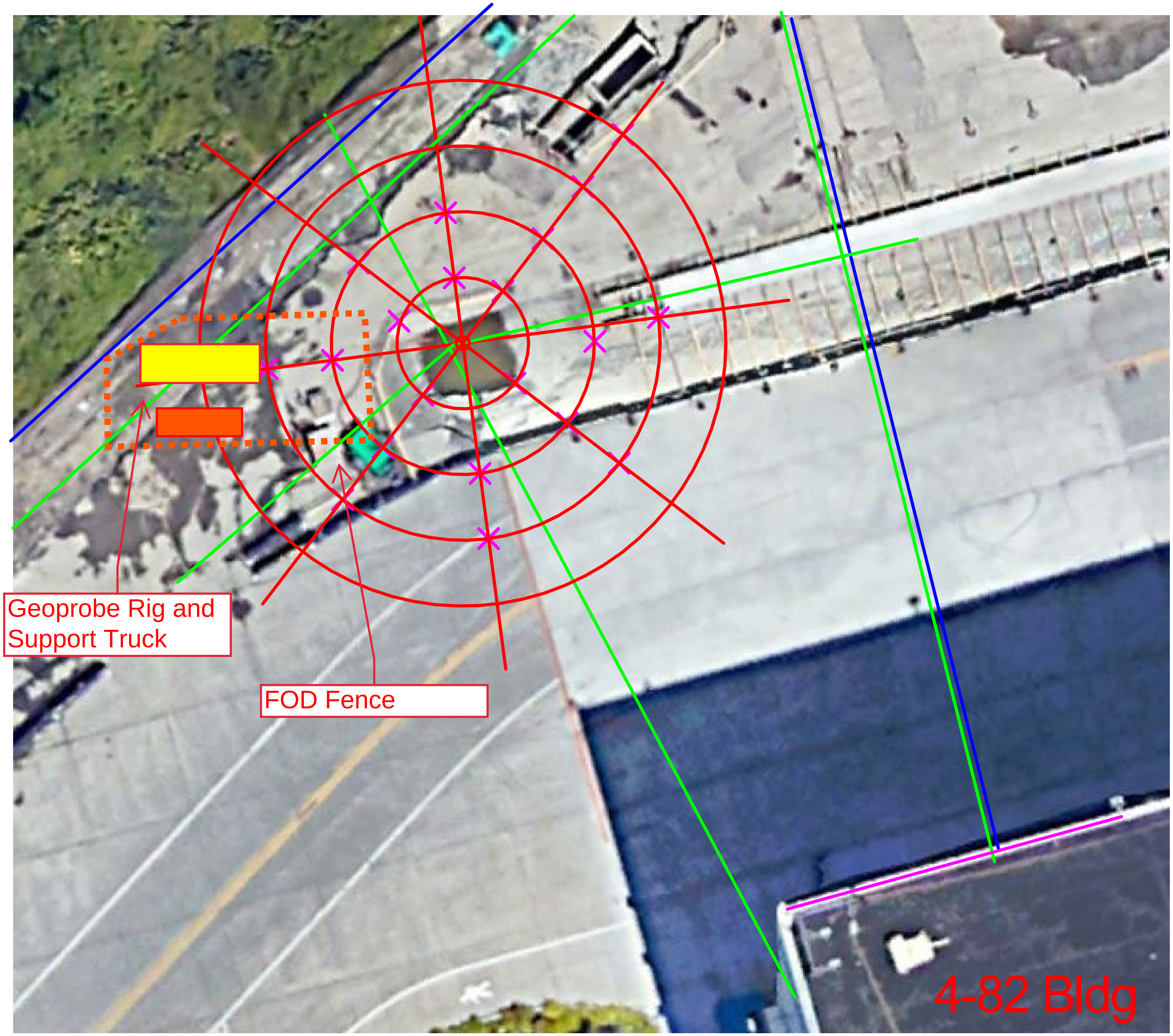
⊕ Monitoring Well

▭ Former EMF Building Footprint

▭ EMF VOC Plume Boundary

0 20 40 80 Feet

Figure 2 - Proposed Replacement Wells near KCIA LAP and UPS Development Areas



CALIBRE Systems Inc.

Utilities
Water 🟦
Storm drain 🟩
Geoprobe Location ✕

Boeing Renton
Apron R
Fuel investigation

Figure
Apron R
Geoprobe Locations


Regular
3.69 9/10
Diesel
3.49 9/10
Food Mart
Car Wash
ATM
4
Shell V-Power NITRO+
4


3.69
3.49
Food Mart
Car Wa
ATM
ESQUIN
BOYS AUTO


Food Mart


CASCADE DRILLING
Food Mart

FOREIGN OBJECT DEBRIS/DAMAGE (FOD)
AWARENESS/PREVENTION PROGRAM
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in conducting field work on job sites at or near a flight line will abide by the procedures outlined in this document. These procedures are designed to meet or exceed the Air Force Occupational Safety and Health (AFOSH) standards or Department of Labor Occupational Safety and Health Act (OSHA) standards.

2.0 PURPOSE/SUMMARY

This document presents a program that will be implemented by CALIBRE to prevent FOD during conduct of environmental remediation activities. This program is applicable to all work performed by CALIBRE in areas where implementation of a FOD awareness/prevention program is required.

FOD awareness and prevention is a critical aspect of work conducted by and for companies working on or near airport runways and taxiways. CALIBRE has developed an active FOD awareness/prevention program that is applicable to work performed on or near airports. This program is based on the procedures, training, and disciplines practiced with regard to tool accountability and control and safe housekeeping practices reflecting a "clean as you go" work environment. This program includes the requirements of this document. Additional job-specific measures will be added as conditions dictate (See section 7, Job-Specific Activities).

2.1 Acronyms

FOD	Foreign Object Debris/Damage
CALIBRE	CALIBRE SYSTEMS
PPE	personal protective equipment

2.2 Definitions

"Clean-as-You Go"

A process for managing work areas to eliminate debris that could result in foreign object damage. Clean-as-you-go includes immediately picking up any dropped parts, process debris, tools, or other objects. In addition, the job site and work area are to be cleaned up immediately after completion of each job and prior to job inspection, and at the end of each shift.

Foreign Object Damage (FOD)

Any damage caused by a foreign object that can be expressed in physical or economic terms that may or may not degrade the required products, safety, and/or performance characteristics.

Foreign Object Debris (FOD)

A substance or article alien to the flight line, aircraft or assembly that has been allowed to invade the product. On the flight line, a foreign object is also any object on the ground that might come aboard the assembly or be ingested by the engines.

2.3 General

A. All CALIBRE personnel, including subcontractors and suppliers, performing work in areas subject to FOD awareness and prevention requirements will be FOD trained and will be responsible for understanding and adhering to the FOD awareness/prevention program described in this document.

B. All CALIBRE personnel, including subcontractors and suppliers, requiring access to the flightline are required to receive FOD training prior to entry or be escorted.

C. Elimination of FOD is the responsibility of all persons while on the flightline.

D. Any individual working on a job is responsible for FOD control in that area. The completion of each job is an acknowledgment that this area is free of FOD.

2.4 Control and Accountability of Tools and Hardware in and Around Flight Line

A. All individuals will account for and control the use of Company and/or personal tools.

B. Small hardware such as fasteners and small parts shall be contained. Use of closeable containers or five gallon buckets is recommended wherever possible.

C. Hardware debris (such as drill shavings, removed fasteners, bits of wire, string, etc.) produced from work processes will be removed as generated using good housekeeping “clean as you go“ techniques and at the completion of the job.

D. A central staging area for tools, material, and debris disposal will be identified. Where possible, a containment barrier will be erected to isolate this area. Disposal containers will have weighted and/or lockable lids to prevent being blown open by wind.

E. To the extent possible, materials and supplies will not be brought onto the flightline until ready for use. Only the amounts of materials and supplies needed to complete the job should be brought onto the flightline.

2.5 Reporting FOD

All FOD related incidents should be immediately reported and investigated. When FOD occurs, operations should immediately cease, and an investigation should be initiated to determine the cause. Corrective action will be immediately enforced to preclude similar occurrences from happening in the future.

2.6 Responsibilities

A. Supervision/Craft/FOD Focal/Safety Personnel

1. Supervision will:

    a. Ensure foreign object awareness training is provided to all assigned personnel. Briefings will be conducted during crew meetings to cover this procedure and any other material deemed pertinent.

    b. Notify the client Project Manager and/or the designated client contact person of ANY damage caused by FOD.

    c. Identify any corrective action, if/as required, from inspection findings.

    d. Show visibility and performance measures to crew.

    e. Coordinate FOD walks on an as required basis.

2. Craft personnel will:

    a. Remove any FOD. Ensure that construction activities meet "good house-keeping" standards that enhance FOD elimination. This includes sweeping and vacuuming flightline and production areas, as well as a regular schedule for sweeping ramp areas.

    b. Participate in FOD walks. Pay special attention to ramp, stalls and areas where construction support vehicles and construction support equipment are operated and/or maintained.

    c. Take onto the flightline only those parts, tools, and materials necessary to perform the required task.

    d. Establish tool accountability zone around each work area at start of each job performed on the flightline. All tools taken out of the tool accountability zone must be inventoried and accounted for. The tool accountability zone shall be the exclusion zone set up for health and safety access control. Upon completion of work in a specific work area, that zone shall be thoroughly inspected for any misplaced tools or other FOD.

    e. Report any missing tools or items to the supervisor or FOD Focal as required.

    f. Turn in any tool found or item that appears to be abandoned to the supervisor or FOD Focal.

    g. Use protective barriers, where feasible, to isolate work area from flight/taxi areas.

        h. Practice “clean as you go” techniques.

3. FOD Focal/Safety Manager
    a. Provide awareness training to employees.
    b. Provide visitors with awareness briefing consistent with the purpose of the visit.
    c. Ensure flight line is FOD free by:
        i. Inspecting the flightline for FOD.
        ii. Ensuring removal of all accessible debris.
        iii. Calling sweeper if debris is too small or too numerous to pick up by hand.
        iv. Notifying supervisor if a chronic FOD problem exits.
        v. Providing supervision with recorded findings from inspections, which will include amount and type of debris found.

2.7 Job-Specific Activities

CALIBRE has identified these specific environmental remediation activities that have the potential for generating FOD. These activities will be conducted as follows.

Contamination control:

1. Place disposable personal protective equipment (PPE) (e.g., tyvek suits) in receptacles with weighted or lockable lids immediately after removal.
2. To the extent possible, perform decontamination activities (e.g., steam cleaning drilling equipment) away from flightline.

Well drilling:

1. Contain drill cuttings in metal drums or roll-off box as they are brought to the surface.
2. If necessary to prevent dispersal of drill cuttings by wind, construct temporary protective barrier around drilling area.
3. Place material packaging (e.g., protective well screen wrappers) in receptacle with weighted or locked lid immediately after removal.

4. Place empty containers (e.g., filter pack bags, bentonite pails) in receptacle with weighted or locked lid immediately after emptying.

5. Remove excess annular materials (e.g., filter pack, bentonite chips) from ground surface immediately after completion of well construction and place in covered receptacle.

6. Implement “clean-as-you-go” practices, including frequent sweeping of work area to prevent accumulation of cuttings around drill rig.

7. Contain drilling fluids directly into drums or tanks.

Saw cutting and coring (wet process):

1. Capture slurry at time of work.

2. Provide disposal location and means of transportation that prevents spillage.

Excavation and trenching:

1. Take precautions to minimize re-handling debris.

2. Water area in dry weather to minimize dust generation.

3. Implement “clean as you go” practices.

Drilling of metal or concrete (dry process):

1. Capture remnants at time of drilling.

2 Vacuum as needed during activity (concrete drilling).

F. Unpacking materials:

1. Unpack off-site or in dedicated staging area (sealed, decontaminated materials such as well casings and bailers may be unpacked at the work site).

2. Dispose of packing materials in weighted lid/lockable lid containers.

G. Vehicles and equipment:

2. Inspect for foreign object contamination.

3. Clean tires, wheel wells, etc. as required.

H. Equipment installation, field fabrication:

1. Capture remnants (e.g., pipe scraps, cuttings, wire scraps and stripped insulation, old connectors) at time of cut or alteration.

2. Fabricate off-site when feasible.

3. Place empty containers and packaging (e.g., pipe solvent cans, connector packages) in receptacles with weighted or lockable lids immediately after emptying.

I. Building concrete form materials:

  1. Perform bulk form fabrication off-site.

  2. Implement “clean as you go” process during form assembly, alteration, cutting stripping, and removal.

J. Concrete Placement Activities:

  1. Access/egress routes will be identified for craft personnel whose activities require contact with wet concrete. This will allow for cleaning of clothing and tools at the point of egress, and immediate capture of activity remnants.

  2. Lined tub skids will be utilized for disposal of remnants.

  3. Concrete trucks during placement will be:

    a. In staged areas, with visqueen and/or plywood strategically placed to capture spillage/seepage at time of offload.

    b. When truck is empty, concrete remaining in chute will be scraped into a containment box, and the bottom of the chute bagged to prevent spillage while exiting to cleaning site.

    c. Truck will be followed to designated cleaning area to immediately capture any remnants that may still be capable of contaminating the area.

K. Concrete Breaking

  1. Barricade area with 4’ high plywood stanchions to isolate from the flight/taxi area.

L. Well Surveying Oversight
  1. Check in with Boeing representative and/or flight line shack prior to accessing monitoring wells or setting up survey equipment.
  2. Tools and equipment utilized for well surveying will be accounted for prior to and following completion of work.

TOOL ACCOUNTABILITY PROGRAM TO SUPPORT
FOREIGN OBJECT DEBRIS/DAMAGE (FOD)
PREVENTION PROGRAM
CALIBRE STANDARD OPERATING PROCEDURES

1.0 POLICY

It is the policy of CALIBRE that any individual engaging in conducting field work on job sites at or near a flight line will abide by the procedures outlined in this document. These procedures are designed to meet or exceed the Air Force Occupational Safety and Health (AFOSH) standards or Department of Labor Occupational Safety and Health Act (OSHA) standards.

2.0 PURPOSE/SUMMARY

The objective of a positive tool control program is to eliminate accidents/incidents due to tool FOD; this document presents actions that will be implemented by CALIBRE to prevent tool FOD during conduct of environmental remediation activities. This program is applicable to all work performed by CALIBRE in areas where implementation of a FOD prevention program is required. The basic objective is to use this tool control program to quickly determine that all tools are accounted for at the end of a work task in a restricted area.

There are many methods used in the industry to facilitate tool accountability: use of shadow boards, shadowboxing, bar coding, etc. These standard industry methods are best applied to manufacturing operations where a defined set of tools are used repeatedly (such as daily) in manufacturing or testing operations. A tool checklist is the primary means used to ensure tool accountability for the typical work CALIBRE conducts on client sites. All loose tools should be carried and stored in a tote tray, soft tool bag or other suitable container and not be placed in a manner that would cause damage to other flight line hardware or injury to personnel.

It is the responsibility of all personnel, especially those working near aircraft operations and maintenance areas, to ensure that tool control practices and accountability guidelines are accomplished in accordance with this policy.

3.0 TOOL INVENTORY

A tool inventory should be accomplished on a regular basis so that any missing tools can quickly be identified and searched for before they affect safety. This shall be done after each work task or at least once a day. A typical inventory is completed at the beginning and end of each shift (or with each ingress/egress from a restricted area).

Tools not required for use in, on, or around the restricted area (such as a flight line) do not fall entirely under this policy and shall not be transported into the restricted area. All tools must be accounted for at the beginning and end of daily work shifts and at the completion of work. Tools will be returned to the appropriate toolbox and the box secured before leaving the work area. Tools will NOT be left unattended in a restricted area except for short periods of time such as breaks, lunch, etc.

The attached tool inventory checklist shall be completed with each ingress/egress of a restricted area.

Missing Tool Reporting

An important part of this tool control program is a process for missing tool reporting. If a tool is missing following the checkout inspection the team shall go back to identify and recover the tool and notify the customer if the tool cannot be found. This procedure should be completed on each egress from a restricted area. The customer contact to be notified will typically be the field support engineer.

Tool inventory checklist

Date	**Work Area**	**Name(s)/team**			
Tool container Name/number/ description (e.g., backpack or bin # 1)	**Tool Inventory**	**Check in name & time**		**Check out name & time**	

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 (CERCLA) 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.

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 (CERCLA) 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 goal 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

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.

RAE SYSTEMS

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.

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)

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 all 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.

Radioactive Materials. 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.

Poison A. 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 personally by all team leaders expecting to ship such samples. Begin with 49 CFR 173.2.

Flammable Liquids. 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?

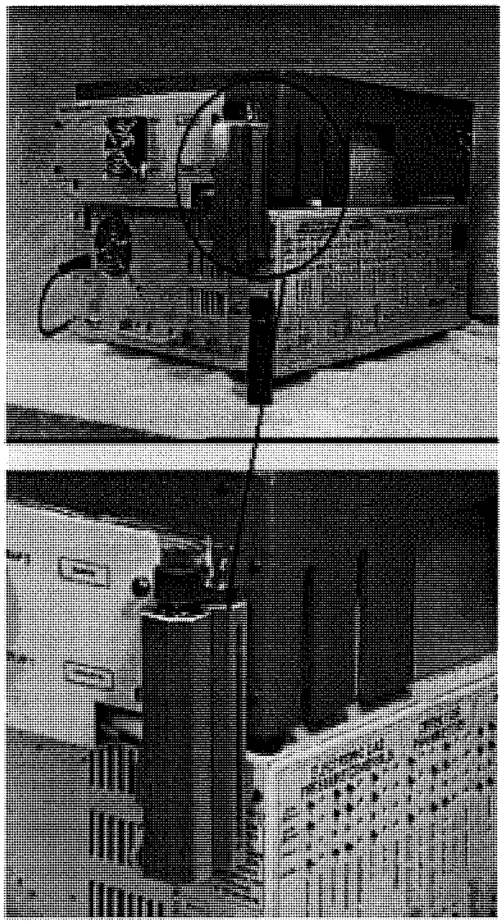
EPA Method 5035A has two main components: a "low-concentration" method and a "high–concentration" method. A brief synopsis of each is as follows:

- 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:

<u>Low-Concentration Method Advantages</u>

- 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.

<u>Limitations</u>

- 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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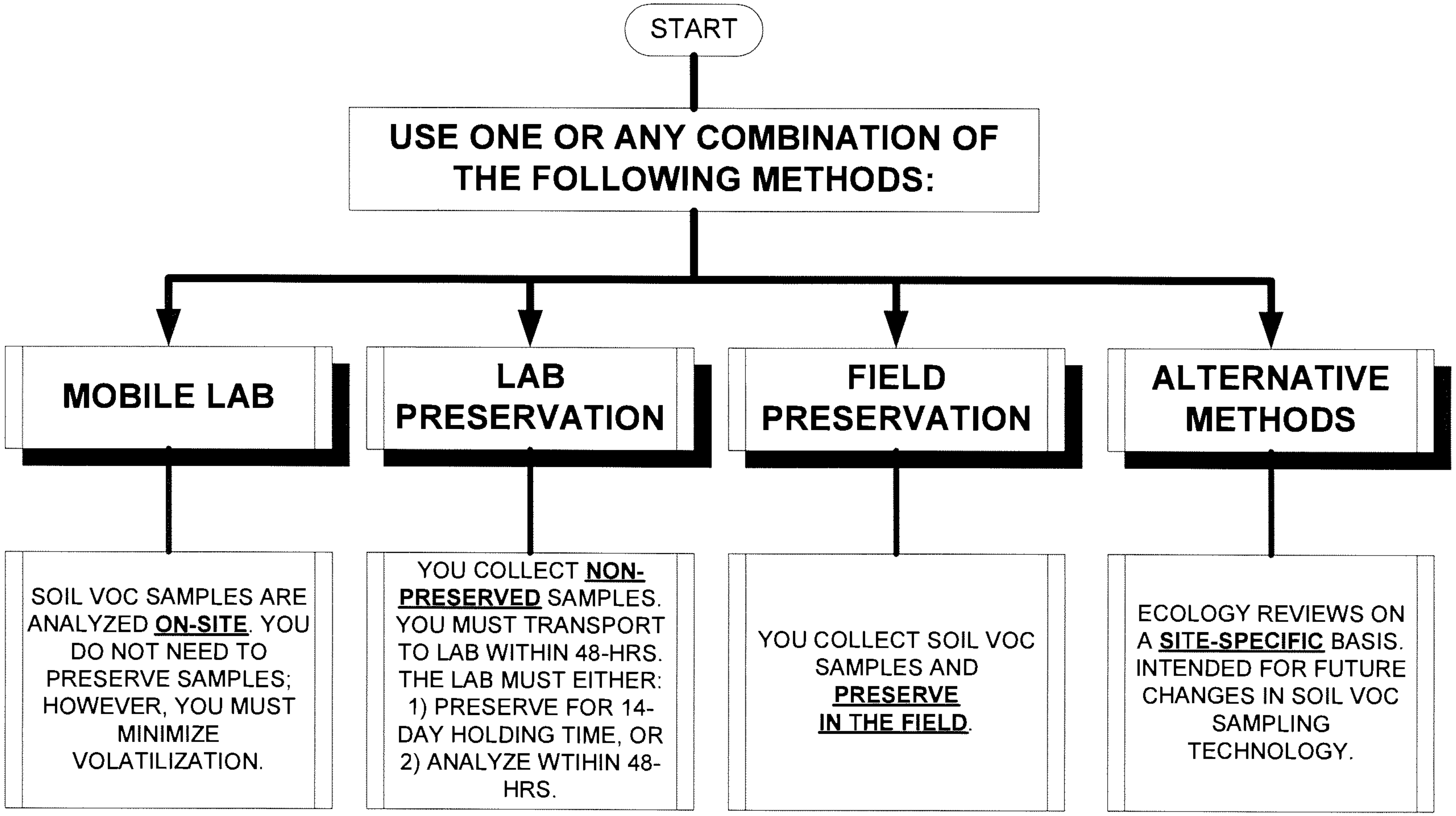
[9] See Refs 3, 17, 26.
[10] See Refs 1, 14, 15, 18, 19, 22, 0.
[11] See also EPA 5035A, Section 8.2.2.
[13] See Ref 19.

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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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 (($NaHSO_4$) 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 (CH_3OH).

- *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 <u>**collect at least two samples for every one location you sample**</u>. 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).

- 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.

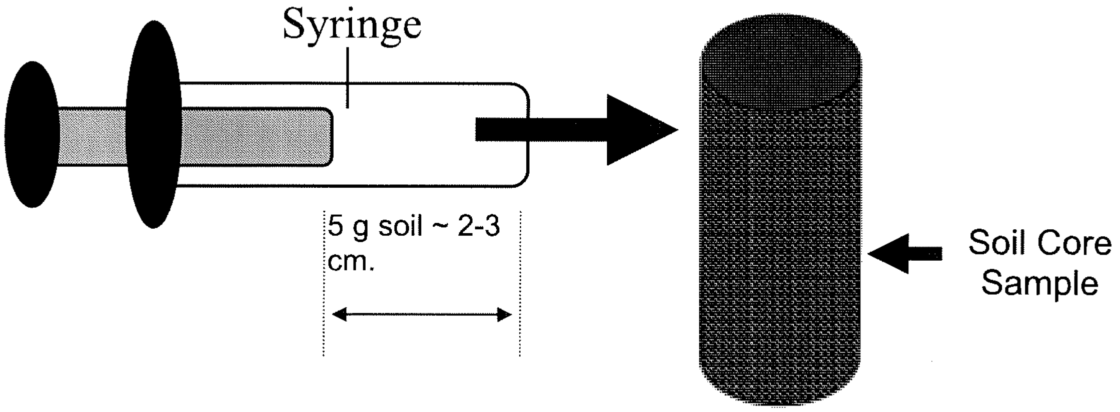
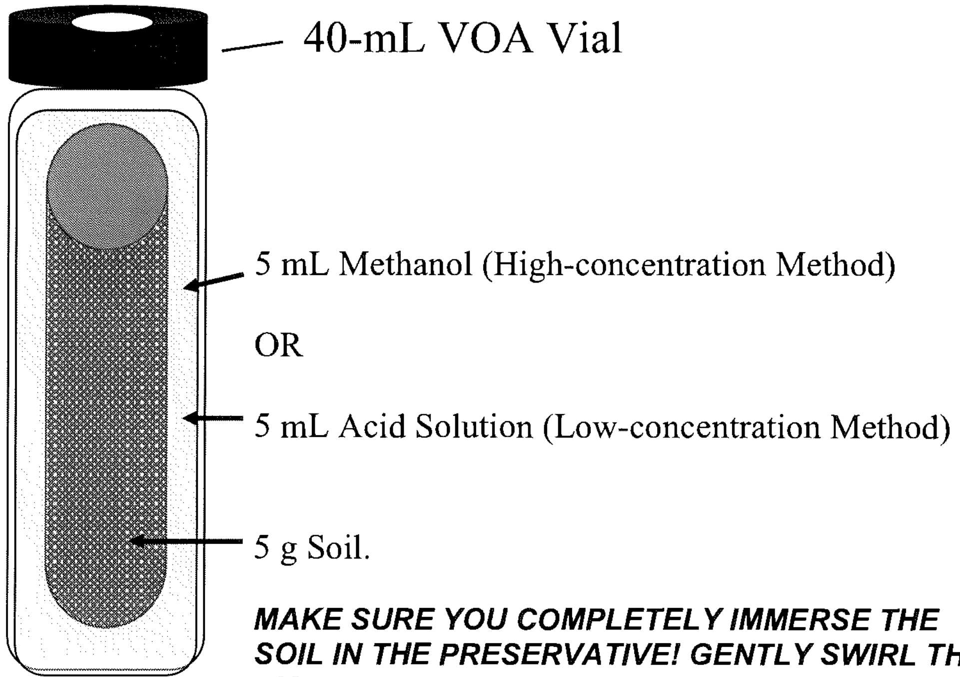


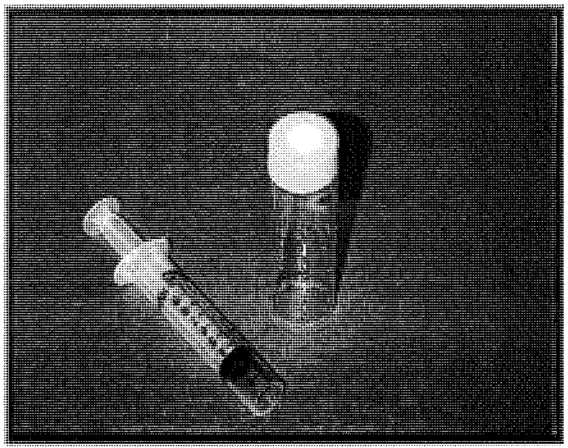
Figure 3: Vial and Sample.



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

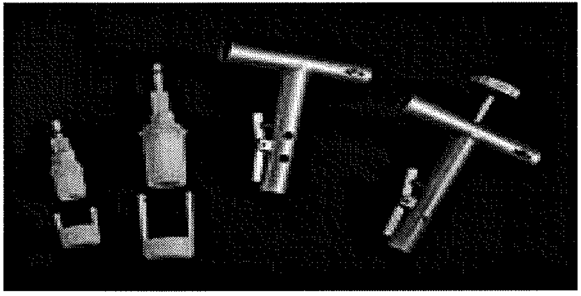
Figure 4: Sample Collection Equipment.

40-mL VOA Vial and Plastic Syringe



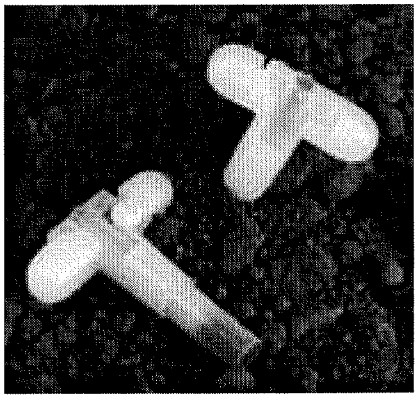
“EasyDraw® Syringe & Powerstop Handle®

“En Core®” Soil Core Sampler



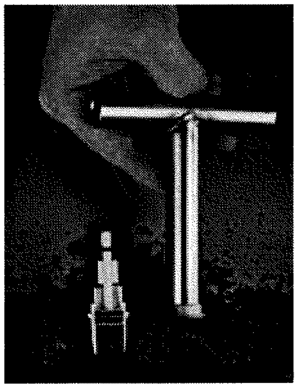
En Novative Technologies, Inc.

Terra Core™ Soil Sampler



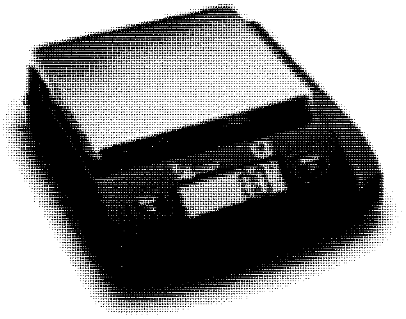
En Novative Technologies, Inc.

“En Core®” T-Handle



En Novative Technologies, Inc.

Field Balance



Portable Scout* Series Electronic Balance by Ohaus*

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.

CALIBRE SYSTEMS, INC.
TRAFFIC CONTROL AND WORK IN ROADWAYS
STANDARD OPERATING PROCEDURES

1.0 PURPOSE

This standard operating procedure (SOP) provides instructions that are to be followed for traffic control and during work conducted 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.

2.0 PERMIT

If a permit is required to conduct work in roadways or on a sidewalk at CALIBRE job sites, a permit will be acquired from the appropriate agency. All rules and requirements listed on the permit or permits must be followed.

3.0 PRESAMPLING ACTIVITIES

Prior to conducting work in a roadway, CALIBRE will contact the Boeing onsite activity representative and notify of the time and location of the road closure/work.

The area where the work will be accomplished must be cordoned off with fluorescent orange traffic cones (see attached figure). If work is within a roadway, a flagger with a “stop/slow” paddle may direct traffic away from the job site activities, if necessary.

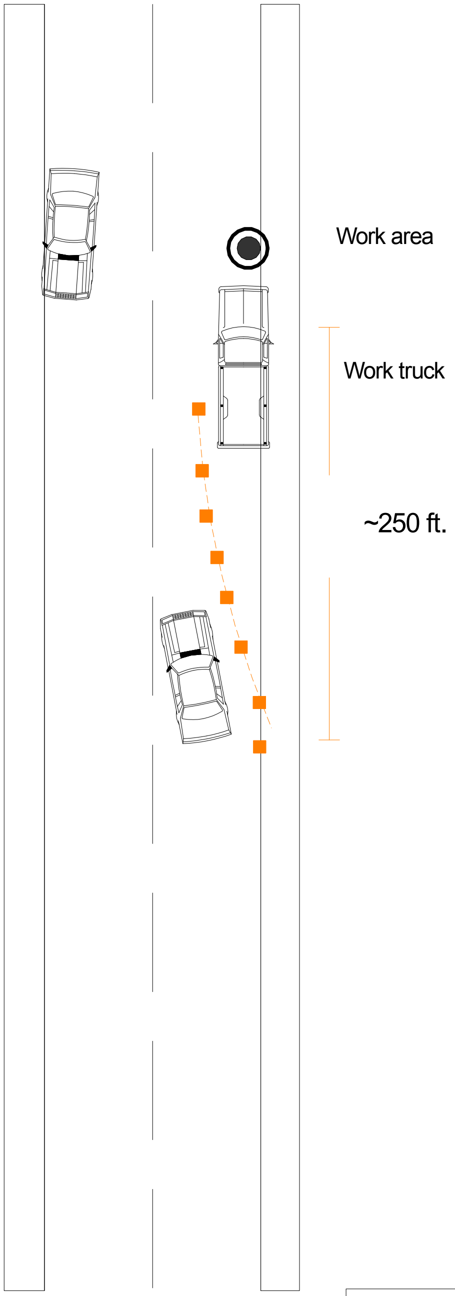
4.0 ACTIVITIES DURING DRILLING, CONSTRUCTION, SAMPLING, AND SUBSTRATE INJECTIONS

Work activities in the roadway should be performed only during daylight hours unless special circumstances dictate otherwise. Orange or other brightly colored safety vests should be worn by all personnel on site. Traffic cones and/or barricades must be placed around the work area before conducting work. Vehicle flashers will be utilized while work is being performed. 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.

1. Turn on hazard lights for work vehicle.
2. Position work vehicle between work area and passing traffic.
3. Drive work vehicle slightly onto shoulder or side walk, far enough to allow traffic to pass (both pedestrians and vehicles).
4. Park work vehicle.
5. Before exiting work vehicle, use mirrors to check for passing traffic or pedestrians on sidewalk.
6. Begin placing cones ~ 250 ft before and after work area.

The exact placement of the cones and work truck will vary depending on the specific conditions encountered at each well.



Legend

🟧 Traffic cone

◉ Well head to be sampled/ injected

*Figure not to scale

BOEING®

CALIBRE Systems Inc.

Standard Operating Procedures 2016

Temporary Traffic Revision for Work in Roadways
CALIBRE

1. Turn on hazard lights for work vehicle.
2. Position work vehicle between work area
 and passing traffic.
3. Drive work vehicle slightly onto shoulder or side walk, far
enough to allow traffic to pass (both pedestrians and vehicles).
4. Park work vehicle.
5. Before exiting work vehicle, use mirrors to check for
passing traffic or pedestrians on sidewalk.
6. Begin placing cones ~ 250 ft before and after work area.

The exact placement of the cones and work truck will vary
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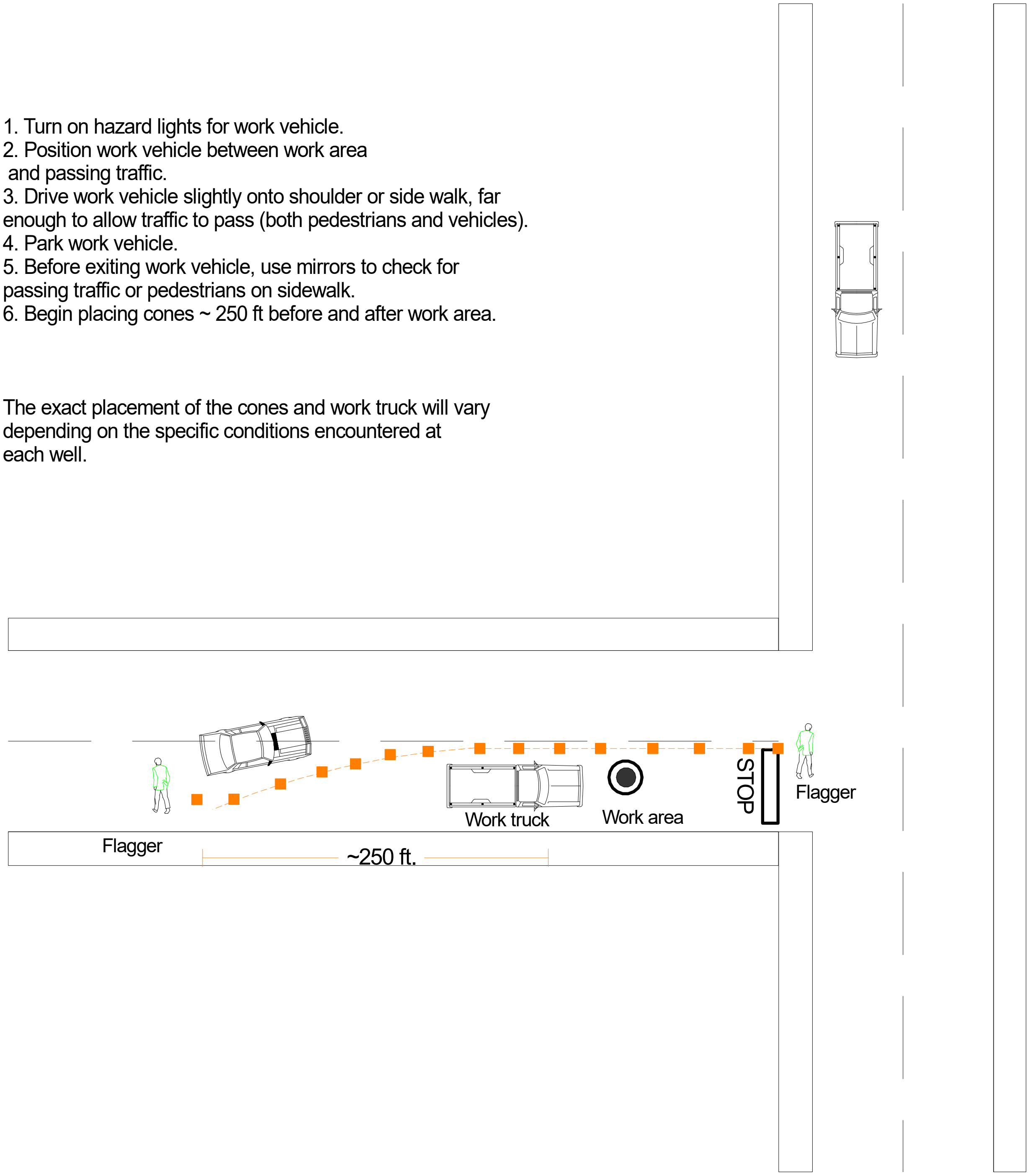


Legend

🟧 Traffic cone

◉ Well head to be sampled/
injected

*Figure not to scale

CALIBRE Systems Inc.

Traffic Control
Standard Operating Procedures
2016

Temporary Traffic Revision for
Work in Roadways
CALIBRE

Standard Operating Procedure-
Contractor Procedures for Management of Waste Streams at Boeing

1.0 MANAGEMENT OF PROCESS WASTE STREAMS

This standard operating procedure describes procedures that will be implemented to manage waste streams generated from various activities at Boeing facilities. Boeing Airplane Programs Safety/Health/Environmental Affairs (APSHEA) Environmental Engineers are responsible for designating all wastes generated on Boeing property and will determine the packaging, labeling, marking, and treatment requirements. If there are any questions about how to manage a waste stream generated from this project contact the Boeing Onsite Activity Representative Jennifer Parsons at (206) 715-7981.

Prior to generating waste, the contractor needs to contact the Boeing onsite activity representative or Accumulation Area for the appropriate containers and labels. The correct label is identified by the Profile number listed in Table1-1.

1.1 Handling of Waste Containers

All wastes will be packaged and transferred to the Accumulation Area on the same day it is generated.

Preparation of all containers of waste must include the following steps:

- Secure the label on the top 1/3 of the container immediately prior to placing the waste in the container (see Figure 1-2).
- Make sure that the label is completely filled out (see Figure1-1). The name in box 4 is the name of the person who first puts waste into the container. The manifest number in box 6 is left intentionally blank.
- Keep the container closed except for the 15 minutes prior to and following the addition of waste.
- Secure all waste containers on pallets as shown in Figure 1-2, 1-3 or 1-4 as appropriate.
- Attach a completed transportation tag (see Figure 1-5).
- Call dispatch at (206) 544-6500 for transfer of the pallet to the Accumulation Area.

1.2 Personnel Training

Personnel that perform operation, maintenance, or monitoring activities that produce a regulated waste stream must have the following training and certification:

- Current Hazwoper certification.
- Site Specific HASP orientation.
- SHEA Service Provider Manual orientation (Boeing document # D0-6000-5965).

Table 1-1 Examples of Regulated Waste Streams

Waste Stream	Origin	Example Contaminant	Estimated Quantity	Profile Number
Spent vapor phase activated carbon (GAC) media (*see note 1*)		PCE, TCE, DCE, VC, methylene chloride, and TPH-G		C0589PL2
Spent liquid phase activated carbon (GAC)		PCE, TCE, DCE, VC, methylene chloride, and TPH-G		C0297PL2
Condensate water (*see note 2*)		PCE, TCE, DCE, VC, methylene chloride, and TPH-G		AR001PL2
Sediment from condensate water (on cleaning rags)		PCE, TCE, DCE, VC, methylene chloride, and TPH-G		C0591PL2 or C0592PL2 for rags
Purge water from well monitoring		PCE, TCE, DCE, VC, methylene chloride, and TPH-G		
Baker tank rinse water following substrate injections		None		
Used oil (drain onto sorbent pads)		None		C0024BOE Or C0592PL2
Used air filters		None		C0592PL2
Solid Waste debris that has contacted TCE waste streams		PCE, TCE, DCE, VC, methylene chloride, and TPH-G		C0592PL2
Non-contaminated Debris and trash		none		garbage

Notes for SVE waste

1. The carbon media exchange procedures will be coordinated with Boeing. Boeing will provide specific direction regarding the location and management of the media exchange.
2. The portable condensate tank when full will be transported to the Renton Facility Accumulation Area for transfer/disposal.

1.3 Emergency Preparedness and Response

The Contractor must have a Contingency Plan and Emergency Response Procedures within the Standard Operating Procedures plan for the specific activity taking place. Personnel that perform operation, maintenance, and monitoring activities must have access to a cellular phone when on site. The emergency contact numbers need to be posted at singular locations around the work area and must be readily visible.

The following emergency response equipment will be maintained at the site:

- Broom
- Shop vac
- PPE potentially including goggles and face shield, rubber gloves or equivalent, rubber over boots, coated Tyvek coveralls or equivalent, and a rubber apron
- Five-pound type ABC dry chemical fire extinguishers
- Emergency contact numbers posted and easily visible

In the event of any emergency call:

1) Boeing Fire and Security (844) 898-6644
2) The designated Boeing Project representative
3) ______________________________

These contact numbers will be posted at the work area. The locations of the fire extinguishers, eye wash stations, first aid kits, and spill control materials shall be known and marked by the Contractor.

1.4 Site Specific Waste Streams

The anticipated waste streams identified in Table 1-1 are specific to the types of remediation systems and monitoring programs selected for this site (SVE, ERD, and groundwater monitoring).

Access to wells for injection of substrate will be required at the site. These activities will result in waste generated and include rinse water from the substrate injection mixing tank. The quantities are dependent on the total number of wells to be treated with substrate injections and the frequency of these activities. Estimated quantities relevant to site specific conditions are as follows:

1. Approximately 55 gallons rinse water from substrate injection mixing tank per injection event

Handling of generated waste will be coordinated in advance with Boeing environmental staff or the project contact and will be contained and disposed of properly following established Boeing protocols. Samples will be collected as required to adequately characterize the wastes generated and to determine the appropriate disposal method. The drums or appropriate containers holding waste will be placed on pallets and banded as required and Boeing waste management personnel will arrange the appropriate transport and disposal locations.

Figure 1-2 Pallet of Drums - 1 or 3

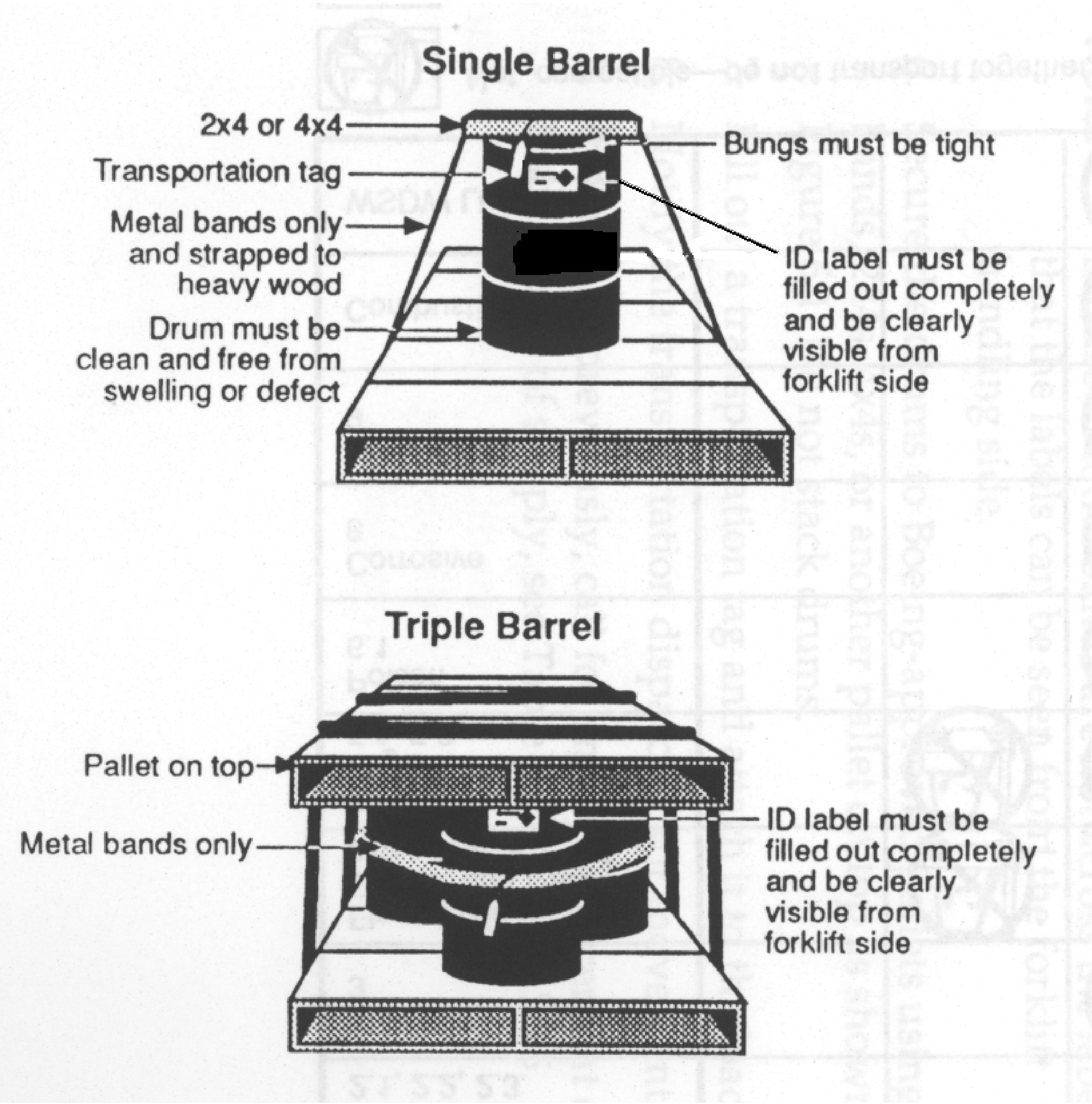


Figure 1-3 Pallet of Drums – 2 or 4

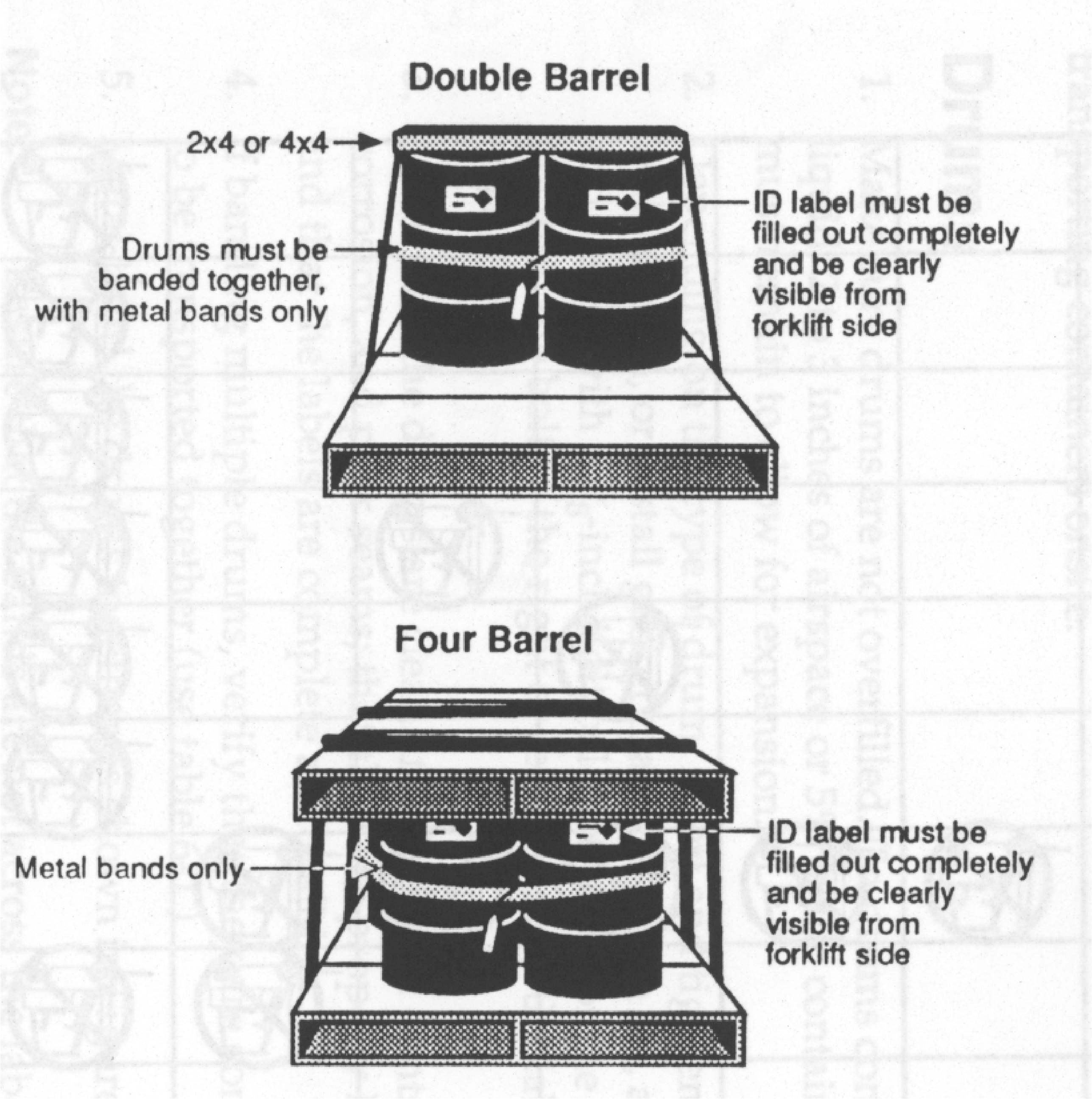
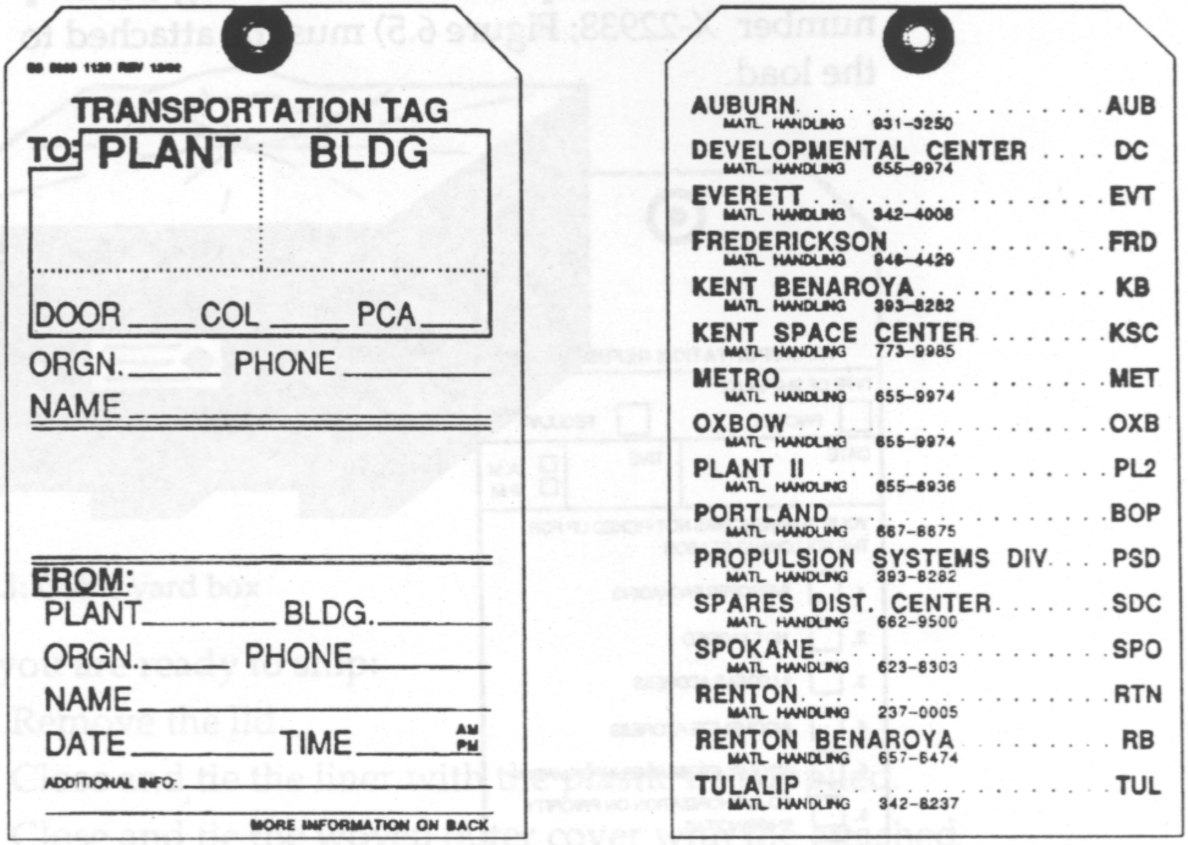


Figure 1-4 Waste Wrangler on Pallet

Figure 1-5 Transportation Tag



[illegible] 1130 REV [illegible]

TRANSPORTATION TAG

TO: PLANT BLDG

DOOR ____ COL ____ PCA ____

ORGN. ______ PHONE ________

NAME ________________

FROM:

PLANT ________ BLDG. ________

ORGN. ______ PHONE ________

NAME ________________

DATE ________ TIME ________ AM PM

ADDITIONAL INFO: ________________

MORE INFORMATION ON BACK

AUBURN	MATL. HANDLING 931-3250	AUB
DEVELOPMENTAL CENTER	MATL. HANDLING 655-9974	DC
EVERETT	MATL. HANDLING 342-4008	EVT
FREDERICKSON	MATL. HANDLING 846-4429	FRD
KENT BENAROYA	MATL. HANDLING 393-8282	KB
KENT SPACE CENTER	MATL. HANDLING 773-9985	KSC
METRO	MATL. HANDLING 655-9974	MET
OXBOW	MATL. HANDLING 655-9974	OXB
PLANT II	MATL. HANDLING 655-6936	PL2
PORTLAND	MATL. HANDLING 667-8875	BOP
PROPULSION SYSTEMS DIV	MATL. HANDLING 393-8282	PSD
SPARES DIST. CENTER	MATL. HANDLING 662-9500	SDC
SPOKANE	MATL. HANDLING 623-8303	SPO
RENTON	MATL. HANDLING 237-0005	RTN
RENTON BENAROYA	MATL. HANDLING 657-6474	RB
TULALIP	MATL. HANDLING 342-8237	TUL

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.

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.