Navy Closure Task Force

Draft Final

Site Characterization Work Plan
Holding Tank-Leach Tank
Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM OAHU HI

DOH Facility ID No. 9-102271
DOH Release ID No. 20211120_2330

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EXECUTIVE SUMMARY

This Site Characterization Work Plan (WP) outlines the proposed scope of work to further investigate the nature and extent of petroleum hydrocarbons impacting the subsurface near a former buried concrete holding tank and leach tank (collectively referred to as the "Site") at the Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, Hawaii (Figure 1). This WP has been prepared for the United States Department of the Navy under the Comprehensive Long-Term Environmental Action Navy Contract N62742-23-D-1802, Contract Task Order N6274224F0224.

During the November 2021 release of Jet Propellant 5 fuel in the Red Hill Bulk Fuel Storage Facility's [redacted] an indeterminate volume of the fuel was inadvertently pumped from a sump within [redacted] into a drainpipe that connected to a buried holding tank-leach tank located outside [redacted] approximately [redacted] of the adit entrance.

A Phase 1 site characterization investigation was conducted in January 2022 with the following objectives: 1) determine whether petroleum or petroleum-impacted water entered the holding tank-leach tank from the Adit 3 drain line, 2) determine whether petroleum or petroleum-impacted water passed through the holding tank and leach tank from the [redacted] drain line and into the surrounding environment, and 3) if petroleum impacts entered the environment adjacent to these features, determine the nature and extent of the contamination. During this Phase 1 investigation, 21 soil borings were advanced at selected locations (illustrated on Figure 2) and soil samples and organic vapor headspace readings were collected. This preliminary sampling identified contaminated soil in the area immediately surrounding and beneath the holding tank-leach tank and associated connection piping (DON 2022c). A groundwater sample was also collected from nearby perched groundwater monitoring well OWDFMW06B.

In March 2022, following this preliminary site characterization, a Phase 2 investigation was conducted to delineate the petroleum in subsurface soil and characterize petroleum in the shallow perched water body beneath the Site. During the Phase 2 investigation, subsurface soil samples and organic vapor headspace readings were collected at eight soil borings from data gap locations, identified after the preliminary site assessment, and groundwater grab samples were collected from three temporary wells, screened within the perched groundwater zone (locations illustrated on Figure 2). Subsurface soil and groundwater sample results from both the Phase 1 preliminary assessment site characterization and Phase 2 investigation were compared to State of Hawaii Department of Health (DOH) environmental action levels for soil, Table A-2 (updated to the most recent July 2024 values for this WP) (DOH 2024b). Based on results from the Phase 1 and Phase 2 investigations, the holding tank-leach tank and connection piping were demolished in-situ and removed. During the removal of the holding tank-leach tank and connection piping, approximately 13.6 tons of concrete and 2,040 gallons of liquid were removed. Approximately 97.2 tons of subsurface soil was removed in the tank footprint, and approximately 2,658 tons of soil was removed from a sloped area immediately surrounding the former holding tank-leach tank location. Confirmation soil sampling indicated total petroleum hydrocarbons (middle distillate) detections in excavated areas, and the highest detections were left in place in the northern sidewall of the excavation area (DON 2023a) (illustrated on Figure 3).

The United States Environmental Protection Agency and DOH identified knowledge gaps during review of the previously completed work at the Site. The current site characterization investigation is intended to fill identified knowledge gaps pertaining to the full magnitude and extent of the release from the holding tank-leach tank in subsurface soil, perched and basal groundwater, and nearby South Halawa Stream.

Specifically, this investigation will address the following at the Site:

- Expanded list of chemicals of potential concern (COPCs)
- Horizontal and vertical delineation of COPCs in subsurface soil
- Horizontal and vertical delineation of COPCs in perched and basal groundwater
- Evaluate potential impacts to nearby South Halawa Stream
- Additional investigation into the nature and extent of the former holding tank-leach tank excavation area
- Identification of other potential subsurface petroleum infrastructure at the Site

This site characterization will be conducted in accordance with the Resource Conservation and Recovery Act, Hawaii Revised Statutes Chapter 342L, "Underground Storage Tanks," and their implementing rules and regulations, including Hawaii Administrative Rules 11-280 and 40 Code of Federal Regulations Part 280.

After the activities described in this WP are completed, a site characterization report will be prepared to present the sampling results, conclusions, and recommendations.

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ACRONYMS AND ABBREVIATIONS

AVGAS	aviation gasoline
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
[redacted]	[redacted].
CoC	chain of custody
COPC	chemical of potential concern
CSM	conceptual site model
DLNR	Department of Land and Natural Resources, State of Hawaii
DOH	Department of Health, State of Hawaii
DOT	Department of Transportation, United States
DRO	diesel range organics
EAL	environmental action level
EPA	Environmental Protection Agency, United States
FID	flame ionization detector
ft	foot/feet
GAC	granular activated carbon
GRO	gasoline range organics
ID	identification
IDW	investigation-derived waste
JP	Jet Propellant
LNAPL	light nonaqueous-phase liquid
mg/kg	milligram per kilogram
MI	multi-increment
MS/MSD	matrix spike/matrix spike duplicate
msl	mean sea level
NAVFAC	Naval Facilities Engineering Systems Command
NPDES	National Pollutant Discharge Elimination System
ORO	residual oil range organics
OWDF	Oily Waste Disposal Facility
PAH	polynuclear aromatic hydrocarbon
PID	photoionization detector
ppmv	parts per million by volume
PSL	project screening level
PSQ	principal study question
QC	quality control
QSM	Quality Systems Manual
RA	Regulatory Agency
RSL	Regional Screening Level
SGC	silica gel cleanup
THQ	total hazard quotient
TPH	total petroleum hydrocarbons
U.S.	United States
VOC	volatile organic compound
WP	work plan

1. Introduction and Purpose

This Site Characterization Work Plan (WP) outlines the proposed scope of work to further investigate the nature and extent of petroleum hydrocarbons impacting the subsurface near a former buried concrete holding tank and leach tank (collectively referred to as the "Site") at the Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, Hawaii. The investigation is intended to fill data knowledge gaps that were identified in the *Site Characterization Plan Addendum* dated October 2024 (DON 2024b), including delineation of chemicals of potential concern (COPCs) in subsurface soil and groundwater, evaluation of impacts to South Halawa Stream, and identification of other subsurface petroleum infrastructure at the Site.

This WP was prepared under the Navy's Comprehensive Long-Term Environmental Action Navy Contract N62742-23-D-1802, Contract Task Order N6274224F0224.

This site characterization will be conducted in accordance with the Resource Conservation and Recovery Act, Hawaii Revised Statutes Chapter 342L, "Underground Storage Tanks", and their implementing rules and regulations, including Hawaii Administrative Rules 11-280 and 40 Code of Federal Regulations Part 280. This Site is located within the former Oily Waste Disposal Facility (OWDF), which is managed by the Environmental Restoration, Navy Program under a separate investigation and regulatory framework.

2. Background

On November 20, 2021, a release of Jet Propellant (JP)-5 fuel occurred in the [redacted] (b) (3) (B) Tunnel of the Red Hill Bulk Fuel Storage Facility (Facility). JP-5 was released from an overhead 14-inch polyvinyl chloride pipe at a location approximately [redacted] (b) (3) (B) of the [redacted] (b) (3) (B) Pump Station and approximately [redacted] (b) (3) (B) of the upper [redacted] (b) (3) (B).

Fuel flowed along the tunnel floor to the west, likely along the low point between the centrally located rail lines. It passed the [redacted] (b) (3) (B), both of which were positioned directly above the water development tunnel. The fuel eventually drained to a sump located approximately 750 ft west of the release point.

Once in the sump, the fuel began to leak into the environment at this location. It is also believed that the fuel spread through a Hume drainage system, a utility corridor shown in historical design drawings running between the rails in [redacted] (b) (3) (B)

Fuel likely traveled eastward and westward in the subfloor Hume drain utility corridor:

- Eastward, fuel was detected in the U.S. Navy Well 2254-01 (Red Hill Shaft) water development tunnel after fuel odors were noted and residents served by the well were affected later in the week of November 21, 2021.
- Westward, fuel was inadvertently pumped via a sump pump approximately [redacted] (b) (3) (B) from the [redacted] (b) (3) (B) entrance, and another [redacted] (b) (3) (B) under the [redacted] (b) (3) (B) [redacted] (b) (3) (B) via a cast-iron drainpipe (illustrated on a historical drawing) to reach the sump drain holding tank and connected sump drain leach tank located at the northwest perimeter of the Facility, adjacent to South Halawa Stream.

On December 18, 2021, a buried holding tank and connected leach tank were identified during investigation of the November 2021 release of JP-5 fuel within the [redacted] (b) (3) (B) Tunnel. Fuel from the release was inadvertently pumped from a sump within [redacted] (b) (3) (B) to an underground cast iron drainpipe that was connected to a sump drain holding tank and a connected sump drain leach tank approximately [redacted] (b) (3) (B) entrance.

The intended purpose of the holding tank and leach tank was to collect and discharge storm water collected in the [redacted] sump. Both cylindrical tanks were 8 ft tall and 7 ft in diameter. Approximately 1,500 gallons of a fuel/water mixture was identified during inspection of the holding tank in December 2021. The fuel/water mixture was pumped out of the tank and was estimated to contain approximately 253 gallons of light nonaqueous-phase liquid (LNAPL) and approximately 1,250 gallons of water. The leach tank was empty and completely dry; however, noticeable petroleum odors were observed in the interior of the tank during the December 2021 investigation.

The holding tank, leach tank, and the piping connecting the tanks were excavated and removed from the Site for disposal in May 2022 (DON 2023a). Soil immediately beneath and surrounding the holding tank and leach tank was excavated, and approximately 2,755 tons of soil was removed from the Site. The excavation areas were backfilled with clean fill. The location of the former holding tank, leach tank, and connection piping is illustrated on Figure 1. This Site is located within the former OWDF, which is managed by the Environmental Restoration, Navy Program under a separate investigation and regulatory framework.

2.1 SITE DESCRIPTION

2.1.1 Climate

The tropical climate of Oahu is warm, humid, and dominated by the prevailing northeast trade winds and ocean currents. Ocean temperatures are approximately 75–85 degrees Fahrenheit in Honolulu, and air temperatures on Oahu average 70–85 degrees Fahrenheit, with the warmest months being June through October. Northeasterly winds persist most of the year, and the northeastern (windward) sides of the island are commonly the wettest due to orographic lifting and cooling of marine air, which increases precipitation. On the island of Oahu, October to April is considered the wet season, and May to September is considered the dry season. On the Koolau Range’s leeward slopes, precipitation generally increases up-valley as elevation increases and decreases down-valley. The average annual precipitation in the upper North Halawa Valley and upper Moanalua Valley, located near the ridge line of the Koolau Range at approximately 1,000 ft mean sea level (msl) is 139 inches and 137 inches, respectively—equivalent to approximately 0.4 inch per day. In lower North Halawa Valley at approximately 180 ft msl near municipal water supply well Halawa Shaft, formerly active precipitation gauges (2005–2009) recorded an average annual precipitation of 33.9 inches (i.e., approximately 0.1 inch per day) (USGS 2017a; 2017b).

2.1.2 Soils/Geology

Soils in the vicinity of the Site are mapped as the Helemano-Wahiawa association consisting of well-drained, moderately fine-textured and fine-textured soils (USDA SCS 1972). These soils are generally found in broad areas with terrain that varies from nearly level to moderately sloping, interspersed with deeply incised, steep gulches. Along the slopes, the basaltic bedrock is covered with approximately 10–30 ft of Koolau residuum. These soils were derived from weathering of the underlying basalt bedrock or were deposited as alluvium/colluvium. The younger alluvium/colluvium deposits were derived from fractured basalts and tuff. Beneath the surficial soils, alternating layers of clay and basalts are encountered at depth. The northwestern slope of Red Hill is generally barren of soil and consists of outcropping basalt lava flows to the valley floor.

The Site is located within the Koolau Volcanic series. The Koolau formation at Red Hill consists of basaltic lava flows that erupted from a fissure line approaching 30 miles in length and trending along a northwest rift zone (Wentworth and Macdonald 1953). Pahoehoe and aa lava flows are present in the Koolau formation. The valleys flanking Red Hill ridge were formed through fluvial erosion and are filled with sedimentary deposits, such as alluvium and colluvium, collectively referred to as valley fill. Beneath these deposits lies residual material, or weathered basalt, known as saprolite. In Hawaii, saprolite zones are typically approximately 75 ft thick but can reach 300 ft or more beneath valley floors or in areas with high precipitation (Hunt Jr. 1996; Macdonald et al. 1983). The results of a seismic survey in North and South Halawa Valleys, Red Hill, and Moanalua Valley (DON 2018) found that valley fill and saprolite extend much deeper in the valleys surrounding Red Hill, particularly in the center of the valleys and below the streambeds.

2.1.3 Surface Water

South Halawa Stream is an ephemeral stream located approximately 70 ft west/northwest of the Site. In Halawa Valley, stream flow may contribute water to perched groundwater within alluvial material (valley fill) but is generally isolated from the underlying basal aquifer due to confining lithological units below perched groundwater zones. Most precipitation percolates to the basal aquifer and does not maintain base flows in the streams (Izuka 1992). South Halawa Stream is located approximately 100 ft above the basal water table.

2.1.4 Groundwater

In the vicinity of Red Hill, the basal aquifer water table lies at 15–20 ft msl (or approximately 100 ft below ground surface [bgs] at the Site), and regionally groundwater flows toward Pearl Harbor (mauka[mountain] to makai [ocean]), although the potential for variability exists in localized flow directions depending on geologic formations and other factors. In addition, the extensive drilling associated with the Red Hill Bulk Fuel Storage Facility has identified low-permeability strata above the basal aquifer in which the infiltration of groundwater slows and perched water-bearing zones are observed. The stratigraphy that results in these perched water-bearing zones, such as weathered clinker zones and massive aa lithology, have significantly lower hydraulic permeabilities than the highly conductive fractured pahoehoe. In addition, fine silt and clay sediments and weathered volcanic rock, known as saprolite, produce perched water bodies associated with the incised valley streambeds, such as South Halawa Stream, that are present at the Site. Perched groundwater was previously observed approximately 30 ft bgs at the Site.

The Site is located at the administrative boundary between the Waimalu Aquifer System of the Pearl Harbor Aquifer Sector and the Moanalua Aquifer System of the Honolulu Aquifer Sector. The underlying aquifer is classified as a basal, unconfined, flank-type aquifer and is currently used as a drinking water source.

The Site is located upgradient of the Hawaii State Underground Injection Control Line, which separates potable groundwater from non-potable groundwater. The nearest drinking water supply well is Navy Supply Well 2254-01 (also known as Red Hill Shaft), located approximately [redacted] ft east of the area. This well is still being utilized as a basal groundwater pump and treatment extraction location. Currently, the granular activated carbon (GAC) system treats approximately [redacted] of basal groundwater. Pre- and post-treatment water from Navy Supply Well 2254-01 is sampled weekly under a National Pollutant Discharge Elimination System (NPDES) permit. As of January 28, 2022, there has been no exceedance of the NPDES permit limits in both pre- and post-treatment samples. Project screening levels (PSLs) were derived from the lower of the corresponding DOH environmental action level (EAL) and United States Environmental Protection Agency (EPA) Regional Screening Level (RSL) and are presented in Appendix B.

2.2 Historical Land Use

Prior to the 1940s, the area of Red Hill supported sugar cane and pineapple agriculture. Construction of the Red Hill tank farm began in 1940.

2.3 CURRENT/FUTURE LAND USE

The Site is located on land zoned as F-1 Federal and Military Preservation and R-5 Residential districts. The nearest residential homes to the Site are located approximately 800 ft southeast in Moanalua Valley. The homes are 150 ft in elevation relative to the Site. The Site is not actively used and consists of shrubs and trees, portions of which are regularly trimmed. No changes to the land use of the Site are anticipated in the future.

2.4 CONCEPTUAL SITE MODEL

Releases of JP-5 at the site have occurred from the holding and leach tanks. The cylindrical tanks were each 8 ft tall and 7 ft in diameter. The tops of the tanks were buried several inches bgs, and the piping connecting the two tanks was located [redacted] ft bgs (former locations illustrated on Figure 1). In 2022, the Navy excavated both tanks and the connecting piping along with underlying contaminated soil. Excavation depths reached approximately 12.5 ft bgs below the former holding tank, 15 ft bgs below the former leach tank, and 3 ft bgs below the former piping (DON 2023a). During a second round of excavation, soil beneath the former piping and partially beneath the former tanks was removed to a depth of 30 ft below the original ground surface (excavation areas are illustrated on Figure 3). Clean soil was then used to backfill the excavations.

Confirmation samples were collected during the 2022 tank removal, and soil excavation activities indicated that TPH-diesel range organics (DRO) and TPH-residual oil range organics (ORO) remained at concentrations greater than their respective Hawaii DOH Direct Exposure EALs in the north sidewall of the excavation at approximately 5–12 ft bgs (confirmation sampling results are illustrated on Figure 3). After receiving the results of this confirmation sampling, the Navy concluded that the soil would not be a direct exposure concern based on depth and the anticipated industrial land use of the Site, and therefore the impacted soil was left in place (DON 2023a). It is possible that contamination remains below and around the excavation footprints. Soil is unlikely to be impacted at 0–5 ft bgs because releases from the former tanks would have occurred from the bottom of the 8-ft-tall tanks (i.e., the bottom of the tanks were at least 8 ft bgs).

The Site is inactive, and the Navy does not have plans to develop the Site in the future. Perched groundwater is not used for beneficial uses. However, the basal aquifer is a drinking water resource. Other investigations at the coincident former OWDF site confirmed that:

- The perched groundwater in this area is underlain by a low-permeability formation (located approximately 80–90 ft msl), which impedes downward flow from the perched aquifer.
- The basal aquifer is confined throughout the OWDF to depths of 15 ft msl to negative 104 ft msl (i.e., well below the basal potentiometric elevation of approximately 17–18 ft msl), with a resultant upward gradient that also impedes downward flow into the basal aquifer (NAVFAC 2024).

The nearest drinking water well is Navy Supply Well 2254-01 (Red Hill Shaft), located approximately [redacted] ft southeast of the Site.

A preliminary conceptual site model (CSM) is presented in Table 2-1. The CSM is based on the DOH *Technical Guidance Manual*'s default CSM (DOH 2024c, Section 4, Appendix B). For the purpose of this CSM, it is conservatively assumed that the release at the Site has impacted subsurface soil, perched groundwater, and basal groundwater. The CSM and exposure pathways will be refined using analytical data obtained as part of the investigation being proposed in this WP. The revised CSM will be presented as part of a report documenting the results of the investigation.

Table 2-1: Preliminary Conceptual Site Model

Primary Source	Primary Release Mechanism	Secondary Sources	Potential Environmental Hazard(s)		Potential Hazard Present Under Current or Future Conditions	
					Current	Future
Former Holding Tank and Leach Tank	Spills and leaks	Surface Soil [a]	Risk to Human Health	Direct Exposure	No	No
				Vapor Intrusion into Buildings	No	No
			Risk to Terrestrial Ecological Habitats		No	No
			Leaching		No	No
			Gross Contamination		No	No
		Subsurface Soil (greater than 5 ft bgs) [b]	Risk to Human Health	Direct Exposure	No	Yes
				Vapor Intrusion into Buildings	No	Yes
			Risk to Terrestrial Ecological Habitats		No	No
			Leaching		Yes	Yes
			Gross Contamination		No	Yes
		Perched Groundwater (approximately 30 ft bgs) [c]	Risk to Human Health	Direct Exposure	No	No
				Vapor Intrusion into Buildings	No	No
			Risk to Aquatic Ecological Habitats		No	No
			Gross Contamination		No	No
		Basal Groundwater (approximately 100 ft bgs) [d]	Risk to Human Health	Direct Exposure	No	No
				Vapor Intrusion into Buildings	No	No
			Risk to Aquatic Ecological Habitats		No	No
			Gross Contamination		No	No

[a] All releases at the Site occurred in the subsurface. As a result, surface soil is not impacted, and no environmental hazards are associated with surface soil.
[b] Subsurface soil greater than 5 ft bgs may be impacted by petroleum hydrocarbons. Potential receptors may directly contact subsurface soil during hypothetical future excavation activities. Although soil vapor may be impacted, there are no current or future vapor intrusion concerns because no buildings are currently present. Future vapor intrusion is listed as "yes" in the event that soil is excavated in the future and used as the subgrade below a building foundation. Leaching and gross contamination (e.g., high-concentration emissions of hazardous vapors and potential explosive hazards) are potentially present.
[c] Perched groundwater is not currently used or planned to be used as a beneficial resource. Since it is unlikely that future excavation would extend to 30 ft bgs, where perched groundwater is located, direct exposure and gross contamination are not considered current or future hazards. South Halawa Stream is a "losing stream," and perched groundwater is therefore not likely a risk to aquatic habitats.
[d] Basal groundwater is a potential future drinking water. The hazard listing of "No" may be revised based on the results of the basal groundwater sampling proposed in this WP.

3. Investigation History

3.1 INITIAL HOLDING TANK AND LEACH TANK CHARACTERIZATION, JANUARY 2022

All field activities were accomplished in accordance with procedures detailed in the *Preliminary Site Characterization Plan* (DON 2022a). All findings are reported in the *Technical Memorandum Holding Tank and Leach Tank Characterization November 2021 Pipeline Release* (DON 2022c).

A total of 22 borings were advanced (Figure 2); one boring (LT-N55) could not be sampled because the drill coring head encountered substrate it could not penetrate (refusal). A total of 35 subsurface soil samples were collected. Discrete subsurface samples were collected from two locations in the soil core; the most contaminated portion of the soil core as determined by headspace analysis (photoionization detector [PID]) as well as visual and olfactory-based professional judgement, and from the bottom of each core. The maximum PID reading was 518 parts per million by volume (ppmv). The boring logs identified soil disturbance at depths up to 20 ft bgs, including observations of concrete rubble.

Several subsurface soil sample results exceeded Hawaii DOH EALs for TPH-gasoline range organics (GRO), TPH-DRO, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene. Results were compared to EALs (updated to most recently approved July 2024 values) from Table A-2, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water source; surface water body is located within 150 meters of the release site) (DOH 2024b). Of the 35 subsurface soil samples analyzed for TPH-DRO, the following exceedances were noted:

- The Leaching to Groundwater EAL of 940 milligrams per kilogram (mg/kg) in 9 samples
- The Direct Exposure EAL of 219 mg/kg in 20 samples
- The Gross Contamination (Odor) EAL of 500 mg/kg in 12 samples

During the Phase 1 Site Characterization, bore logs from two nearby monitoring wells (OWDFMW06A and OWDFMW06B) were evaluated. OWDFMW06B is located approximately 20 ft north-northeast of the holding tank and is screened at approximately 25−35 ft bgs. A groundwater sample was collected from OWDFMW06B on January 26, 2022, and comparison of laboratory results to EALs showed an exceedance above the Drinking Water Toxicity EAL of 91 micrograms per liter (μg/L) for TPH (middle distillates) (DOH 2024b).

In addition, the following information was collected from OWDFMW06B:

- Static water level was 29.13 ft below top of casing.
- A headspace organic vapor measurement within the well casing was 38 ppmv.
- An oil/water interface measurement indicated no oil was present on the water surface.
- Photographs of the bailer indicated no oil or sheen.

A sample was not collected at OWDFMW06A because the well is screened below a thick confining unit, and upward vertical hydraulic gradient was observed during drilling as evidenced by water rising above the confining layer. These conditions suggest that it would be unlikely for COPCs to have impacted groundwater below the confining layer, and therefore it was decided to not collect a groundwater sample at OWDFMW06A.

3.2 PHASE 2 HOLDING TANK AND LEACH TANK CHARACTERIZATION, MARCH 2022

Phase 2 field work was conducted from March 9 to 17, 2022, in accordance with the *Site Characterization Plan Addendum – Holding Tank-Leach Tank Phase 2* (DON 2024b). Findings are documented in the *Technical Memorandum Phase 2 Holding Tank and Leach Tank Characterization November 2021 Pipeline Release* (DON 2023b). The Phase 2 objectives were to fill knowledge gaps identified during the Site Characterization, vertically delineate the petroleum in subsurface soil, and characterize petroleum in the shallow perched water body located at approximately 30 ft bgs at the Site.

Subsurface soil samples and organic vapor headspace readings were collected in eight soil borings advanced at the identified lateral and vertical data gap locations. The borings were advanced to varying depths due to varying depths to refusal. Boring logs noted the presence of boulders and cobbles in the subsurface at depths less than 10 ft bgs. Groundwater grab samples were collected from three temporary wells installed in the perched groundwater zone. Samples were analyzed for TPH, volatile organic compounds (VOCs), and polynuclear aromatic hydrocarbons (PAHs).

Soil and groundwater data collected during this 2022 investigation were compared to updated (July 2024) DOH Soil Action Level EALs, Table A-2 (DOH 2024b).

Subsurface soil EAL exceedances for TPH-DRO were noted in six of the eight soil borings throughout the Site (locations are illustrated on Figure 2).

Groundwater sample analytical results were compared to updated DOH EALs from Table D-1a, Groundwater Action Levels (DOH 2024b). Groundwater samples from all three temporary perched groundwater monitoring wells exceeded the DOH EAL for TPH (middle distillates) and the EPA RSL for naphthalene. One temporary perched groundwater monitoring well also exceeded DOH EALs for 1-methylnapthalene and 2-methylnaphthalene and the EPA RSL for ethylbenzene. Locations of groundwater exceedances are illustrated on Figure 2.

3.3 CONCRETE TANK AND CONTAMINATED SOIL REMOVAL ACTIONS

(b) (4) [redacted] performed two phases of excavation to remove the holding tank-leach tank as well as the contaminated soil identified during the Phase 2 Holding Tank and Leach Tank Characterization (DON 2023b). Excavation preparation and activities are documented in the Final Closure Report Concrete Tank Removal (DON 2023a).

Prior to demolition of the tanks, the contents in the holding tank were removed and the tank was cleaned. The influent pipe to the holding tank was disconnected and capped in place using an expanding plug. Both tanks and the connection piping were demolished in-situ. (b) (4) [redacted] then excavated the demolished tanks, connection piping and grossly contaminated soil to a depth of approximately 12.5 ft bgs under the holding tank, 15 ft bgs under the leach tank, and 3 ft bgs under the pipe trench area. Visual inspection of the excavated soil showed evidence of petroleum staining.

Soil surrounding the holding tank-leach tank was also excavated between 0–12 ft on a slope and 12–30 ft bgs in the immediate footprint of the tanks during the second phase of excavation (Figure 2). During this excavation, various subsurface debris were uncovered, including an aviation gasoline (AVGAS) pipeline, which resulted in the southern sidewall being shifted slightly for protection of the AVGAS line.

Confirmation samples were collected from each excavation area post-excavation. Samples were collected using multi-increment (MI) sampling procedures (DOH 2024c, Section 4). Confirmation samples were analyzed for TPH (-DRO, -GRO, and -lube oil range organics); benzene, toluene, ethylbenzene, and total xylenes (BTEX); and PAHs.

PSLs for confirmation soil sampling were DOH EALs for Groundwater Protection of a Drinking Water Resource, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water source; surface water body is located within (b) (3) (B) [redacted] meters of release), and Direct Exposure Action Levels. Applicable DOH EALs were updated to reflect the most current values updated in July 2024 (DOH 2024b). Confirmation soil sampling results showed exceedances for TPH (middle distillate) above Direct Exposure DOH EALs in 7 of 15 decision units throughout the excavation area. The highest TPH (middle distillate) detections were from samples in the northern sidewall at 5–12 ft bgs (Figure 3).

To quantify the amount of JP-5 recovered from the release, (b) (4) [redacted] coordinated with AECOM Technical Services, Inc. for MI sampling of contaminated soil being loaded into trucks for disposal, in accordance with the *Final Sampling and Analysis Plan for Quantifying Total Petroleum Hydrocarbons Mass* (DON 2022b). Elevated PID readings and odors were observed throughout the 8–30 ft bgs excavation. However, there were no exceedances above DOH EALs for Groundwater Protection of a Drinking Water Resource, Soil Action Levels in the samples collected for laboratory analysis.

Following completion of removal activities and confirmation sampling, the excavation area was backfilled with certified clean fill and restored to its original grade.

4. Site Characterization Objectives

4.1 PROBLEM STATEMENT

This characterization of the Site is being performed to fill knowledge gaps identified by the Regulatory Agencies (RAs) following the Phase 2 Characterization (DON 2023b) and subsequent excavation of the holding tank-leach tank and soil (DON 2023a).

Knowledge gaps identified include:

- Lateral and vertical extent of contamination in the subsurface soil that is not fully delineated.
- Spatial and temporal extent of petroleum in perched groundwater.
- Potential for petroleum and contaminated water to have migrated vertically (into the basal aquifer) and laterally over time.
- Impact to South Halawa Stream and downstream receptors.
- Potential releases from the (b) (3) (B) [redacted] sump pipeline leading to the former holding tank-leach tank location.
- A more extensive analyte list to include additional indicators of petroleum contamination or degradation.
- Further nature and extent investigation of the former holding tank-leach tank excavation area.

4.2 IDENTIFY PRINCIPAL STUDY QUESTIONS AND CHEMICALS OF POTENTIAL CONCERN

The following are the principal study questions (PSQs) that the study will address:

- What are the lateral and vertical extents of contamination in subsurface soil from the location of the former holding tank-leach tank where COPC concentrations are greater than their respective PSLs?
- What is the extent of COPC concentrations greater than their respective PSLs in perched groundwater surrounding the location of the former holding tank-leach tank?
- Are COPCs present in the basal aquifer surrounding the location of the former holding tank-leach tank at concentrations greater than their respective PSLs?
- Are COPCs from subsurface soil or perched groundwater surrounding the location of the former holding tank-leach tank migrating to South Halawa Stream at concentrations greater than their respective PSLs?

The COPCs at the Site are TPH-GRO, TPH-DRO, TPH-ORO, BTEX, trimethylbenzene, fuel additives (1,2-dischloroethane, 1,2-dibromoethane, phenol, 2-2-methoxyethoxyethanol[groundwater only]), Tetraethyl Lead and PAHs.

4.3 IDENTIFY DATA INFORMATION NEEDS

Identified in this subsection are:

- The types and sources of information needed to answer the PSQs
- The quality of information needed

Information inputs will include the following: PSLs for middle distillate (TPH-GRO/DRO/ORO), individual "indicator" compounds (BTEX, trimethylbenzene, PAHs) and fuel additives (1,2-dischloroethane, 1,2-dibromoethane, phenol, and 2-2-methoxyethoxyethanol[groundwater only]) in subsurface soil, groundwater, and surface water. All PSLs were derived from the lower value between current DOH EALs (DOH 2024b) and EPA RSLs (EPA 2024) for soil, groundwater, and surface water. PSLs for subsurface soil samples, groundwater samples and surface water samples are listed in Appendix B, Table B-2.

The DOH EALs will be based on the most recent published EALs (DOH 2024b):

- *Soil:* DOH Table A-2, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site)
- *Groundwater:* DOH Table D-1b, Groundwater Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site)
- *Surface Water:* DOH Table D-2a, Surface Water Action Levels (freshwater habitats)

The EPA RSLs will be based on the most recent published RSLs (EPA 2024):

- *Soil:* Residential Soil RSL using a total hazard quotient (THQ) of 0.1 and a target cancer risk of 1E-06
- *Groundwater/Surface Water:* Tap Water RSL using a THQ of 0.1 and a target cancer risk of 1E-06

Subsurface Soil Sampling: Subsurface soil sample collection will be used to delineate the vertical and lateral extents of contamination across the Site. To delineate the lateral extent of contamination, eight boreholes will be placed in multiple directions outward from the excavated area of the former holding tank-leach tank. To delineate the vertical extent of contamination, two borehole locations will be placed near former footprints of the former holding tank-leach tank within the excavated area (Figure 4). Subsurface soil samples will not be collected in the backfilled excavation footprint where the most contaminated soil was previously removed from ground surface to 30 ft bgs.

Lateral and vertical constraints that impact methods of sample collection are present at the Site. The Site boundary is limited due to the presence of South Halawa Stream to the north, a drainage swale in the northeast section of the Site, Red Hill Facility boundaries, and other Site operations. During previous investigations, basalt boulders were noted at shallow depths (less than 10 ft bgs) as well as concrete rubble observed at subsurface depths up to 20 ft bgs (Section 2). The use of MI sampling was explored but not proposed because it is unlikely that sufficient borings can be completed and sampled through the zone of interest (due to the density of boulders observed in the subsurface of this area) to allow a minimum of 30 increments to be collected. MI sampling would also require complete vegetation clearance of the Site, which is too invasive for this location. Complete tree removal would require permitting and re-grading to inhibit surface water run-off from the Facility from running into the stream. Complete vegetation clearance would also interfere with nearby ongoing GAC water treatment operations.

Therefore, increment subsamples will be collected from each borehole core in accordance with DOH *Technical Guidance Manual Section 4 Appendix G.3* (DOH 2024c). Up to 12 borings will be attempted to be advanced from 5 ft bgs to above the capillary fringe or until 45 ft bgs. If refusal is met prior to the capillary fringe or 45 ft bgs, one additional attempt to advance will be made. If the borehole cannot be advanced, then the borehole will be abandoned and re-attempted within 3 horizontal ft of the original. All refusals will be documented. Seasonal variations toward site conditions will not have any significant impact.

Groundwater Sampling: Up to three perched groundwater monitoring wells and one basal groundwater monitoring well will be installed (rationale included in Table 5-1). Data from the new wells, along with existing nearby wells installed as part of a former OWDF investigation (DON 2021), will be used to evaluate the presence and extent of contamination in the perched and basal groundwater zones, temporal fluctuation in concentrations, and hydraulic gradients of the perched and basal groundwater at the Site. If TPH is detected, the result will undergo a tiered forensic analysis to confirm the source of the contaminant in accordance with the Hawaii DOH Memorandum *Comparison of HIDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* (DOH 2024a). Additional information for the tiered forensic analysis and flow chart is provided in Appendix D. Perched groundwater elevations from the proposed wells will also be used to evaluate the relative elevation to South Halawa Stream and contribution (if any) to stream flow. Quarterly sampling for 1 year is proposed.

Surface Water Sampling: To assess potential mobilization of contaminants into South Halawa Stream, differences in elevation between the perched groundwater and stream channel will be evaluated. This assessment will occur during the quarterly groundwater sampling to take into account seasonal variations. This assessment will also consider the Red Hill Shaft pumping schedule and elevations will be recorded when the pump system is off, as to only capture water levels that accurately represent South Halawa Stream. Comparison of the stream's elevation relative to the elevation of perched groundwater will provide a line of evidence that the stream is either losing or gaining (i.e., it will be inferred that the stream is "losing" if perched groundwater is present at a lower elevation that the stream). After 1 year of monitoring water level elevations of South Halawa Stream, and in the case that a potential transport pathway is confirmed with a gaining stream, discrete grab surface water samples will be collected from South Halawa Stream. United States Geological Survey data may also be considered in the stream evaluation, including stream flow data.

4.4 DEVELOP THE ANALYTIC APPROACH AND DECISION RULES

1. If COPC concentrations in the subsurface are not detected at a concentration above the most conservative DOH Tier 1 EAL in any sampling location, then recommend no further sampling. If COPC concentrations in subsurface soil are detected at concentrations above the most conservative DOH Tier 1 EALs, then evaluate if exceedances are delineated laterally and vertically with additional borings. If exceedances are delineated, then no additional subsurface soil sampling will be conducted.

   If exceedances are not delineated, then conduct step-out borings to further delineate the lateral extent of contamination, or deeper borings to further delineate the vertical extent of contamination.

2. If none of the COPC concentrations in perched groundwater samples collected during 1 year of quarterly monitoring are detected above the most conservative DOH Tier 1 EALs, then recommend no further sampling.

   If COPC concentrations in perched groundwater exceed the most conservative DOH Tier 1 EALs, then conduct a longer temporal study or install additional step-out perched groundwater monitoring wells down gradient of the source area to define the extent of perched groundwater impacts.

   If COPC concentrations in basal groundwater exceed the most conservative DOH Tier 1 EALs, then conduct an expanded study to include more existing basal wells at the Facility and install more basal groundwater monitoring wells downgradient of the source area to define the extent of basal groundwater impacts.

3. If quarterly perched groundwater level monitoring for 1 year indicates that the elevation of South Halawa Stream is higher than the elevation of the perched groundwater (i.e., the stream is not receiving water from the perched groundwater due to relative elevation), then recommend no further action. If water levels indicate that the perched groundwater is seeping into the stream, then collect surface water samples at the locations most likely influenced by this seepage for analysis of COPCs.

5. Scope of Work and Description of Sampling Activities

Activities described below will be conducted in accordance with the cited procedures in the Naval Engineering Systems Command (NAVFAC), Pacific's Environmental Restoration Program *Project Procedures Manual* (DON 2015). The procedures are reproduced in Appendix A.

5.1 PRE-INTRUSIVE WORK REQUIREMENTS

Prior to beginning field work:

- A permit will be obtained from the Hawaii Department of Land and Natural Resources (DLNR) Commission on Water Resource Management to construct the basal groundwater monitoring well. Well construction permit applications will be submitted by a drilling company licensed in the State of Hawaii.
- The Navy will complete dig permits for each potential intrusive activity, as described in Procedure I-A-5, *Utility Clearance Surveying*.
- If needed, an opening in the security fence along the property perimeter will be installed to allow for the passage of drilling equipment upon approval from Security. The opening will be fitted with a lockable gate facing inward toward the Facility. Vegetation clearance of the entire Site will be completed to facilitate access for a geophysical and land survey and to allow for the ingress and egress of drilling equipment upon approval. A topographic survey will be completed for the entire Site via Second Order, Class I Leveling Survey techniques with a horizontal accuracy of ±0.1 ft and vertical accuracy of ±0.01 ft, and according to Procedure I-I, *Land Surveying.*
- The Site boundary, proposed monitoring well installation locations, and soil sampling borehole locations will be established using a differential Global Positioning System such as a Trimble with sub-meter accuracy.
- A topographic survey of the invert elevation of the concrete channel of South Halawa Stream will be completed to determine the elevation of the stream relative to the elevation of perched groundwater. Coordination with the City and County of Honolulu and State of Hawaii departments will be conducted as necessary prior to entering the stream channel. Staff will not enter the channel following heavy rains that may result in flash flooding.
  - The survey will be completed using Second Order, Class I Leveling Survey techniques with a horizontal accuracy of ±0.1 ft and vertical accuracy of ±0.01 ft and according to Procedure I-I, *Land Surveying.*
- A geophysical survey will be completed over the entire Site using electromagnetic or ground-penetrating radar methods as described in Procedure I-A-5, *Utility Clearance*. The purpose of the geophysical survey will be to locate both previously unidentified infrastructure and drilling points that can be safely drilled.

5.2 SUBSURFACE SOIL SAMPLING DESIGN

The subsurface soil sampling design will use an increment subsampling approach that employs weight-of-evidence/field observations to guide step-out and vertical delineation sampling. The assessment and use of increment subsampling will be in accordance with the DOH *Technical Guidance Manual* (DOH 2024, Section 4, Appendix G.3). Various drilling methods may be used (e.g., hollow-stem auger, solid-stem auger, or air rotary) based on the subsurface conditions at each boring location. Samples will be collected from undisturbed soil using a split-spoon. If refusal is encountered prior to reaching the target depth (capillary fringe), a second boring will be drilled within 3 ft of the initial borehole. Continuous soil cores will be collected from the ground surface to the terminated depth of the boring to record lithology in accordance with Procedure I-E, *Soil and Rock Classification*.

The following lateral and vertical delineation approaches will be used:

- *Lateral delineation:* Up to eight initial borings will be completed around the perimeter of the previous investigation and excavation areas to determine the lateral extent of contamination (Figure 5). Each boring will be completed to the perched groundwater's capillary fringe. If the capillary fringe is not encountered, each boring will be advance to a total depth of 45 ft bgs. The soil core from each boring will be screened via headspace analysis using a flame ionization detector (FID) or PID and observed for visible or olfactory indications of petroleum impacts (e.g., staining or odors). If field observations of the soil core suggest that the location is impacted by petroleum hydrocarbons, then a step-out boring will be completed. Additional step-out borings may be completed if necessary.
- *Vertical Delineation:* Up to two borings will be completed in the holding tank and leach tank release area to determine whether exceedances of petroleum hydrocarbons in soil extend deeper than the perched groundwater (Figure 5). Each boring will be advanced to 10 ft into unsaturated soil below the perched groundwater's confining layer (estimated to be approximately 40 ft bgs). The soil core from the unsaturated soil will be inspected with an FID or PID and for observations of visible or olfactory indications of petroleum impacts. If field observations of the soil core suggest that the soil is impacted by petroleum hydrocarbons, then an additional 10 ft will be drilled and the core will be inspected for evidence of petroleum impacts. Vertical advancement will continue in 10-ft intervals until no evidence of petroleum impact is observed. If contamination is observed in the soil or perched groundwater, then casing will be installed to seal the intervals of contamination and prevent migration deeper into the subsurface. The purpose of subsurface soil sample collection for vertical delineation below the confining unit is to evaluate for potential migration of COPCs below the confining unit.

Soil samples will be collected from each boring for laboratory analysis. For borings intended to delineate contamination laterally, soil will be collected from 5 ft bgs to the capillary fringe. Soil between 0 and 5 ft bgs will not be sampled, as releases at the Site occurred at depths greater than 5 ft bgs, and this upper layer is unlikely to have been impacted. Each soil sample will be collected from a 5-ft interval. Each soil boring could have a maximum of eight samples collected if it is advanced to the maximum depth of 45 ft bgs.

In borings intended for vertical delineation, soil will be collected for laboratory analysis once unsaturated soil is encountered below the perched groundwater's confining layer. Up to two soil samples will be collected from 5-ft intervals for up to 10 ft below the confining layer (e.g., 40−45 ft bgs and 45−50 ft bgs).

Samples will be submitted for analysis of the following (as detailed in Appendix B):

- *TPH:* TPH-GRO, TPH-DRO, TPH-ORO
- *TPH with Silica Gel Cleanup (SGC):* TPH-DRO, TPH-ORO
- *VOCs*: BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene
- *Fuel Additives:* 1,2-dichloroethane, 1,2-dibromoethane (ethylene dibromide), phenol, tetraethyllead
- *PAHs:* 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, and pyrene

Soil for VOC analysis will be collected directly from the soil cores immediately using 5-gram plugs after retrieval of the core sampler to avoid VOC losses. Depending on the amount of recovery, sixty 5-gram plugs (increments) will be collected per sample for VOC analysis. Plugs will be collected approximately every 1 inch from each 5-ft interval and submitted to the laboratory as an incremental sample in methanol-preserved glass jars. Care will be taken to prevent the spillage or splashing of methanol from the sample jar. Every effort will be made to minimize volatilization by limiting the time the lid remains off the sample container. Following collection of soil plugs for VOC analysis, the remainder of the core will be split in half vertically and half of the core will be submitted as a bulk sample to the laboratory for incremental subsampling analysis of the other analytes.

Once soil sampling is completed, each borehole will be abandoned in accordance with Procedure I-B-1, *Soil Sampling*.

5.3 Monitoring Well Installation

Proposed groundwater monitoring well locations are listed in Table 5-1 and illustrated on Figure 5. To evaluate the lateral extent of contamination in the perched groundwater layer at the Site, up to three perched groundwater monitoring wells will be installed:

- One perched well will be installed at the location of the initial release (i.e., the former leach tank).
- Two perched wells will be installed downgradient of the release area, to the northwest and northeast, along South Halawa Stream.

If PSLs are exceeded at any of these locations, the Navy will evaluate the data and determine whether additional step-out wells should be installed.

One basal groundwater monitoring well (HTLTMW02A) is proposed to monitor the underlying basal aquifer down gradient of the source location, according to assumed basal groundwater flow direction (Section 2.1.4). The proposed location of the basal groundwater monitoring well is near previous temporary well LT-W35 which previously had PSL exceedances for PAHs and TPH-DRO in 2022 (Section 3.2). This basal groundwater monitoring well will be co-located with a perched groundwater monitoring well, HTLTMW02B, which will monitor the perched groundwater in the location of the previously recorded COPC exceedances. Well installation activities will be conducted in accordance with Procedures I-C-1, *Monitoring Well Installation and Abandonment*, I-C-2, *Monitoring Well Development*, and Appendix C.

The proposed perched groundwater monitoring wells will be installed so that the 10-ft screened interval captures the assumed minimum and maximum perched groundwater levels including the capillary fringe. Depths for screen installation will vary between wells dependent on the depth at which the perched layer is encountered. Based on the temporary wells installed during the Phase 2 Holding Tank and Leach Tank Characterization (DON 2023b) and installation information for perched groundwater monitoring wells located within the former OWDF, perched groundwater can be expected to be encountered at a depth of approximately 25–35 ft bgs. The existing former OWDF wells are positioned in clusters on the eastern side of the Site and southwest of the Site (Figure 5).

Table 5-1: Proposed Groundwater Installation and Sampling Locations

Sample Type	Installation Status	Monitoring Well	Sampling Rationale
Perched	Proposed	HTLTMW01	Proposed perched groundwater monitoring well to be located in the footprint of the former holding tank-leach tank. This well will provide source area concentrations of COPCs in perched groundwater.
		HTLTMW02B	Proposed perched groundwater monitoring well is to be located northwest of the former holding tank-leach tank area. The proposed location is near where previous subsurface sampling activities reported COPC exceedances of PSLs (Section 3). Will provide lateral delineation of COPCs in the subsurface. Proposed to be co-located with HTLTMW02A.
		HTLTMW03	Proposed perched groundwater monitoring well is to be located northwest of the former holding tank-leach tank area. The proposed location will be the closest perched groundwater well adjacent to South Halawa Stream to provide lateral delineation of COPCs in that direction. Proposed well will also aid in addressing potential impacts of perched groundwater to South Halawa Stream.
	Installed	OWDFMW03B	Groundwater monitoring well is southwest of the Site and will provide lateral delineation of COPCs in perched groundwater in that direction.
		OWDFMW05B	Groundwater monitoring well is the farthest well southwest of the Site and will provide lateral delineation of COPCs in perched groundwater in that direction.
		OWDFMW06B	Groundwater monitoring well is on the eastern side of the Site and will provide lateral delineation of COPCs in perched groundwater in that direction. Co-located with OWDFMW06A.
		OWDFMW07B	Groundwater monitoring well east of the Site area and in an elevated topography, this well will provide lateral delineation of COPCs in perched groundwater in that direction. Co-located with OWDFMW07A and OWDFMW07C.
Elevated Head	Installed	OWDFMW07C	Groundwater monitoring well east of the Site area and included in the OWDFMW07B/C well cluster. This well is screened deeper than the OWDFMW07B perched groundwater well and is in elevated head conditions. Data from this well will provide vertical delineation of COPCs in the zone between the perched groundwater and basal aquifer.
Basal	Proposed	HTLTMW02A	Proposed basal groundwater monitoring well is to be located northwest of the former holding tank-leach tank area. The proposed location is near where previous subsurface sampling activities reported COPC exceedances of PSLs (Section 3). Will provide data pertaining to the potential vertical migration of COPCs in the subsurface to the basal aquifer. Proposed to be co-located with HTLTMW02B.
	Installed	OWDFMW03A	Groundwater monitoring well is southwest of the Site and will provide lateral and vertical delineation of COPCs in basal groundwater in that direction. Co-located with OWDFMW03B.
		OWDFMW05A	Groundwater monitoring is the furthest well southwest of the Site and will provide lateral and vertical delineation of COPCs basal groundwater in that direction. Co-located with OWDFMW05B.
		OWDFMW06A	Groundwater monitoring well is on the eastern side of the Site area and will provide lateral and vertical delineation of COPCs in basal groundwater in that direction. Co-located with OWDFMW06B.
		OWDFMW07A	Groundwater monitoring well is east of the Site area in elevated topography and will provide vertical delineation of COPCs in perched groundwater in that direction. Co-located with OWDFMW07B and OWDFMW07C.

One basal groundwater monitoring well will also be installed at the Site. This well will be installed within 15 ft of one of the proposed perched groundwater monitoring wells, northwest of the location of the former holding tank-leach tank (Figure 5). The anticipated depth to the basal aquifer is 100 ft bgs (Section 2.1.4). The basal well will be screened to capture the top extent of the basal aquifer where, due to the nature of COPCs and LNAPL in water, contamination are likely present and will be isolated from the overlying perched aquifer. If contamination is encountered during installation of the basal groundwater monitoring well, then conductor casing will be installed to seal intervals of contaminated perched groundwater and subsurface soil. Conductor casing will be installed in accordance with DLNR standards (DLNR 2004).

After the wells have been installed, each well will be surveyed to establish the horizontal and vertical coordinates and measurement point elevation for the final well completion using Second Order, Class I procedures consistent with those described in the *Technical Memorandum, Topographic Survey* (DON 2017).

Perched and basal groundwater monitoring well drilling and installation procedures, including contamination scenarios, and well installation diagrams, are included in Appendix C.

New monitoring wells will be labeled with the prefix of "HTLTMW" followed by the well number. In the cluster location with both a basal and perched groundwater monitoring well, the basal well will be designated with an "A" suffix (e.g., HTLTMW02A) and the perched groundwater monitoring well will be designated with a "B" suffix (e.g., HTLTMW02B).

5.4 QUARTERLY GROUNDWATER MONITORING

Quarterly groundwater monitoring for 1 year is proposed for the proposed perched groundwater and basal groundwater monitoring wells and nearby existing perched and basal groundwater monitoring OWDF wells. A list of the wells to be sampled and target analytes is presented in Table 5-1, and the location of the wells is illustrated on Figure 5.

Prior to sampling, an oil/water interface probe will be used to both collect a depth to water measurement and signal if there is product present. If product is present, the product only will be sampled with a bailer and submitted to the laboratory for speciation via a tiered forensic approach in accordance with the Hawaii DOH Memorandum *Comparison of HIDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* (DOH 2024a). No groundwater sample will be collected if product is present in this particular location. If product is not present, samples will be collected via a low-flow pump and conducted in accordance with Procedure I-C-3, *Monitoring Well Sampling* (Appendix A). Field quality control (QC) samples will consist of field duplicates, matrix spike/matrix spike duplicate (MS/MSD) samples, field blanks, and equipment blanks (Appendix B).

Samples will be submitted for analysis of the following (as detailed in Appendix B):

- *TPH:* TPH-GRO, TPH-DRO, TPH-ORO
- *TPH with SGC:* TPH-DRO, TPH-ORO
- *VOCs:* BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene
- *Fuel Additives:* 1,2-dichloroethane, 1,2-dibromoethane (ethylene dibromide), phenol, 2-(2-methoxyethoxy)ethanol
- *PAHs:* 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, pyrene

If TPH is detected in a groundwater sample, the result will be further analyzed using a tiered forensic approach in accordance with the Hawaii DOH Memorandum *Comparison of HIDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* (DOH 2024a), to confirm the source of the contaminant (additional information is provided in Appendix D).

5.5 SURFACE WATER SAMPLING

Four quarterly groundwater gauging events will be conducted to evaluate temporal changes in the elevation of perched groundwater at the Site. The elevation of perched groundwater will then be compared to the elevation of South Halawa Stream to evaluate whether the stream in the vicinity of the Site is gaining or losing. If the elevations of the perched groundwater and stream suggest that the stream is gaining (and therefore may be impacted by perched groundwater), then surface water samples from the stream will be collected concurrently with quarterly groundwater monitoring sample collection. Surface water samples will be collected from two locations: upgradient of the Site to establish background conditions specific to the Site, and adjacent to the Site prior to the Red Hill Shaft water treatment system discharge location. No downstream samples of the Site are proposed because the results would be more indicative of the water treatment discharge. If contaminants are identified in the background stream conditions sample taken upgradient from the Site, then recommendations for further investigation will be included in the report. Surface water samples will be collected in accordance with Procedure I-B-5, *Surface Water Sampling*.

Samples will be submitted for analysis of the following (as detailed in Appendix B):

- *TPH:* TPH-GRO, TPH-DRO, TPH-ORO
- *TPH with SGC:* TPH-DRO, TPH-ORO
- *VOCs:* BTEX, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene
- *Fuel Additives:* 1,2-dichloroethane, 1,2-dibromoethane (ethylene dibromide), phenol, 2-(2-methoxylethoxy)ethanol, tetraethyllead
- *PAHs:* 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, and pyrene

The proposed stream sampling locations are illustrated on Figure 6. If the stream is dry at the time of sampling, then no sample will be collected. Field QC samples will consist of field duplicates, MS/MSD samples, field blanks, and equipment blanks (Appendix B).

5.6 INVESTIGATION-DERIVED WASTE MANAGEMENT

Solid, liquid, and mud investigation-derived waste (IDW) generated during soil boring and monitoring well installation and development activities will be collected at the end of each workday. The IDW will be handled, stored, and labeled in accordance with Procedure I-A-6, *Investigation-Derived Waste Management* (Appendix A). Soil IDW from soil sample borings will be collected and stored in 55-gallon U.S. Department of Transportation (DOT)-approved drums. Monitoring well installation and development activities will use appropriate containers for the media and could include 55-gallon U.S. DOT-approved metal drums, 20-cubic-yard roll-off bins, or tanks up to 10,000-gallons. Bulk containers and drums will be segregated according to matrix, and at least one composite IDW sample will be collected from each grouping for waste characterization in accordance with Procedure I-D-1, *Drum Sampling*. IDW characterization samples will be submitted for analysis to a laboratory certified by the Department of Defense Environmental Laboratory Accreditation Program. Waste profile forms will be prepared and submitted to potential disposal facilities for approval. The IDW will be kept at a staging area until the IDW analytical data are received and associated waste profile forms are approved by the disposal facilities. The IDW will then be removed from the staging area, transported to, and disposed of at the approved disposal facilities. IDW will be disposed of within 90 calendar days of the generation date. Disposable personal protective equipment and disposable sampling equipment will be collected in plastic trash bags and disposed of as municipal solid waste.

6. Quality Assurance/Quality Control Plan

The following additional details of collecting subsurface unconsolidated material, groundwater, surface water, and LNAPL samples are presented in Appendix B:

- Data Deliverable Requirements
- Field Sampling, Analytical and Quality Management Reference Tables
  - Location-Specific Sampling Methods/Standard Operating Procedure (SOP) Requirements
  - Analyte List and Reference Limits
  - Preparation and Analytical Requirements for Field/QC Samples
  - Analytical Services
  - Analytical SOP References
  - Laboratory QC Samples for Chemistry Analyses
  - Analytical Instrument and Equipment Maintenance, Testing, and Inspection
  - Analytical Instrument Calibration
  - Data Verification and Validation Process

Procedures cited in this section are from the NAVFAC Pacific Project Procedures Manual (DON 2015) and are reproduced in Appendix A.

6.1 Sample Custody Requirements

Each sample will be assigned a chain of custody (CoC) sample identification (ID) number and a descriptive ID number in accordance with Procedure I-A-8, *Sample Naming*. All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks*. The CoC sample ID number (the only ID number submitted to the analytical laboratory) is used to facilitate data tracking and storage. The CoC sample ID number allows all samples to be submitted to the laboratory without providing information on the sample type or source. The descriptive ID number is linked to the CoC sample ID number, which provides information regarding sample type, origin, and source.

6.1.1 CoC Sample Identification Number

A CoC sample ID number will be assigned to each sample as follows, to facilitate data tracking and storage:

ERHxxx

Where:

ERH	=	Designates the samples for the Red Hill Bulk Fuel Storage Facility program
xxx	=	Chronological number, starting with next consecutive number (will be determined prior to field work and is dependent on the last number used in the most recent sampling event)

QC samples will be included in the chronological sequence.

6.1.2 Descriptive Identification Number

A descriptive ID number (for internal use only) will identify the sampling location, type, sequence, matrix, and depth. The descriptive ID number is used to provide sample-specific information (e.g., location, sequence, and matrix). The descriptive identifier is not revealed to the analytical laboratory. The descriptive ID number for all samples is assigned as follows:

For soil: AAB##-CCDD##-##.#

For water: AAB##-CCDD##-######

Where:

AA	=	Site area (HTLT) (Table 6-1)
B	=	Location Type (e.g., BH, MW) (Table 6-2)
##	=	Location ID (e.g., 01, 02)
CC	=	Matrix (e.g., WG, SO) (Table 6-3)
DD	=	SACODE (normal or QC) (Table 6-4)
##	=	Chronological sample number from a particular sampling location (e.g., 01, 02)

If SOIL:

##	=	Depth of sample in ft bgs (measured to the tenth of a foot) for soil (Table 6-5)

If WATER:

######	=	Month, day, and year of collection (e.g., 031525 for March 15, 2025)

As a soil example, the sample number HTLTBH01-SON01-22.0 would indicate that the sample is collected from:

- LOCID HTLTBH01 (Bore Hole Location 01)
- Matrix is “SO” (subsurface soil)
- SACODE is “N” (normal environmental sample—not a QC sample)
- Sample Number is “01” (the first normal sample taken at that location)
- Beginning sample depth is 22.0 (depth from ground surface in decimal feet)

As a groundwater example, the sample number HTLTMW01-WGN01-031522 would indicate that the sample is collected from:

- LOCID HTLTMW01(Monitoring Well Location 01)
- Matrix is “WG” (groundwater)
- SACODE is “N” (normal environmental sample—not a QC sample)
- Sample Number is “01” (the first normal sample taken at that location that day)
- Sample Date is “031522” (March 15, 2022)

The duplicate groundwater sample would be designated as:

- HTLTMW01-WGFD01-031522 (SACODE “N” is replaced by “FD”)

These characters will establish a unique descriptive identifier that will be used during data evaluation.

Table 6-1: Area Identifiers

Identifier	Site Area
HTLT	Holding Tank-Leach Tank

Table 6-2: Direction-Distance Identifiers

Identifier	Direction and Distance
BH	Borehole
MW	Monitoring Well
UG	Upgradient Stream Surface Water Sample
ADJ	Adjacent Stream Surface Water Sample
DS	Downstream Stream Surface Water Sample

Table 6-3: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
SO	Subsurface Unconsolidated Material	Unconsolidated Material
WG	Groundwater	Water
WS	Surface Water	Water
GS	Soil Vapor	Gas
LA	Light Nonaqueous-Phase Liquid	LNAPL
WQ	QC Water	Water
SQ	QC Soil	Core

Table 6-4: Field QC (SACODE) Type Identifiers

Identifier	Field or QC Sample Type	Description
N	Primary Sample	All field samples, except QC samples
FD	Duplicate	Co-located for unconsolidated material
EB	Equipment Blank	Water
TB	Field Blank	Water
AB	Ambient Blank	Water

Table 6-5: Sample Depth Identifiers

Identifier	Field or QC Sample Type	Description
###.#	Beginning Depth Interval	Top of soil Interval sampled
###.#	Bottom Depth Interval	Bottom of soil Interval sampled

6.1.3 Handling, Shipping, and Custody

All samples collected for analysis will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks*. All samples will be labeled and recorded on CoC forms in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. Samples will be handled, stored, and shipped in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping*. All samples collected for this project will be shipped to the analytical laboratory via overnight airfreight.

All samples received at the analytical laboratory will be managed in accordance with laboratory SOPs for receiving samples, archiving data, and sample disposal and waste collection, as well as storage and disposal per Module 1, Section 4.2 "Handling of Samples" of the Department of Defense *Quality Systems Manual (QSM)* v. 6.0 (DoD and DOE 2023).

6.2 Laboratory Quality Control Samples

Laboratory QC samples will be prepared and analyzed in accordance with the methods and procedures detailed in Appendix B.

7. Schedule

Activity	Deliverable	Organization	Anticipated Dates
Draft WP submitted to RAs	Draft WP	—	February 7, 2025
RA review of Draft WP	Review comments	—	February 7 – April 30, 2025
Navy evaluation of comments and preparation of comment responses and redline WP	Comment responses and redline WP	—	April 30 – June 9, 2025
RA review of comment responses and redline WP	Review comments	June 10 – July 10, 2025 (30 days)	—
Navy evaluation of comments and preparation of comment responses and redline WP	Comment responses and redline WP	July 10 – August 24, 2025 (45 days)	—
RA acceptance of comment responses and redline WP	Acceptance letter	August 24 – September 23, 2025 (30 days)	—
Final WP due to RAs	Final WP	September 23 – October 23, 2025 (30 days)	—
Field sampling, laboratory analysis, and data validation	—	November 2025 – October 2026	—
Draft report preparation	Draft report	November 2026 – January 2027	—

Note: Dates presented are hypothetical and subject to change.
— no data

8. Health and Safety Plan

An accident prevention plan for Red Hill projects has been prepared as a standalone document for the Navy's internal use (DON 2024a).

9. References

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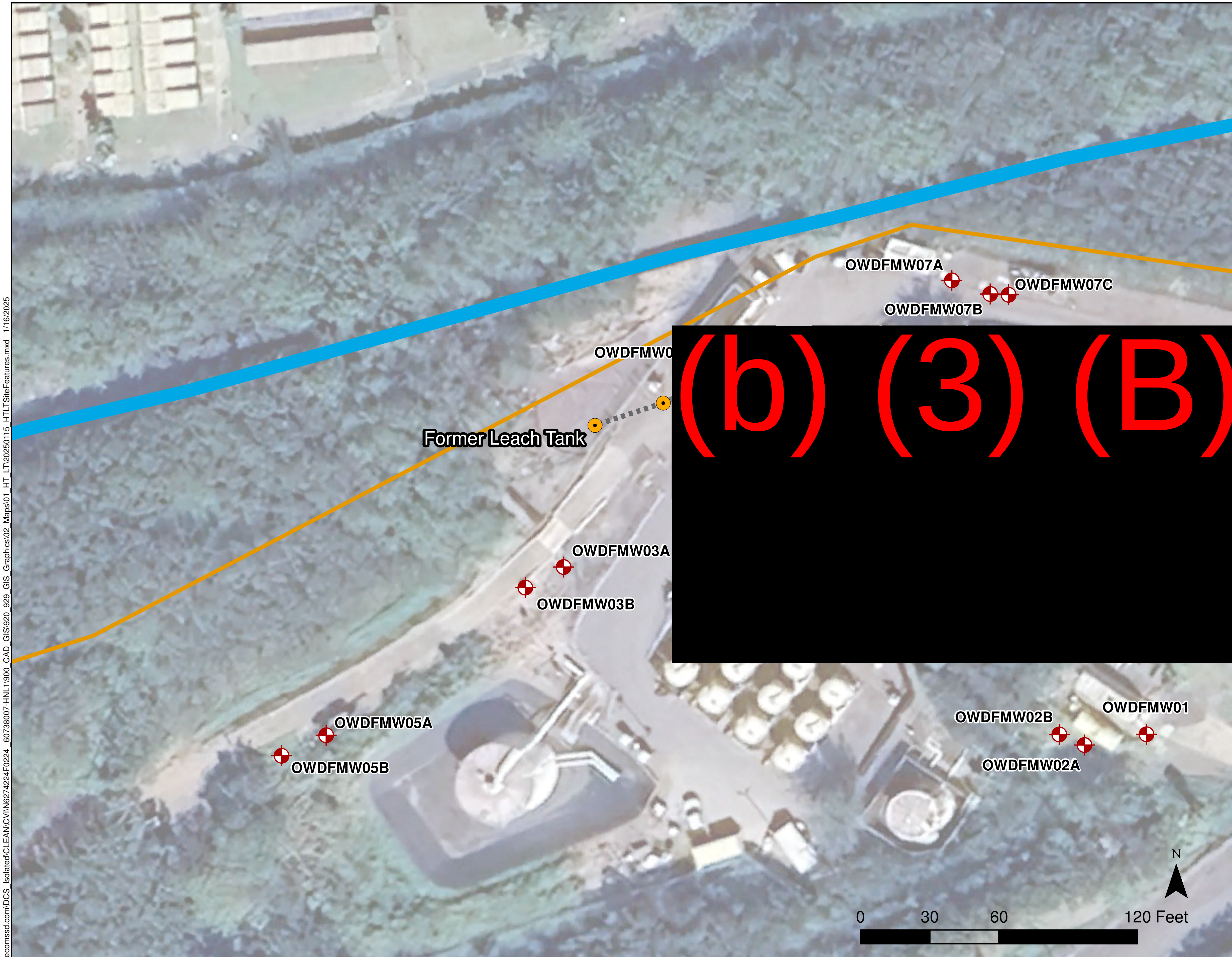
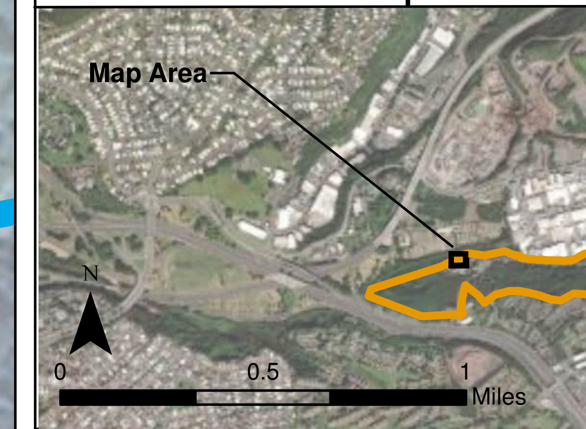
Figures



Location Map



Legend

- OWDF Monitoring Well
- Former Tank Location
- Approximate Location of Buried 4-inch Cast Iron Drain Pipe from [redacted] (b) (3) (B)
- Approximate Location of Removed 4-inch Cast Iron Drain Pipe Between Tanks
- Red Hill Facility Boundary
- South Halawa Stream

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: U.S. Geological Survey, 2011, USGS High Resolution Orthoimagery for Honolulu, Hawaii
3. Location Map Source:Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/ Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
4. Coordinates: NAD 1983 Hawaii State Plane Z3 ft
5. OWDF = Oily Waste Disposal Facility

Figure 1
Former Holding Tank-Leach Tank
Site Area
SIte Characterization Work Plan
Holding Tank-Leach Tank
JBPHH, Oahu, Hawaii

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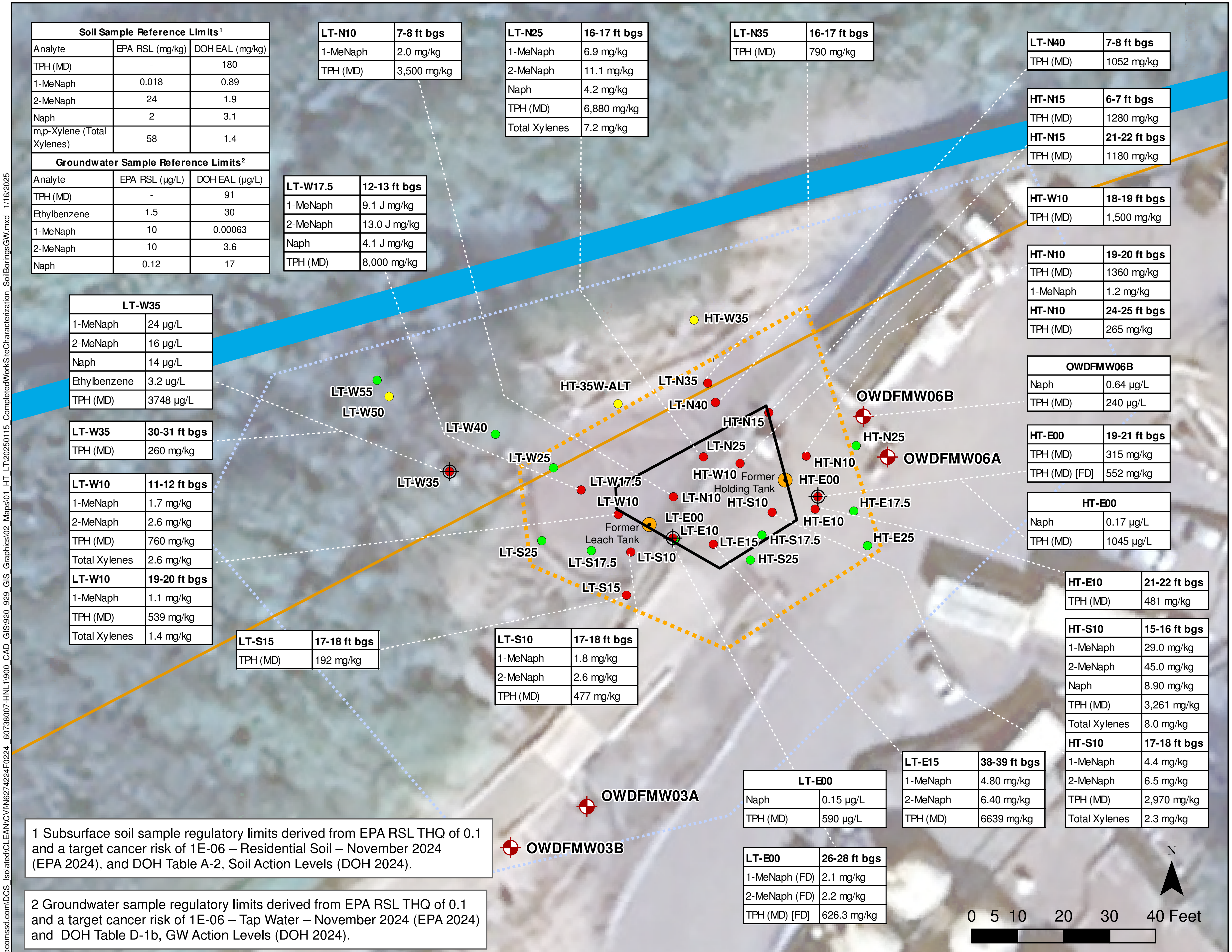

Soil Sample Reference Limits[1]		
Analyte	EPA RSL (mg/kg)	DOH EAL (mg/kg)
TPH (MD)	-	180
1-MeNaph	0.018	0.89
2-MeNaph	24	1.9
Naph	2	3.1
m,p-Xylene (Total Xylenes)	58	1.4

Groundwater Sample Reference Limits[2]		
Analyte	EPA RSL (µg/L)	DOH EAL (µg/L)
TPH (MD)	-	91
Ethylbenzene	1.5	30
1-MeNaph	10	0.00063
2-MeNaph	10	3.6
Naph	0.12	17

LT-N10	7-8 ft bgs
1-MeNaph	2.0 mg/kg
TPH (MD)	3,500 mg/kg

LT-N25	16-17 ft bgs
1-MeNaph	6.9 mg/kg
2-MeNaph	11.1 mg/kg
Naph	4.2 mg/kg
TPH (MD)	6,880 mg/kg
Total Xylenes	7.2 mg/kg

LT-N35	16-17 ft bgs
TPH (MD)	790 mg/kg

LT-N40	7-8 ft bgs
TPH (MD)	1052 mg/kg

HT-N15	6-7 ft bgs
TPH (MD)	1280 mg/kg
HT-N15	21-22 ft bgs
TPH (MD)	1180 mg/kg

LT-W17.5	12-13 ft bgs
1-MeNaph	9.1 J mg/kg
2-MeNaph	13.0 J mg/kg
Naph	4.1 J mg/kg
TPH (MD)	8,000 mg/kg

HT-W10	18-19 ft bgs
TPH (MD)	1,500 mg/kg

HT-N10	19-20 ft bgs
TPH (MD)	1360 mg/kg
1-MeNaph	1.2 mg/kg
HT-N10	24-25 ft bgs
TPH (MD)	265 mg/kg

LT-W35	
1-MeNaph	24 µg/L
2-MeNaph	16 µg/L
Naph	14 µg/L
Ethylbenzene	3.2 ug/L
TPH (MD)	3748 µg/L

LT-W35	30-31 ft bgs
TPH (MD)	260 mg/kg

OWDFMW06B	
Naph	0.64 µg/L
TPH (MD)	240 µg/L

HT-E00	19-21 ft bgs
TPH (MD)	315 mg/kg
TPH (MD) [FD]	552 mg/kg

HT-E00	
Naph	0.17 µg/L
TPH (MD)	1045 µg/L

LT-W10	11-12 ft bgs
1-MeNaph	1.7 mg/kg
2-MeNaph	2.6 mg/kg
TPH (MD)	760 mg/kg
Total Xylenes	2.6 mg/kg
LT-W10	19-20 ft bgs
1-MeNaph	1.1 mg/kg
TPH (MD)	539 mg/kg
Total Xylenes	1.4 mg/kg

HT-E10	21-22 ft bgs
TPH (MD)	481 mg/kg

HT-S10	15-16 ft bgs
1-MeNaph	29.0 mg/kg
2-MeNaph	45.0 mg/kg
Naph	8.90 mg/kg
TPH (MD)	3,261 mg/kg
Total Xylenes	8.0 mg/kg
HT-S10	17-18 ft bgs
1-MeNaph	4.4 mg/kg
2-MeNaph	6.5 mg/kg
TPH (MD)	2,970 mg/kg
Total Xylenes	2.3 mg/kg

LT-S15	17-18 ft bgs
TPH (MD)	192 mg/kg

LT-S10	17-18 ft bgs
1-MeNaph	1.8 mg/kg
2-MeNaph	2.6 mg/kg
TPH (MD)	477 mg/kg

LT-E15	38-39 ft bgs
1-MeNaph	4.80 mg/kg
2-MeNaph	6.40 mg/kg
TPH (MD)	6639 mg/kg

LT-E00	
Naph	0.15 µg/L
TPH (MD)	590 µg/L

LT-E00	26-28 ft bgs
1-MeNaph (FD)	2.1 mg/kg
2-MeNaph (FD)	2.2 mg/kg
TPH (MD) [FD]	626.3 mg/kg

1 Subsurface soil sample regulatory limits derived from EPA RSL THQ of 0.1 and a target cancer risk of 1E-06 – Residential Soil – November 2024 (EPA 2024), and DOH Table A-2, Soil Action Levels (DOH 2024).

2 Groundwater sample regulatory limits derived from EPA RSL THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024) and DOH Table D-1b, GW Action Levels (DOH 2024).

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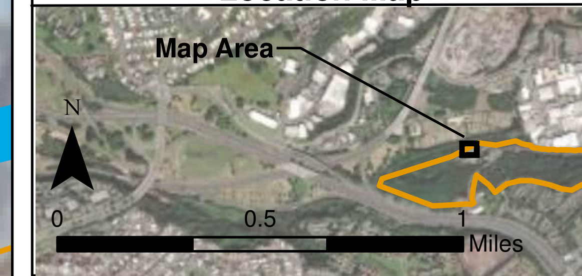
Location Map



Legend

- Phase 2 Temporary Well
- Boring with Exceedance(s)
- Phase 1 Boring with No Exceedances
- Phase 2 Boring with No Exceedances
- Former Tank Location
- OWDF Monitoring Well
- Data Gap Investigation
- CAPE 0-12 ft Excavation
- CAPE 12-30 ft Excavation
- Red Hill Facility Boundary
- South Halawa Stream

Notes

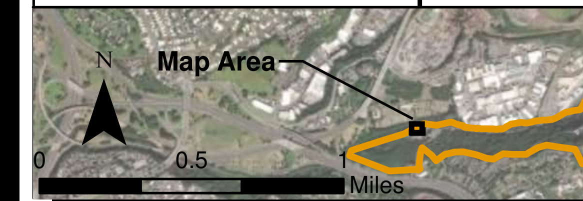
1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: U.S. Geological Survey, 2011, USGS High Resolution Orthoimagery for Honolulu, Hawaii
3. Location Map Source:Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
4. Tables display analytical result exceedances based on limits listed in the table on the top left.
5. TPH observed was characterized as a Middle Distillate. Historical Data of Total Extractable and Total Purgable TPH were summmated.
6. Data Gap Investigation Area identified as requiring further lateral and vertical delineation of contamination.
7. DOH = Hawaii Department of Health
   DU = decision unit
   EAL = Environmental Action Level
   EPA = United States Environmental Protection Agency
   FD = field duplicate
   ft bgs = feet below ground surface
   GW = groundwater
   MD = middle distillate
   MeNaph = methylnapthalene
   mg/kg = miligrams per kilogram
   µg/L = micrograms per liter
   Naph = naphthalene
   OWDF = Oily Waste Disposal Facility
   RSL = Regional Screening Level
   TPH = total petroleum hydrocarbons

Figure 2
Results of Previous Investigations
Soil Borings & Groundwater
Site Characterization Work Plan
Holding Tank-Leach Tank
JBPHH, Oahu, Hawaii

(b) (3) (B)

[redacted]

Location Map



Legend

- Phase 2 Temporary Well
- Boring with Exceedance(s)
- Phase 1 Boring with No Exceedances
- Phase 2 Boring with No Exceedances
- Former Tank Location
- OWDF Monitoring Well
- Approximate Location of [redacted]-inch Steel AVGAS Line
- Data Gap Investigation Area
- CAPE Sampling DU - No Exceedances
- CAPE Sampling DU - Exceedance(s)
- CAPE 0-12 ft Excavation Area
- CAPE 12-30 ft Excavation Area
- Red Hill Facility Boundary
- South Halawa Stream

Notes

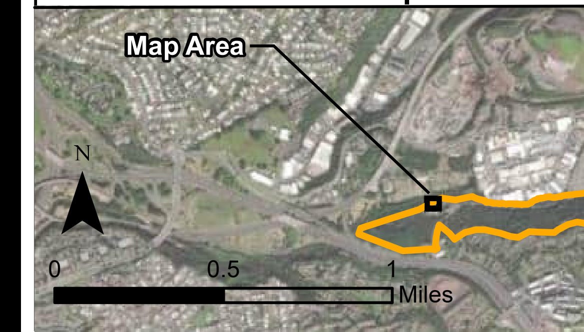
1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: U.S. Geological Survey, 2011, USGS High Resolution Orthoimagery for Honolulu, Hawaii
3. Location Map Source:Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/ Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
4. Tables display analytical result exceedances based on limits listed in the table on the top left.
5. TPH observed was characterized as a Middle Distillate. Historical Data of Total Extractable and Total Purgable TPH were summmated.
6. Data Gap Investigation Area identified as requiring further lateral and vertical delineation of contamination.
7. AVGAS = aviation gasoline
   DOH = Hawaii Department of Health
   DU = decision unit
   EAL = Environmental Action Level
   EPA = United States Environmental Protection Agency
   ft bgs = feet below ground surface
   MD = middle distillate
   mg/kg = miligrams per kilogram
   OWDF = Oily Waste Disposal Facility
   RSL = Regional Screening Level
   TPH = total petroleum hydrocarbons

Figure 3
Results of Previous Investigations
Soil Sampling Decision Units
Site Characterization Work Plan
Holding Tank-Leach Tank
JBPHH, Oahu, Hawaii

(b) (3) (B)

[redacted]

Location Map



Legend

- Proposed Soil Sampling Location
- Proposed Step-out Soil Sampling Location
- Proposed Vertical Delineation Soil Sampling Location
- Proposed Basal Monitoring Well & Soil Sample Location
- Proposed Perched Monitoring Well & Soil Sample Location
- Phase 2 Temporary Well
- Boring with No Exceedances
- Soil Boring with Exceedance(s)
- Former Tank Location
- OWDFMW03A; OWDFMW03B; OWDFMW06A; OWDFMW06B
- Approximate Location of Buried Utilities/Pipelines
- Data Gap Investigation Area
- GAC Pipe Line
- Red Hill Facility Boundary
- CAPE 0-12 ft Excavation Area
- CAPE 12-30 ft Excavation Area
- South Halawa Stream

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: U.S. Geological Survey, 2011, USGS High Resolution Orthoimagery for Honolulu, Hawaii
3. Location Map Source:Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/ Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
4. Coordinates: NAD 1983 Hawaii State Plane Z3 ft
5. Data Gap Investigation Area identified as requiring further lateral and vertical delineation of contamination.
6. OWDF = Oily Waste Disposal Facility

Figure 4
Proposed Soil Sampling Locations
Site Characterization Work Plan
Holding Tank-Leach Tank
JBPHH, Oahu, Hawaii

(b) (3) (B)

[redacted]

(b) (3) (B)

[redacted]

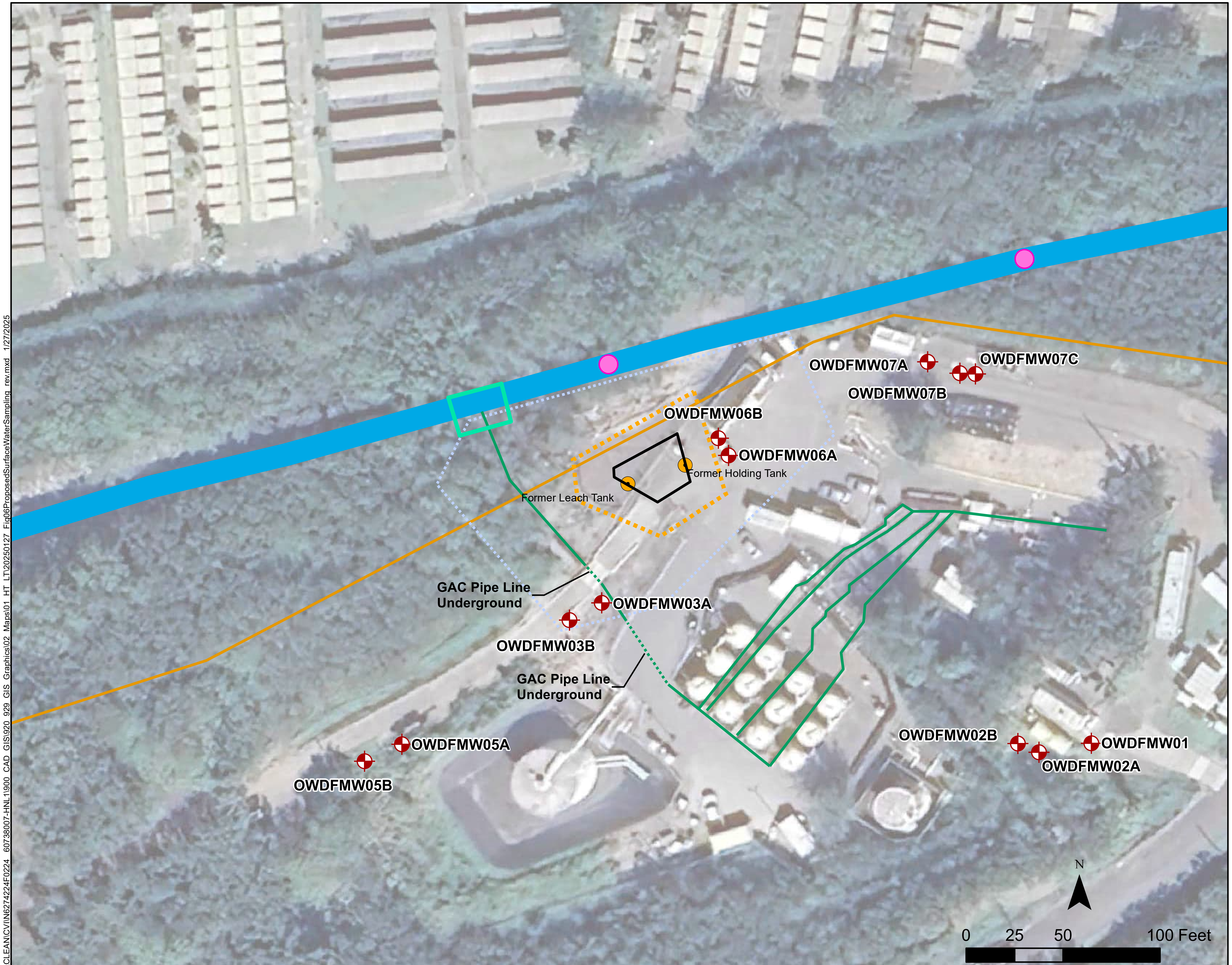
Legend

- Proposed Basal Monitoring Well
- Proposed Perched Monitoring Well
- OWDF Monitoring Well
- Former Tank Location
- Data Gap Investigation Area
- Approximate Location of Buried Utilities/Pipelines
- GAC Pipe Line
- CAPE 0-12 ft Excavation Area
- CAPE 12-30 ft Excavation Area
- Red Hill Facility Boundary
- South Halawa Stream

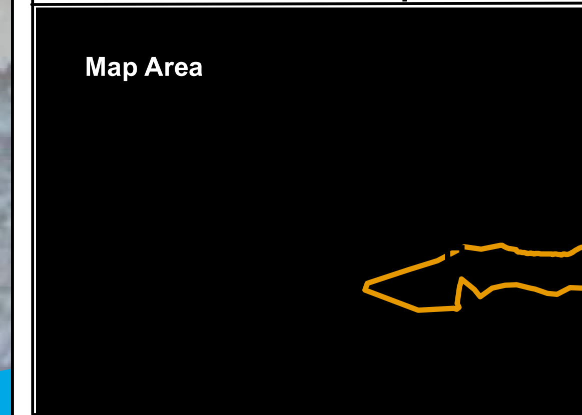
Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: U.S. Geological Survey, 2011, USGS High Resolution Orthoimagery for Honolulu, Hawaii
3. Location Map Source:Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/ Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
4. Coordinates: NAD 1983 Hawaii State Plane Z3 ft
5. Data Gap Investigation Area identified as requiring further lateral and vertical delineation of contamination.
5. OWDF = Oily Waste Disposal Facility

Figure 5
Proposed Location of New Groundwater Monitoring Wells
Site Characterization Work Plan
Holding Tank-Leach Tank
JBPHH, Oahu, Hawaii



Location Map



Legend

- Approximate Location of Red Hill Shaft Water Treatment System Discharge
- CAPE 0-12 ft Excavation
- CAPE 12-30 ft Excavation
- Proposed Surface Water Sample
- OWDF Monitoring Well
- Former Tank Location
- Data Gap Investigation
- GAC Pipe Line
- Aboveground GAC Treatment Piping
- Underground GAC Treatment Piping
- South Halawa Stream
- Red Hill Facility Boundary

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: U.S. Geological Survey, 2011, USGS High Resolution Orthoimagery for Honolulu, Hawaii
3. Location Map Source:Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
4. Coordinates: NAD 1983 Hawaii State Plane Z3 ft
5. Data Gap Investigation Area identified as requiring further lateral and vertical delineation of contamination.
6. GAC = granular activated carbon
OWDF = Oily Waste Disposal Facility

Figure 6
Proposed Locations for Surface Water Sampling
Site Characterization Work Plan
Holding Tank-Leach Tank
JBPHH, Oahu, Hawaii

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Appendix A:
NAVFAC Pacific Project Procedures (DON 2015)

I. Field Procedures

- Procedure I-A Planning
  - Procedure I-A-5 Utility Clearance
  - Procedure I-A-6 Investigation-Derived Waste Management
  - Procedure I-A-8 Sample Naming
- Procedure I-B Sampling
  - Procedure I-B-1 Soil Sampling
  - Procedure I-B-5 Surface Water Sampling
- Procedure I-C Well Construction and Well Development
  - Procedure I-C-1 Monitoring Well Installation and Abandonment
  - Procedure I-C-2 Monitoring Well Development
  - Procedure I-C-3 Monitoring Well Sampling
- Procedure I-D Miscellaneous Sampling
  - Procedure I-D-1 Drum Sampling
- Procedure I-E Soil and Rock Classification
- Procedure I-H Direct-Push Sampling Techniques
- Procedure I-I Land Surveying

II. QC Procedures

- Procedure III-D Logbooks
- Procedure III-E Record Keeping, Sample Labeling, and Chain-of-Custody
- Procedure III-F Sample Handling, Storage, and Shipping

Utility Clearance

1. Purpose

This standard operating procedure describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials. The procedure applies to the following activities: soil gas surveying, excavating, trenching, drilling of borings and installation of monitoring and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities. The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

2. Scope

This procedure applies to all United States Navy Environmental Restoration (ER) Program projects performed in the Naval Facilities Engineering Command, Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 UTILITY

For this procedure, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

3.2 AS-BUILT PLANS

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

3.3 ONE-CALL

The Utility Notification Center is the one-call agency for Oregon, Washington, Montana, and Hawaii. The Utility Notification Center is open 24 hours a day, and accepts calls from anyone planning to dig in. The phone number for the Hawaii One Call Center is 1-866-423-7287 (or 811). Additional information can be found at http://www.callbeforeyoudig.org/hawaii/index.asp.

Calling before you dig ensures that any publicly owned underground lines will be marked, so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines, but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a request is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address.
- What type or work is being done. This should be a description of the specific reason for the work, not the method used.
- Who the work is being done for.
- The county and city the work is taking place in.
- The address or the street where the work is taking place.
- Marking instructions, (specific instructions as to where the work is taking place).

Under normal circumstances it takes between 2 days to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested, but must be handled via voice contact with One-Call.

3.4 TONING

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned.

4. Responsibilities

The prime contractor CTO Manager is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The onsite Field Manager (FM) and Site Safety and Health Officer (SSHO) are responsible for planning utility clearance and for locating and marking underground utilities according to this procedure.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Follow the following steps at all sites where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

5.1 PREPARE PRELIMINARY SITE PLAN

Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the work plan. Include as many of the cultural and natural features as practical in this plan.

5.2 REVIEW BACKGROUND INFORMATION

Search existing plan files to review the as-built plans and available geographic information system databases to identify the known location of utilities at the site. In addition, the contractor should contact the Navy RPM to obtain the most updated GIS layers. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the CTO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The CTO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.

Include the utility location information gathered during investigation (e.g., remedial investigation or remedial site evaluation) work in the project design documents for removal or remedial actions. In this manner, information regarding utility locations collected during implementation of a CTO can be shared with the other contractors during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the other contractor may have to perform.

Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.

During the pre-fieldwork interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

5.3 DIG PERMIT

Prior to all activities requiring excavation work that may disrupt utility services, vehicular or aircraft traffic flow, protection provided by fire and intrusion alarm systems, or routine activities at Navy bases (including Joint Base Pearl Harbor-Hickam and Naval Base Guam), as well as intrusive work at Marine Corps Base Hawaii, current procedures shall be followed. The dig permit process tries to identify, as much as practical, any known, potentially hazardous work condition related to excavation activities and is intended to prevent accidents. It also informs key Navy personnel of the digging work and coordinates the required work with these activities to minimize inconveniences (JBPHH 2013).

5.4 Site Visit – Locate Utilities – Toning

Prior to the initiation of field activities, the field task manager or similarly qualified staff personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.

Following the initial site visit by the FM, a trained utility locator will locate, identify, and tone all utilities depicted on the preliminary site plan. The locator should use appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. This may involve the use of surface geophysical methods (Procedure I-B-2, *Geophysical Testing*). At a minimum, use a utility locator, metal detector, and/or magnetometer; however, it is important to consider the possibility that non-metallic utilities or tanks might be present at the site. Use other appropriate surface geophysical methods, such as Ground Penetrating Radar, if non-metallic cultural features are likely to be present at the site. Clear proposed exploration areas of all utilities in the immediate area where subsurface exploration is proposed. Clearly tone all anomalous areas. Clearly identify all toned areas on the preliminary site plan. After toning the site and plotting all known or suspected buried utilities on the preliminary site plan, the utility locator shall provide the FM with a copy of the completed preliminary site plan. Alternatively, the FM or designee shall document the results of the survey on the preliminary site plan.

Report to the FM anomalous areas detected and toned that are in close proximity to the exploration or excavation areas. The FM shall determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate proposed exploration or excavation areas. If this is required, the FM or a similarly qualified individual shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In some instances, such as in areas extremely congested with subsurface utilities, it may be necessary to dig by hand to determine the location of the utilities.

5.5 Prepare Site Plan

Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the Contracting Officer’s Representative (COR), the CTO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the COR to verify its accuracy prior to initiating subsurface sampling activities.

6. Records

Keep a bound field logbook detailing all activities conducted during the utility locating procedure. The logbook will describe any changes and modifications made to the original exploration plan. The trained utility locator shall prepare a report and keep it in the project file. Also keep a copy of the final site plan on file.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Joint Base Pearl Harbor-Hickam (JBPHH). 2013. *Dig Permit Requests.* JBPHH Instruction 11013.1. 15 March 2013.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-2, *Geophysical Testing.*

9. Attachments

None.

Investigation-Derived Waste Management

1. Purpose

This standard operating procedure describes the activities and responsibilities of the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific with regard to management of investigation-derived waste (IDW). The purpose of this procedure is to provide guidance for the minimization, handling, labeling, temporary storage, inventory, classification, and disposal of IDW generated under the ER Program. This procedure will also apply to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste generated during implementation of removal or remedial actions. The information presented will be used to prepare and implement work plans (WPs) for IDW-related field activities. The results from implementation of WPs will then be used to develop and implement final IDW disposal plans.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

This procedure focuses on the requirements for minimizing, segregating, handling, labeling, storing, and inventorying IDW in the field. Certain drum inventory requirements related to the screening, sampling, classification, and disposal of IDW are also noted in this procedure.

3. Definitions

3.1 IDW

IDW consists of all materials generated during site investigations that might be contaminated with chemicals of concern. IDW might consist of many types of potentially contaminated materials, including but not limited to, PPE, disposable sampling and decontamination equipment, investigation-derived soil, sludge, and sediment, well development and purge water, and decontamination fluids.

3.2 PPE

PPE, as defined in this procedure, refers to all disposable materials used to protect personnel from contact with potentially contaminated site media, such as inner and outer gloves, Tyvek suits and overboots, and disposable respirator cartridges. Non-consumable items, such as steel-toe boots, respirators, and hard hats are not included in this procedure.

3.3 DISPOSABLE SAMPLING EQUIPMENT

Disposable sampling equipment consists of all single-use equipment that might have come in contact with potentially contaminated site media, including sample bailers, Draeger air monitoring tubes, used soil sampling trowels and spatulas, plastic drop cloths, plastic bags and bucket liners, and sample containers from field analytical test kits.

3.4 INVESTIGATION-DERIVED SOIL, SLUDGE, AND SEDIMENT

Investigation-derived soil consists of all potentially contaminated soil that is disturbed as part of site investigation activities. The most commonly encountered form of IDW soil is drill cuttings brought to the ground surface by drilling. Other forms of disturbed soil, including trenching spoils and excess soil remaining from surface sampling, should not be stored as IDW. Excavated soil should be returned to its source if site conditions permit.

Investigation-derived sludge consists of all potentially contaminated sludge materials generated or disturbed during site investigation activities. Generated sludge might consist of drilling mud used or created during intrusive activities. Other sludge might include solvents or petroleum-based materials encountered at the bottom of storage tanks and grease traps.

Investigation-derived sediment consists of all potentially contaminated sediments that are generated or disturbed during site investigation activities. Generated sediments might include solids that settle out of suspension from well development, purge, or decontamination water (see Definitions 3.5 and 3.6) while stored in 55-gallon drums or during sample filtration. Disturbed sediments might also consist of catch basin sediments or excess sediment from surface water activities.

3.5 WELL DEVELOPMENT AND PURGE WATER

Development water consists of groundwater withdrawn from newly installed monitoring wells in preparation for well purging or pump testing. Monitoring well development methods are discussed in Procedure I-C-2, *Monitoring Well Development*.

Purge water consists of groundwater that is removed from monitoring wells immediately prior to sampling. Well purging methods are discussed in Procedure I-C-3, *Monitoring Well Sampling*. Groundwater derived during aquifer testing shall be addressed on a site-specific basis. Procedures for handling groundwater generated during aquifer testing shall be included in the WP or equivalent document for the CTO.

3.6 DECONTAMINATION FLUIDS

Decontamination fluids consist of all fluids used in decontamination procedures conducted during site investigation activities. These fluids consist of wash water, rinse water, and solvents used for the decontamination of non-consumable PPE, sampling equipment, and drilling equipment. Decontamination procedures are discussed in Procedure I-F, *Equipment Decontamination*.

3.7 NON-IDW TRASH

Non-IDW trash is all waste materials, such as waste paper, drink containers, food, and packaging, generated in the support zone that have not come in contact with potentially contaminated site media.

3.8 Non-Indigenous IDW

Non-indigenous IDW consists of all waste materials from offsite sources that are generated in the transition or contamination reduction zones and have not come in contact with potentially contaminated site media. Non-indigenous IDW includes materials, such as PPE from "clean" field activities (e.g., field blank generation, water sampling events) and refuse from monitoring well installation (e.g., unused sections of well casing, used bentonite buckets, sand bags, and cement bags).

Non-indigenous waste does not include material/waste that is abandoned at the ER site (including the IDW waste storage area) by other parties not associated with the ER work. Disposal of abandoned material/waste in the vicinity of IDW is the responsibility of the property owner (e.g., Navy Region Hawaii) or party responsible for abandoning the material/waste. The ER contractor shall notify the Contracting Officer's Representative (COR) of the situation as soon as possible so that recovery actions can be coordinated by the Government.

3.9 Resource Conservation and Recovery Act (RCRA) Hazardous Waste

Under the RCRA, a solid waste that is not excluded from regulation is defined as hazardous if it:

- Is "listed" as a hazardous waste in Chapter 40, Code of Federal Regulations (CFR), Parts 261.31 through 261.33
- Exhibits any of four hazardous "characteristics"—ignitability, corrosivity, reactivity, or toxicity (as determined using the Toxicity Characteristic Leachate Procedure [TCLP]) (40 CFR 261.20-24)
- Is subject to certain "mixture" or "derived-from" rules (40 CFR 261.3).

Under certain circumstances, petroleum- or polychlorinated biphenyl (PCB)-contaminated wastes are not considered RCRA hazardous when they only exhibit toxicity characteristic (40 CFR 261.4(b)(10) and 261.8). If IDW is determined to be RCRA hazardous waste, then RCRA storage, transport, and disposal requirements shall apply unless exempt.

3.10 RCRA Land Disposal Restrictions (LDR)

Land disposal, as defined in RCRA, is any placement of RCRA hazardous waste on the land in a waste pile, landfill, impoundment, well, land treatment area, etc. LDRs are regulatory restrictions placed on land disposal, including pre-treatment standards, engineered containment, capacity constraints, and reporting and permitting requirements.

3.11 Area of Contamination (AOC)

The U.S. Environmental Protection Agency (EPA) considers the RCRA AOC to be a single land-based disposal unit, usually a "landfill," and includes non-discrete land areas in which there is generally dispersed contamination. Storing IDW in a container (i.e., portable storage devices, such as drums and tanks) within the AOC and returning it to its source, whether RCRA hazardous or not, does not trigger RCRA LDRs. In addition, sampling and direct replacement of wastes within an AOC do *not* constitute land disposal.

3.12 CERCLA Hazardous Substances

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances are listed in 40 CFR Table 302.4 and include substances regulated by the RCRA Subtitle C, Clean Water Act (CWA), Clean Air Act (CAA), and Toxic Substances Control Act (TSCA). The CFR is updated annually; therefore, the most recent CFR should be referenced for the CERCLA hazardous waste list.

CERCLA hazardous substances are defined independent of their concentration level (i.e., any detection of a listed CERCLA constituent is considered a “CERCLA hazardous substance”). “Reportable quantities” identified for chemicals in 40 CFR Table 302.4 concern only CERCLA and RCRA requirements for notification to EPA when a release has occurred; they do not dictate whether a chemical is a hazardous substance.

The definition of CERCLA hazardous substances excludes “petroleum, including crude oil or any fraction thereof;” natural gas; natural gas liquids; liquefied natural gas; and synthetic gas usable for fuel, unless specifically listed or designated under the act. Excluded fractions of crude oil contain hazardous substances, such as benzene, that are indigenous in those petroleum substances or that are normally mixed with or added to petroleum during the refining process. However, hazardous substances that are (1) added to petroleum after the refining process, (2) increase in concentration as a result of contamination of the petroleum during use, or (3) commingled with petroleum after a release to the environment, are not considered part of the petroleum exclusion provision, and therefore, are regulated under CERCLA. In addition, some waste oils are regulated under CERCLA because they are specifically listed.

The scope of CERCLA hazardous substances includes the smaller subsets of RCRA hazardous wastes, PCB Aroclors, and other constituents. Therefore, a RCRA hazardous waste is always considered a CERCLA hazardous substance for a CERCLA-driven response action; however, a CERCLA hazardous substance is not always a RCRA hazardous waste.

CERCLA only regulates releases or threats of releases of hazardous substances into the environment. If there is no evidence that (1) a release has occurred (based on site history, visual observations, background metals evaluation), (2) there is a threat of release (as from abandoned, discarded, or non-maintained chemical receptacles), or (3) the release has entered the environment (as defined below), then CERCLA does not regulate the constituent even though it is identified on the CERCLA hazardous substance list.

3.12.1 CERCLA Hazardous Substances: TSCA/PCBs

PCBs are a CERCLA hazardous substance. PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned in 1979. They have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. Although no longer commercially produced in the United States, PCBs may be present in products and materials produced before the 1979 PCB ban.

If PCBs are detected at concentrations equal to or greater than 50 parts per million (ppm), the sample is considered TSCA-regulated. Current PCB regulations can be found in the CFR at 40 761. The EPA Q and A Manual (EPA 2009), referring to CFR 761.61 explains PCB remediation waste must be managed and disposed of based on the concentration at which the PCBs are found. It is unacceptable to dilute the as-found concentration of the contaminated soil by mixing it with clean soil during excavation or other IDW management activities.

3.13 ENVIRONMENT

Environment means navigable waters, ocean waters, surface water, groundwater, drinking water supply, land surface or subsurface strata, and ambient air, within the U.S. or under federal jurisdiction (see Section 101(8) of CERCLA or 40 CFR 300.5 for complete definition).

3.14 ONSITE AREA

The CERCLA onsite area is defined in 40 CFR 300.400(e)(1) as an area that includes:

- AOC
- All suitable areas in very close proximity to the contamination that are necessary for the implementation of the response action

The delineation of the onsite area is further discussed in Volume 55 Federal Register (FR) Page 8688 and EPA guidance.

Neither CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan, nor RCRA define the terms “area of contamination” or “contamination.” However, the area of contamination is interpreted as containing “varying types and concentrations of contaminants” (55 FR 8760) that may or may not pose a risk to human health or the environment.

The onsite area may also include several noncontiguous aerial extents of contaminations if they share a common nexus (55 FR 8690).

3.15 OFFSITE AREA

The offsite area consists of all areas outside the onsite area.

3.16 CERCLA OFFSITE RULE

The CERCLA offsite rule (400 CFR 300.440) states that IDW containing CERCLA hazardous substances (at any concentration) must be stored, treated, or disposed of offsite only at facilities having current EPA approval to accept such CERCLA wastes. RCRA-permitted facilities (Subtitle C and D) must also have specific EPA approval to accept waste generated at a CERCLA site (even if the waste is RCRA hazardous).

With some restrictions, the offsite rule does not apply to the following:

- Wastes generated during non-CERCLA actions
- Treatability study samples

- Wastes generated during emergency response actions
- Laboratory samples

CERCLA allows IDW to be managed, stored, and disposed of onsite within or near the AOC without the need for EPA approval (i.e., CERCLA facility approval) or RCRA permits. If IDW is to be stored or disposed of on site, the onsite area (and the AOC) should be delineated on a figure in the project field book and revised, based on best professional judgment, as site data become available.

4. Responsibilities

The prime contractor CTO Manager is responsible for preparing WPs and IDW disposal plans and reports in compliance with this procedure, and is responsible for documenting instances of noncompliance. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for implementing this IDW procedure and ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. IDW Management Procedures

The procedures for IDW management in the field are described below.

5.1 Planning for IDW Management

The project team should begin planning for IDW issues early in the site investigation planning stage. The proper management of IDW involves all of the following tasks:

- Obtain Navy approval for a designated IDW storage area prior to commencement of field work
  - Complete Navy form, including IDW Tracking Sheet and provide to remedial project manager (RPM) for processing
- Waste generation and minimization
- Chemical screening and characterization of the waste
- Waste handling, storage, and associated maintenance in compliance with all regulations (prepare an IDW drum inventory, ensure storage areas are compliant with type of waste [double containment, TSCA requirements, etc.] maintain condition of drum and labeling, maintain safety and assess controls, comply with permit requirements [for offsite storage])
- Waste transport and disposal within required holding times
- Waste tracking, documentation, record keeping, and reporting

As part of IDW planning, the CTO Manager should consult with the COR and environmental regulatory agencies to clearly identify the primary federal or state regulatory authority that is driving the site investigation. This authority may be CERCLA, RCRA (Subtitle C), RCRA (subtitle I), TSCA, CWA, or an equivalent state program. The primary investigation authority and regulations promulgated under this authority set forth requirements for IDW management. These requirements may differ under the various response authorities. For CERCLA-driven actions, IDW storage and disposal should comply with all applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria to the extent practicable.

Lastly, the CTO Manager should consider the disposal criteria of the anticipated disposal facility when developing the sampling and analysis plan (SAP). Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Facility disposal criteria may dictate laboratory reporting limits.

If unknown waste is observed onsite, notify the project RPM and COR for further instructions.

5.2 IDW MINIMIZATION

Field managers (FMs) and their designates shall minimize the generation of onsite IDW to reduce the need for special storage or disposal requirements that might result in substantial additional costs and provide little or no reduction in site risks (EPA 1992b). Reduce the volume of IDW by applying minimization practices throughout the course of site investigation activities. These minimization strategies include substitution of biodegradable raw materials; using low-volume IDW-generating drilling techniques; where possible, returning excess material to the source location; using disposable sampling equipment versus generating more decontamination fluids from reusable sampling equipment; using bucket and drum liners; and separating trash from IDW.

Material substitution consists of selecting materials that degrade readily or have reduced potential for chemical impacts to the site and the environment. An example of this practice is the use of biodegradable detergents (e.g., Alconox or non-phosphate detergents) for decontamination of non-consumable PPE and sampling equipment. In addition, field equipment decontamination can be conducted using isopropyl alcohol rather than hexane or other solvents (for most analytes of concern) to reduce the potential onsite chemical impacts of the decontamination solvent. Select decontamination solvents carefully so that the solvents, and their known decomposition products, are *not* potentially RCRA hazardous waste, unless absolutely necessary.

Give priority to drilling methods that minimize potential IDW generation. Select hollow-stem auger and air rotary methods, where feasible, over mud rotary methods. Mud rotary drilling produces waste drilling mud, while hollow stem and air rotary drilling methods produce relatively low volumes of soil waste. Use small-diameter borings and cores when soil is the only matrix to be sampled at the boring location; however, the installation of monitoring wells requires the use of larger-diameter borings.

If possible, return soil, sludge, or sediment removed from borings, containment areas, and shallow test trenches to the source immediately after sampling and/or geological logging of the soils (EPA 1991, 1992b). Immediate replacement of solid waste in the source location during investigation activities avoids RCRA LDRs, which permit movement of IDW within the same AOC without considering land disposal to have occurred, even if the IDW is later determined to contain RCRA hazardous material (EPA 1991). Place soil IDW from borings and trenches on polyethylene sheeting (e.g., Visqueen) during excavation and segregate it by approximate depth and any apparent contamination (i.e., visible staining). Following excavation, replace the soil IDW from above the saturated layer into the boring or trench and compact it, if possible. Efforts should be made to return the waste to the approximate depth from which it was generated. Soil and sludge IDW generated at or below the saturated layer of a boring or trench should be placed in drums and not returned to the source area. Suspected contaminated soil and sludge IDW generated above the saturated layer of a boring or trench should not be returned below the saturated layer."

Often monitoring wells are constructed outside the area of concern for soil contamination to sample for potential groundwater contamination or collect characteristic background data. At these locations, soil cuttings generated from above the saturation zone may be immediately disposed of near the wellhead in a shallow pit covered with natural topsoil from the site, and compacted. Contain soil and sludge IDW generated at or below the saturated layer in drums.

Reduce the quantity of decontamination rinse water generated by using dedicated and disposable sampling equipment, such as plastic bailers, trowels, and drum thieves that do not require decontamination. In general, decontamination fluids, and well development and purge water should not be minimized because the integrity of the associated analytical data might be affected.

Minimize the storage of visibly soiled PPE and disposable sampling equipment IDW by implementing decontamination procedures. If, based upon the best professional judgment of the FM, the PPE and disposable sampling equipment can be rendered non-contaminated after decontamination, then double-bag the PPE and disposable sampling equipment and dispose of it off site at a (RCRA Subtitle D) municipal solid waste disposal facility at the end of each work day (EPA 1991, 1992b). Since the decontaminated waste does not contain CERCLA hazardous substances, it need not be disposed of at a CERCLA-approved disposal facility in accordance with the CERCLA offsite rule.

Bucket liners can be used in the decontamination program to reduce the volume of solid IDW generated, and reduce costs on larger projects. The plastic bucket liners can be crushed into a smaller volume than the buckets, and only a small number of plastic decontamination buckets are required for the entire project. The larger, heavy-duty, 55-gallon drum liners can be used for heavily contaminated IDW to provide secondary containment, and reduce the costs of disposal and drum recycling. Drum liners may extend the containment life of the drums in severe climates and will reduce the costs of cleaning out the drums prior to recycling.

All waste materials generated in the support zone are considered non-IDW trash. To minimize the total volume of IDW, separate all trash from IDW, seal it in garbage bags, and properly dispose of it off site as municipal waste at the end of each work day.

Keep excess cement, sand, and bentonite grout prepared for monitoring well construction to a minimum. FMs shall observe well construction to ensure that a sufficient, but not excessive, volume of grout is prepared. Some excess grout may be produced. Unused grout (that should not come in contact with potentially contaminated soil or groundwater) shall be considered non-hazardous trash, and the drilling subcontractor shall dispose of it off site. Surplus materials from monitoring well installation, such as scrap plastic sections, used bentonite buckets, and cement/sand bags that do not come in contact with potentially contaminated soil, shall be considered non-IDW trash, the drilling subcontractor shall dispose of it off site.

Following proper segregation procedures, as discussed in the next section, can minimize the quantity of contaminated IDW generated.

5.3 SEGREGATION OF IDW BY MATRIX AND LOCATION

It is necessary to properly segregate IDW in order to:

- Avoid commingling contaminated waste with clean waste, thereby creating a larger volume of waste that must be treated as contaminated
- Facilitate the sampling, screening, classification, and disposal of waste that may require different management methods

Take efforts to segregate IDW even when these activities will increase storage container and storage space requirements. These efforts will drastically reduce the sampling and documentation required for characterizing the waste and their associated costs.

In general, segregate IDW by matrix and source location and depth at the time it is generated. IDW from only one matrix shall be stored in a single drum (e.g., soil, sediment, water or PPE shall *not* be mixed in one drum). Groundwater and decontamination water should not be commingled; however, development and purge water from the same well may be stored together.

In general, IDW from separate sources should not be combined in a single drum or stockpile. Take efforts to segregate waste by increments of depth below ground surface. Most importantly, segregate soil IDW generated at or from below the saturated zone from soil generated above this zone (soil below this zone might be impacted by contaminated groundwater, whereas soil above the zone may be “clean”). Similarly, segregate soil above and below an underground storage tank (UST). Label each drum of soil to indicate the approximate depth range from which it was generated; this task may require cuttings to be segregated on plastic sheeting as they are generated or drums to be filled during the trenching or boring operation if this can be done in a safe manner.

It is possible that monitoring well development and purge water will contain suspended solids, which will settle to the bottom of the storage drum as sediment. Include significant observations on the turbidity or sediment load of the development or purge water in the logbook see Procedure III-D, *Logbooks* and Section 5.5). To avoid mixed matrices in a single drum (i.e., sediment and water), it may be necessary to decant the liquids into a separate drum after the sediments have settled out. This segregation may be accomplished during subsequent IDW sampling activities or during consolidation in a holding tank prior to disposal.

Place potentially contaminated well construction materials in a separate drum. No soil, sediment, sludge, or liquid IDW shall be placed in drums with potentially contaminated waste well construction materials. In addition, potentially contaminated well construction materials from separate monitoring wells shall not be commingled.

Store potentially contaminated PPE and disposable sampling equipment in drums separate from other IDW. Segregate PPE from generally clean field activities, such as water sampling, from visibly soiled PPE, double-bag it, and dispose of it off site as municipal waste. Disposable sampling equipment from activities, such as soil, sediment, and sludge sampling, includes plastic sheeting used as liner material in containment areas around drilling rigs and waste storage areas, disposable sampling equipment, and soiled decontamination equipment. If, according to the Field Manager's best professional judgment, the visibly soiled PPE can be decontaminated and rendered non-hazardous, then double-bag the decontaminated PPE and disposed of it off site as municipal waste (EPA 1991, 1992b). PPE and disposable sampling equipment generated on separate days in the field may be combined in a single drum, provided clean and visibly soiled IDW are segregated as discussed above.

IDW generated from the use of field analytical test kits consists of those parts of the kit that have come into contact with potentially contaminated site media, and used or excess extracting solvents and other reagents. Contain potentially contaminated solid test kit IDW in plastic bags and store it with contaminated PPE or disposable sampling equipment IDW from the same source area as soil material used for the analyses. Segregate the small volumes of waste solvents, reagents, and water samples used in field test kits, and dispose of it accordingly (based upon the characteristics of the solvents as described in this procedure). Most other test kit materials should be considered non-IDW trash, and be disposed of as municipal waste.

Store decontamination fluids in drums separate from groundwater and other IDW. If practical, decontamination fluids generated from different sources should not be stored in the same drum. If decontamination fluids generated over several days or from different sources are stored in a single drum, record information about the dates and IDW sources represented in the drum. Note this information in the field notebook, on the drum label (Section 5.4.3), and in the drum inventory (Section 5.5).

The FM and designated personnel should separate the liquid and sediment portions of the equipment decontamination fluid present in the containment unit used by the drilling or excavation field crew. The contents of this unit normally consist of turbid decontamination fluid above a layer of predominantly coarse-grained sediment. When the contents of the containment unit are to be removed for storage in IDW drums, the FM shall instruct the field crew to place as much of the liquid into drums as possible and transfer the remaining solids into separate drums. Note observations of the turbidity and sediment load of the liquid IDW in the field notebook, on the drum label (Section 5.4.3), and in attachments to the drum inventory (Section 5.5). It is likely that decontamination fluids will contain minor amounts of suspended solids that will settle out of suspension to become sediment at the bottom of IDW storage drums. As noted above, it may be necessary to segregate the drummed water from sediment during subsequent IDW sampling or disposal activities.

Documentation for waste storage containers should include IDW source and segregation information and be maintained as follows:

1. Field logbook should be updated, at least weekly, with all IDW drum additions – update storage area location map to include new drum position and drum number.

2. External drum log (hard copy and electronic copy) should be updated with each IDW drum addition (drum numbers, source, and generation date) and closure of drum (fill date).

5.4 DRUM FILLING, HANDLING, AND LABELING, AND INVENTORYING

Drum handling consists of those actions necessary to prepare an IDW drum for labeling. Drum labeling consists of those actions required to legibly and permanently identify the contents of an IDW drum.

5.4.1 Drum Filling

Each drum of solid IDW shall be completely filled, when possible. For liquid IDW, drums should be left with headspace of approximately 5 percent by volume to allow for expansion of the liquid and potential volatile contaminants.

5.4.2 Drum Handling

IDW shall be containerized using U.S. Department of Transportation-(DOT) approved drums. The drums shall be made of steel or plastic, have a 55-gallon capacity, be completely painted or opaque, and have removable lids (i.e., United Nations Code 1A2 or 1H2). Drums having removable lids with bung holes are preferred to facilitate verification of drum contents. Typically 55-gallon drums are used, however small drums may be used depending on the amount of waste generated. New steel drums are preferred over recycled drums. Recycled drums should not be used for hazardous waste, PCBs or other regulated shipments. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. For this scenario, consider the scheduling and cost-effectiveness of this type of bulk storage, treatment, and discharge system versus longer-term drum storage.

The Guam Environmental Protection Agency may require double-walled drums or other secondary containment for the storage of liquid IDW. For long-term IDW storage at other project locations, the DOT-approved drums with removable lids are recommended. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids. If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, select another drum lid with a sealing ring that is in sound condition.

To prepare IDW drums for labeling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and disposable sampling equipment. Label all IDW drums and place them on appropriate pallets prior to storage.

5.4.3 Drum Labeling

Proper labeling of IDW drums is essential to the success and cost-effectiveness of subsequent waste screening and disposal activities (see Attachment I-A-6-1 and Attachment I-A-6-2). Labels shall be permanent and descriptive to facilitate correlation of field analytical data with the contents of individual IDW drums. Label all IDW drums using the **three distinct labeling methods** described below to ensure durability of the information. These three methods are completing and affixing preprinted NAVFAC Pacific ER Program labels; marking information on drum surfaces with paint; and, affixing aluminum tags to the drum. **Use of the preprinted labels, painted labeling, and aluminum tags is *mandatory***. These methods are described below.

5.4.3.1 PREPRINTED LABELS

Complete **two** preprinted NAVFAC Pacific ER Program drum labels as described below and presented in Attachment I-A-6-1. Seal both labels in separate heavy-duty, clear plastic bags, or use permanent markers on weatherproof stickers, to prevent moisture damage.

1. Place one label on the outside of the drum with the label data facing outward. Affix the bag/sticker to the drum at the midpoint of the drum height using a sufficient quantity of adhesive tape (e.g., duct tape, packing/strapping tape) so the bag will remain on the drum as long as possible during storage.

2. Affix the second label (sealed as mentioned above) to the underside of the drum lid, sealing it inside the drum when the lid is replaced.

The use of two or more preprinted labels for outer IDW drum identification purposes should be considered as a short-term backup to the information on the aluminum tags discussed below.

Print the requested information legibly on the drum labels in black, indelible ink. Instructions for entering the required drum-specific information for each label field are presented below:

CTO: Enter the four-digit number of the CTO for the project during which the IDW was generated. Include any initial zeroes in the CTO number (e.g., CTO 0047).

Activity-Site: Enter the name of the Navy activity responsible for the project site (e.g., Naval Supply Center, Naval Facilities Engineering Command Hawaii) and the name of the site where the project is taking place (e.g., Orote, Landfill, Building [Bldg.] 18).

Drum#: Enter the drum identification number according to the convention described below.

(xxxx-AA-DMzzz);

Where:

xxxx represents the four-digit CTO number

AA represents the unique site identifier assigned by the CTO Manager for multiple site CTOs (e.g., for CTO 0047, OW denotes Old Westpac, OR denotes Orote)

DM represents a *drum* identification number

zzz the sequential drum number for the site, beginning with 001

Date Collected: Enter the date the IDW was generated and placed in the drum. If IDW was generated over a number of days, enter the start and end dates for the period.

Contents: Record the source identification number on the label. Enter a "√" in the box corresponding to the type of IDW placed in the drum. For "Soil" and "Water," use the line provided to record observations on the condition of the drum contents (e.g., diesel odor, high turbidity, specific liquid IDW type). Check "Solid Waste" for PPE and indicate that PPE is present in the drum. Check

"Other" for disposable sampling equipment and potentially contaminated monitoring well construction materials, and indicate the type of waste on the line provided.

Project Type: Enter a "√" in the box corresponding to the type of investigation. Choices are Remedial Investigation, RCRA Facility Inspection, UST, and Other. If "Other" is specified, indicate the type of project in the "Comments" area, as described below.

Comments: Enter any additional information regarding the drum contents that will assist individuals who will characterize and dispose of the contents of the drum. "Other" project types include Site Inspection, Feasibility Study, Removal/Remedial Action, and Emergency Response activity. In addition, use this space on the label to complete any descriptions that were too large to fit in preceding label fields, such as the turbidity of decontamination water or the site activities from which the PPE was generated.

For Information Contact: Enter the project COR activity / code, address, and phone number.

It is essential that all relevant information recorded on individual drum labels be repeated in the field notebook for later development of the drum inventory database (see Section 5.5 and Procedure III-D, *Logbooks*).

5.4.3.2 PAINTED LABELS

The second method for labeling drums is to paint label information directly on the outer surface of the drum. At a minimum, the information placed on the drum shall include the CTO number, the drum number (following the numbering convention given above), the source identification number and type, the generation date(s), and the telephone number provided at the bottom of the preprinted label appropriate for the project location. The drum surface shall be dry and free of material that could prevent legible labeling. Confine label information to the upper two-thirds of the total drum height. The top surface of the drum lid may be used as an additional labeling area, but this area should only be used *in addition* to the upper two-thirds of the sides of the drum. The printing on the drum shall be large enough to be easily legible. Yellow, white, black, or red paint markers (oil-based enamel paint) that are non-photodegradable are recommended to provide maximum durability and contrast with the drum surface.

5.4.3.3 ALUMINUM TAGS

The third method for labeling drums is to affix an aluminum tag to the drum with neatly printed information that shall consist of the **CTO number**, the **drum identification number**, the **type of contents**, the **generation date(s)**, the **source** identification number and type, and the **telephone number** provided at the bottom of the appropriate preprinted label. Attachment I-A-6-2 to this procedure presents an example of the aluminum tag, which shall measure approximately 1 inch by 3 inches, or larger. When a ballpoint pen is used to fill out the aluminum tag, the information is permanently recorded as indentations on the tag. A fine ballpoint pen shall be used, and block-printed lettering is required for legibility. Indentations on the tag shall be sufficiently deep to be legible after the label has been exposed to weathering for an extended period.

Complete aluminum tags after the drum has been sealed. Affix the tags to the drum using a wire, which passes through predrilled holes in the label and shall be wrapped around the bolt used to seal the drum lid. The wire is the most likely part of the aluminum tag to decay during exposure. Use of plastic insulated, copper-core electrical wire of appropriate diameter is recommended if long-term exposure to severe weathering is anticipated.

5.4.3.4 WASTE LABELS

Standard green and white non-hazardous and/or other hazardous waste stickers may be used in conjunction with, but not in lieu of, the above labeling procedures.

5.5 DRUM INVENTORY

Accurate preparation of an IDW drum inventory is essential to all subsequent activities associated with IDW drum tracking and disposal. Prepare an inventory for each project in which IDW is generated, stored, and disposed of. This information provided in the inventory report constitutes the results of preparing and implementing an IDW sampling, screening, characterization, and disposal program for each site.

The drum inventory information shall include 10 elements that identify drum contents and indicate their outcome. These elements are discussed in Sections 5.5.1 through 5.5.10.

5.5.1 Navy Activity (Generator)/Site Name

Inventory data shall include the Navy activity and the site name where the IDW was generated (e.g., Fleet Industrial Supply Center Pearl/Red Hill, Naval Magazine Headquarters/USTs).

5.5.2 CTO Number

Inventory data shall include the four-digit CTO number associated with each drum (e.g., 0089) and contract number as necessary.

5.5.3 Drum Number

Include the drum number assigned to each drum in the inventory database. Drum numbers shall adhere to the numbering convention presented in Section 5.4.3.1 (e.g., 0091-LF-DM006).

5.5.4 Storage Location Prior to Disposal

Include the storage location of each drum prior to disposal in the inventory database (e.g., Bldg. 394 Battery Disassembly Area, or Adjacent to West end of Bldg. 54). As part of the weekly inventory, a site visit to the IDW storage location shall be performed to observe the condition of the drums and covers. Drums and covers are considered acceptable when the integrity of the drums and covers are structurally intact, drum identification is legible, and the location of the drum storage is secure. An unacceptable classification will require recommendations to remedy the unacceptable classification.

5.5.5 Origin of Contents

Specify the source identification of the contents of each IDW drum in the inventory database (e.g., soil boring number, monitoring well number, sediment sampling location, or the multiple sources for PPE- or rinse water-generating activities).

5.5.6 IDW Type

Inventory data shall include the type of IDW in each drum (e.g., soil, PPE, disposable sampling equipment, sludge, sediment, development water, steam cleaning water, decontamination rinse water).

5.5.7 Waste Volume

Specify the amount of waste in each drum in the inventory database as a percentage of the total drum volume or an estimated percentage-filled level (e.g., 95 percent maximum for liquid IDW).

5.5.8 Generation Date

Inventory data shall include the date IDW was placed in each drum. If a drum contains IDW generated over more than one day, the start date for the period shall be specified in dd-mmm-yy format. This date is *not* to be confused with a RCRA hazardous waste accumulation date (40 CFR 262).

5.5.9 Expected Disposal Date

Specify the date each drum is expected to be disposed of as part of the inventory in mmm-yy format. This date is for the Navy's information only and shall not be considered contractually binding.

5.5.10 Actual Disposal Date

The actual drum disposal date occurs at the time of onsite disposal, or acceptance by the offsite treatment or disposal facility. Enter this date in the drum inventory data base only when such a date is available in dd-mmm-yy format.

Information required to complete all 10 of the inventory elements for the monthly inventory report described above and summarized in Attachment I-A-6-3, will be located on the IDW labels or provided by the CTO Manager.

Actual disposition of the IDW drum contents will be provided to the Navy.

5.6 IDW CLASSIFICATION

In general, the CTO Manager should follow IDW classification guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1991, 1992a). The IDW classification process consists of chemical screening and characterization of the waste.

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the type(s) and concentrations of chemicals present in the waste. To ensure that IDW is managed in compliance with these requirements and to evaluate disposal options, the CTO Manager should

- Directly sample and analyze the IDW or associate it with historical data, observed site conditions, and/or samples collected on site at the source of the waste
- Screen the waste to identify the maximum concentrations of individual chemicals in, or associated with, the waste

- Screen waste constituents against chemical background data, if available
- Characterize the waste based on regulated groups of chemical constituents present in the waste
- Screen waste constituents against risk-based health criteria, ARARs, and TBC criteria for onsite disposal, or disposal facility criteria for offsite disposal

Each of the above steps is distinct and should be performed separately to avoid potential mistakes in the IDW classification process. The following subsections discuss these steps in greater detail.

5.6.1 IDW Sampling and Chemical Screening

IDW should be screened to identify chemicals present in the waste and their maximum concentrations. Screening may be facilitated by (1) directly sampling the waste, (2) associating the waste with analytical results from samples collected at the source of the IDW (e.g., a well boring), (3) visual observation of the waste, (4) historical activity data from the site, or (5) a combination of these methods (e.g., association with limited sampling). Composite sampling may be required if the unit volume of IDW is non-homogeneous. Data from samples collected directly from the IDW should take precedence over associated site sample data when making waste management decisions. Procedure I-D-1, *Drum Sampling* discusses methods for drum sampling.

Typically, IDW is screened for chemicals of potential concern at the site and against background data if available. If IDW is generated from outside the suspected AOC (e.g., soil cuttings from the installation of a background monitoring well), assume it is clean, and dispose of it accordingly.

The CTO Manager should consider the disposal criteria of any offsite disposal facility anticipated to be used when developing the SAP. Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Direct sampling and analysis of the waste may be required for these other constituents. Some disposal facilities prefer to collect and analyze the samples themselves. In addition, disposal facility criteria may dictate laboratory reporting limits. When possible, the CTO Manager should coordinate sampling and data requirements with the disposal subcontractor and anticipated disposal facility. Such efforts may allow IDW sampling to be conducted while the field team is mobilized for the site investigation, rather than conducting a separate IDW sampling event later.

5.6.2 IDW Characterization

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the particular constituent or *group(s) of chemical constituents* present in the waste. Therefore, to ensure that IDW is managed in compliance with these requirements, characterize IDW based on the chemical screening results to determine whether any of the following regulated constituents are present in the waste:

- Petroleum hydrocarbons (regulated by RCRA Subtitle I when released from a UST; see 40 CFR Part 280)
- Hazardous wastes (regulated by RCRA Subtitle C; see 40 CFR 261-299)
- Non-hazardous, solid wastes (regulated by RCRA Subtitle D; see 40 CFR 257-258)

- Hazardous substances and commingled petroleum (regulated by CERCLA; see 40 CFR 300.400 and 302.4)
- PCBs (regulated by TSCA; see 40 CFR 700)
- Asbestos (regulated by CAA for disposal; see 40 CFR 61, Subpart M)
- Radioactive wastes (regulated by the Nuclear Regulatory Commission; see 10 CFR [various parts], 40 CFR, Subchapter F, and other applicable laws)

EPA regulations and guidance do not require IDW to be tested to properly characterize it. Instead waste may be characterized based on historical site data, site observations, analytical data from the source of the IDW, and professional judgment (EPA 1991). Specifically, the EPA has indicated that IDW may be assumed not to be "listed" wastes under RCRA unless available information about the site suggests otherwise (53 FR 51444). Similarly, RCRA procedures for determining whether waste exhibits RCRA hazardous characteristics do not require testing if the decision can be made by "applying knowledge of the hazard characteristic in light of the materials or process used" (40 CFR 262.11(c); EPA 1991). If applicable, the disposal plans and reports should state, "there is no evidence based on site data and observations that the IDW contains listed RCRA wastes or exhibits RCRA characteristics."

For soil IDW, the potential for exhibiting toxicity may be determined by comparing constituent concentrations in the waste against screening values that are 20 times the TCLP criteria as specified in Section 1.2 of EPA Method Solid Waste-846 1311 *Toxicity Characteristic Leaching Procedure* (EPA 2007). Otherwise, samples associated with the soil can be tested using the TCLP.

5.7 IDW STORAGE

In general, the CTO Manager should follow IDW storage guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992a).

Always store IDW in a manner that is secure, protected from weather, and protective of human health and the environment. It is preferable to store IDW within the AOC(s) or on site; however, the Navy may assign a specific IDW storage area away from the project site.

If the IDW is determined to be RCRA hazardous, then RCRA storage, transport, and disposal requirements may apply, including a limited **90-day** storage permit exemption period prior to required disposal. If onsite disposal is an option, store RCRA waste within the AOC so that RCRA LDRs will not apply in the future. LDRs may be triggered if the waste is stored within the onsite area, but outside of the AOC or if the waste is removed from and later returned to the AOC for disposal. The AOC concept does not affect the approach for managing IDW that did not come from the AOC, such as PPE, decontamination equipment and fluids, and groundwater. If RCRA hazardous, these wastes must be managed under RCRA and drummed and disposed of off site (EPA 1991).

RCRA waste should not be stored within the AOC prior to disposal when professional judgment suggests the IDW might pose an immediate or permanent public endangerment (EPA 1991b).

Offsite storage of CERCLA waste must comply with the CERCLA offsite rule (40 CFR 300.440).

If the IDW is determined to be TSCA-regulated, then TSCA storage requirements as described in CFR 764.65, transport, and disposal requirements apply, including a limited **30-day** storage period prior to required disposal. Storage requirements are as follows:

1. Storage facilities must provide an adequate roof and walls to prevent rain water from reaching the stored PCBs.

2. Storage facilities must provide an adequate floor that has continuous curbing with a minimum 6-inch-high curb.

3. Storage facilities must contain no drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area.

4. Storage facilities must provide floors and curbing constructed of continuous smooth and impervious materials to minimize penetration of PCBs.

5. Storage facilities must not be located at a site that is below the 100-year flood water elevation.

6. PCBs in concentrations of 50 ppm or greater must be disposed of within 1 year after being placed in storage.

PCB waste can also be stored in a RCRA-approved waste storage area for 30 days from date of generation.

NAVFAC Pacific requires that all CERCLA, RCRA, and other types of waste be removed from JBPHH areas within 90 days of its generation, particularly within the shipyard area, and 30 days of generation for TSCA waste. Efforts should also be made to dispose of IDW within the 30- and 90-day periods at other Navy installations, unless the IDW will be managed with remediation waste to be generated during a cleanup action in the near future. The Navy may approve extensions of the storage time limit for wastes that are non-hazardous on a project-specific basis.

5.7.1 Drum Storage

Implement drum storage procedures to minimize potential human contact with the stored IDW and prevent extreme weathering of the stored drums. Place all IDW drums upright on pallets before the drums are stored. RCRA storage requirements include the following: containers shall be in good condition and closed during storage; wastes shall be compatible with containers; storage areas shall have a containment system; and spills or leaks shall be removed as necessary.

Place all IDW drums generated during field activities at a single AOC or designated IDW storage area together in a secure, fenced onsite area to prevent access to the drums by unauthorized personnel. When a secure area is not available, place drums in an area of the site with the least volume of human traffic. At a minimum, place plastic sheeting (or individual drum covers) around the stored drums. Post signage at the IDW storage area stating that drums should not be removed from the area without first contacting the Navy COR.

Liquid IDW drums must be stored under secondary containment (either secondary containment pallets or handmade plastic sheeting/polyvinyl chloride frame containment) and all IDW drums (soil and water) must utilize secondary containment when stored within 15 feet of a surface water body or storm drain inlet.

Drums from projects involving multiple AOCs shall remain at the respective source areas where the IDW was generated. IDW should not be transferred off site for storage elsewhere, except under rare circumstances, such as the lack of a secure onsite storage area.

Implement proper drum storage practices to minimize damage to the drums from weathering and possible human exposure to the environment. When possible, store drums in dry, shaded areas and cover them with impervious plastic sheeting or tarpaulin material. Make every effort to protect the preprinted drum labels from direct exposure to sunlight, which causes ink on the labels to fade. In addition, store drums in areas that are not prone to flooding. Secure the impervious drum covers appropriately to prevent dislodging by the wind. It may be possible to obtain impervious plastic covers designed to fit over individual drums; nonetheless, repeat the labeling information on the outside of these opaque covers.

Drums in storage shall be placed with sufficient space between rows of drum pallets and shall not be stacked, such that authorized personnel may access all drums for inspection. Proper placement will also render subsequent IDW screening, sampling, and disposal more efficient when individual drum removal is necessary. It is recommended that IDW drums be segregated in separate rows/areas by matrix (i.e., soil, liquid or PPE/other).

If repeated visits are made to the project site, inspect the IDW drums to clear encroaching vegetation, check the condition and integrity of each drum, secondary containment if applicable, check and replace aluminum tags as necessary, and replace or restore the tarpaulin covers.

5.7.2 IDW Stockpiles

Consider IDW stockpiling only when a very large quantity of IDW will be generated. Segregate stockpiled IDW, and inventory it by source location and depth to the extent practicable. Stockpiling and media mixing should not be used as methods to dilute chemical concentrations in the waste. Line stockpiles on the bottom, cover it with sturdy plastic, and locate it in areas where weather elements (e.g., wind, rainfall runoff) will not cause migration of the waste. Never dispose of liquid IDW on a stockpile; drum or store liquid waste in other appropriate containers. Follow applicable regulation and guidance when sampling stockpiled waste for characterization purposes.

5.8 IDW DISPOSAL

Various methods and requirements for onsite and offsite disposal of IDW are discussed in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992b). This section explains the disposal evaluation process and highlights some of the more important requirements for onsite and offsite IDW disposal options.

IDW sampling, characterization, and disposal analysis, particularly for onsite disposal, can be unexpectedly complex and require compliance with many different laws (that act as ARARs for IDW management and disposal). Before preparing the IDW disposal plan, compare estimated costs for onsite vs. offsite disposal. Offsite disposal may be more cost effective than devising and documenting the justification for onsite disposal when the quantity of IDW is small (less than 10 drums) and/or the waste fails the initial conservative screening against conservative risk-based criteria. Also weigh cost savings against the policy preference of the EPA and State of Hawaii Department of Health to manage and dispose of IDW on site, when possible.

5.8.1 Onsite Disposal

In general, the EPA preference is to dispose of IDW on site when the disposal action:

- Does not pose an unacceptable long-term risk to human health and the environment
- Is in accordance with chemical-, location- and action-specific ARARs "to the extent practicable" (40 CFR 300.415(i); 55 FR 8756)
- Does not introduce contaminants into clean soil or other site media
- Does not mobilize or significantly increase concentrations of any hazardous constituents already present in the environment
- Is consistent with the final remedy planned for the site
- Takes into account any community concerns regarding waste storage and the disposal method

Base onsite disposal options on best professional judgment and available site-specific data. For some projects, it may be prudent to store the waste temporarily until additional site data become available (e.g., sample analytical data, preliminary risk-assessment results, AOC delineation, and establishment of background values). Factors to consider include, but are not limited to the following:

- The detected or suspected contaminants, their concentrations, and total volume of IDW
- Media potentially affected (e.g., groundwater drinking source)
- Background metals data for site media
- Site access, conditions, and potential receptors
- Current and future land use
- Public perceptions (especially if drum storage and/or disposal takes place in open view)
- Time limits for IDW storage
- Potential requirements to treat waste before disposing of it on site
- Lack of unpaved areas to disposed of waste on site
- Potential wind, erosion, runoff, or flood conditions that might cause offsite migration of disposed waste
- Proximity to the ocean, surface water, or environmentally sensitive habitats
- Natural attenuation processes
- Need for additional utility survey before excavating to backfill waste
- Need for land use controls required to limit exposure pathways (e.g., backfill waste, provide permanent security around site, replant site to prevent erosion)

Protection of human health can be evaluated by comparing chemical concentrations in the waste to the more conservative of EPA residential regional screening levels), environmental action levels, and chemical-specific ARARs and TBC criteria. Ecological receptors can be protected by screening the IDW against EPA ecological soil screening levels. Onsite disposal of surface and groundwater IDW can be evaluated by initially screening against EPA tap-water PRGs, State Safe Drinking Water Standards (maximum contaminant levels and non-zero maximum contaminant level goals), and/or State Surface Water Quality Standards. These criteria are not always ARARs for the disposal method or site conditions; however, they may be useful to affirmatively show that the disposal is protective. Alternatively, the IDW may be associated with human-health and eco-risk assessment results for the site if the onsite placement of IDW is consistent with exposure pathway assumptions made during the risk assessment (e.g., contaminated soil might not present an unacceptable health risk at depth, but could pose such a risk if disposed of at the ground surface).

In general, return IDW consisting of environmental media to or near its source, and return waste generated from depth to its original depth, if possible and approved by NAVFAC in advance. Bury all contaminated soil and water IDW to be disposed of on site below grade at a depth of at least 3 feet and cover it with clean soil to reduce the potential for future exposure to human and ecological receptors.

Dispose of non-indigenous IDW and contaminated decontamination fluids off site. The cleaning detergent Alconox, often used in the decontamination process, is itself non-hazardous and biodegradable. Small quantities of clean decontamination water containing Alconox may be disposed of to clean areas on site. If onsite disposal is appropriate for RCRA IDW, this waste should be disposed of within the AOC to avoid the need to comply with LDRs.

IDW from several non-contiguous onsite areas may be consolidated and disposed of at one of the areas, provided a nexus exists between the wastes generated and response projects (55 FR 8690-8691).

IDW may also be temporarily disposed of back to the AOC without detailed analysis or documentation if the waste will be addressed with other site contamination during a future response action and will not present a significant short-term threat to human health and the environment.

5.8.2 Offsite Disposal

If onsite disposal is not a viable option, dispose of the IDW at an appropriate offsite treatment and/or disposal facility. Offsite transport and disposal of IDW must comply with all applicable laws and criteria specific to the chosen disposal facility. These requirements may include, but are not limited to the following:

- RCRA LDRs
- RCRA waste storage permits and time limits
- National Pollutant Discharge Elimination System and sewer disposal criteria
- CERCLA offsite rule
- TSCA treatment requirements
- DOT hazardous material transport packaging, manifesting, and security provisions

- International Maritime Organization ocean transport rules
- Certifications and training for waste transport contractors
- State notification requirements when importing certain types of waste

The CERCLA offsite rule (40 CFR 300.440) requires that CERCLA waste be disposed of only at facilities specifically approved by the EPA to receive such waste for treatment, storage, or disposal. The acceptability status of a disposal facility can change quickly (e.g., if there is a release at the facility); therefore, the CTO Manager should contact the EPA Region 9 CERCLA Offsite Rule Coordinator no more than 60 days prior to disposal of the IDW to verify the facility's approval status. The offsite rule applies to any CERCLA-driven remedial or removal action involving the offsite transfer of waste containing hazardous substances regardless of the concentrations present.

RCRA hazardous waste manifests must always be signed by authorized Navy personnel. In some cases, the Navy may authorize contractors to sign non-hazardous manifests. Navy authorization to allow contractor signature of non-hazardous manifests shall be based upon a Navy review of the contractor's RCRA and DOT training records. In addition, the Navy shall always be allowed the opportunity to review/approve non-hazardous manifests and waste profiles prior to waste disposal efforts.

Disposal of liquid IDW into the Navy sanitary sewer shall occur only if first approved by the Navy. Requests for disposal to Navy facilities should be coordinated through the COR. Discharge to the public sewer system is discouraged and should occur only if approved by state and local government agencies.

5.9 RECORDS

The CTO Manager is responsible for completing and updating the site-specific IDW drum inventory spreadsheet and submitting it as needed, and reviewing the IDW disposal plan (IDW disposal paperwork).

FMs and designates are responsible for documenting all IDW-related field activities in the field notebook including most elements of the IDW drum inventory spreadsheet. The correct methods for developing and maintaining a field notebook are presented in Procedure III-D, *Logbooks*.

Guidance related to preparing an IDW disposal plan (if required) is presented in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995).

5.9.1 IDW Disposal Documentation

Upon receipt of analytical data from the investigation or from IDW-specific analytical data, the generator information request form will be completed and provided to the IDW subcontractor to begin IDW characterization. Completed IDW disposal paperwork received from the IDW subcontractor should be reviewed for accuracy prior to submitting for Navy review.

The CTO Manager is responsible for submitting backup documentation (actual site or drum sampling results) along with the IDW disposal paperwork to the Navy.

Navy-approved contractor personnel may sign non-hazardous waste IDW documentation. Hazardous waste IDW documentation must be signed by an authorized Navy Environmental Coordinator.

All manifests (non-hazardous and hazardous) must be tracked, and if completed manifests (signed by disposal facility) are not received within 30 days of initial transportation, then contractor must notify the RPM weekly of the shipping status (e-mail is acceptable). Hazardous waste must be disposed of within 45 days of initial transportation. If not, specific IDW transportation details must be supplied to the Navy in order to prepare and file an exception report.

TSCA-regulated waste must be physically destroyed and or buried within 1 year of generation (date placed in IDW drum). Disposal certificates should be provided by the waste facility to the IDW subcontractor and Navy contractor.

Following disposal of IDW, the CTO Manager should prepare a short IDW disposal report summarizing the disposal operation and appending any associated records (e.g., final drum log, waste profiles, transport manifests, bills of lading, disposal facility certifications). Minimal topics to include in the report:

- IDW inventory and storage
- IDW chemical screening and characterization
- IDW transport and disposal
- Manifests
- Drum storage photographs
- Site figure

6. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

7. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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———. 1995. Generic IDW Screening, Sampling, Analysis, and Disposal Plan for Various Hawaii Naval Installations. Pearl Harbor, HI: Pacific Division, Naval Facilities Engineering Command. April.

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Procedure I-C-2, *Monitoring Well Development*.

Procedure I-C-3, *Monitoring Well Sampling*.

Procedure I-D-1, *Drum Sampling.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-D, *Logbooks.*

8. Attachments

Attachment I-A-6-1: IDW Drum Label

Attachment I-A-6-2: Drum Label – Aluminum Tag

Attachment I-A-6-3: Monthly IDW Drum Inventory Updates

Attachment I-A-6-1
IDW Drum Label

IDW Drum Label

Contract #:

CTO #:

ACTIVITY SITE:

(_ _ _ _ - _ _ - D M _ _ _)
DRUM #

DATE COLLECTED

CONTENTS: (please ✓ and explain)

☐ Soil

☐ Water

☐ Solid Waste

☐ Other

PROJECT TYPE

☐ RI ☐ RFI ☐ UST ☐ Other

COMMENTS:

FOR INFORMATION CONTACT:

COR Activity/ Code:

Address:

Telephone:

Attachment I-A-6-2
Drum Label - Aluminum Tag

Drum Label - Aluminum Tag

Attachment I-A-6-3
Monthly IDW Drum Inventory Updates

Table I-A-6-1: Monthly IDW Drum Inventory Updates

Navy Activity / Site Name (Generator Site)	CTO Number (0bbb)	Drum Number (xxxx-AA-DMzzz)	Drum Storage Location	Origin of Contents (Source ID #)	IDW Type	Waste Volume (Fill level %)	Waste Generation Date (dd-Mon-yy)	Expected Disposal Date (Mon-yy)	Actual Disposal Date (dd-Mon-yy)
Inspector:									
Date of Inspection:									
NSC Pearl Harbor/ Landfill	0068	0068-LF-DM001	NSC, Bldg 7	SB-1	Soil Cuttings	100	16-Dec-92	Dec-93	N/A
		0068-LF-DM002	N/A	MW-1	Purge Water	75	20-Dec-92	Jul 93	26-Jul-93
				MW-2					
				MW-3					
		0068-LF-DM003	N/A	MW-1	Decon. Water	95	20-Dec-92	Jul-93	26-Jul-93
				MW-2					
				MW-3					
		0068-LF-DM004	NSC, Bldg.16	SB-1	PPE	50	16-Dec-92	Oct-93	N/A
				SB-2					
				SB-3					
				SB-4					
				MW-1					
				MW-2					
				MW-3					
NAVSTA Guam/ Drum Storage	0047	0047-DS-DM001	Hazmat Storage Area	SB-1	Soil Cuttings	100	18-Feb-93	Sep-93	N/A
				SB-2					

N/A Not Applicable

Sample Naming

1. Purpose

This standard operating procedure describes the naming convention for samples collected and analyzed, and whose resulting data will be stored in the database for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific projects. Unique sample names are used to facilitate tracking by laboratory personnel and project personnel, and for purposes of storing, sorting, and querying data in the database.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Chain of Custody Sample Number

The chain of custody (COC) sample number is a five-character identification number that is used by the laboratory and project personnel for tracking purposes. A unique COC sample number must be used for each sample collected from a particular location at a particular time. It is useful for the first two characters to be letters unique to a particular site or project, while the remaining three characters may be digits from 001 to 999 (e.g., AA001). The COC sample number is the only identifier that should be presented to the laboratory.

3.2 Sample Identification Number

The sample identification number is a unique multi-alpha, multi-numeric identifier that is used by the field team to associate sampling results to the particular sampling location, sample type, number of times the location has been sampled, and depth. To avoid potential bias in sample analysis, the sample identifier is not provided to the laboratory. The sample identification number shall be recorded in the field logbook concurrently with the COC sample number.

4. Responsibilities

The prime contractor CTO Manager shall ensure that a proper sample naming convention is identified in the field sampling plan. The Field Quality Control (QC) Supervisor or other field-sampling leader shall ensure that the sample naming convention is implemented. The laboratory coordinator, CTO Manager, and/or other designated personnel shall ensure on a daily basis that unique, appropriate COC sample numbers and sample identifiers have been assigned. The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The prime contractor Technical Director will designate one person in each office (e.g., the laboratory coordinator) to track site designations used in the COC sample number.

5. Procedures

A COC sample number and sample identifier shall be assigned as described below. It is critical that each sample name have a unique COC sample number and sample identifier; otherwise, data cannot be properly stored and tracked in the database.

5.1 COC Sample Number

Use the following format for the COC sample number:

abccc

Where:

a = A letter indicating the office managing the CTO

b = A letter indicating the project or site, for example

A = first site

B = second site

C = third site, etc.

ccc = Chronological number, for example

001 = first sample from the site

002 = second sample from the site

105 = 105th sample from the site

Field QC samples should be included in this chronological sequence

For example, the 23rd sample from the Carpentry Shop Dip Tank site (assigned project "A" for b above; the office will be assigned "D") being investigated would be referred to as "DA023." This might be a soil sample, water sample, trip blank, equipment blank, field duplicate, or other sample type. Using this COC sample number, the samples will be submitted to the laboratory "blind," that is, the laboratory should not know whether each sample received is a site or field QC sample.

If a sample is lost during shipping, the replacement sample must be assigned a new COC sample number. If different containers for the same sample are shipped on different days, a new COC sample number must be assigned.

When numbering reaches the letter Z, the 26th site, it may begin with a new first letter "a," which must be coordinated with the prime contractor QA Manager or Technical Director and Coordinator or designee to ensure that it has not been used by another CTO.

Alternatively, the "ab" designators can serve to identify a unique project field, such as "RH" for the Red Hill site.

5.2 SAMPLE IDENTIFICATION NUMBER

The following format is provided as a suggested guidance. Individual site objectives may necessitate variations to the suggested guidance. Coordinate with the prime contractor QA Manager or Technical Director when considering deviating from this guidance.

AA-bbcc-dee-Dff.f

Where:

AA = Designates the site identification

bb = Sample type and matrix (see Table I-A-8-1)

cc = Location number (e.g., 01, 02, 03)

d = Field QC sample type (see Table I-A-8-2)

ee = Chronological sample number from a particular sampling location (e.g., 01, 02, 03)

D = The letter "D" denoting depth

ff.f = Depth of sample in feet bgs (to the measured decimal place). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

For example, the first subsurface soil sample collected from the Foundry Building (FB) borehole location four at a depth of 10 feet would be designated "FB-BS04-S01-D10.0." These characters will establish a unique sample identifier that can be used when evaluating data.

Table I-A-8-1 presents the character identifiers to be used in the sample and matrix portion of the sample identification number. In all cases, the second letter indicates the sample matrix. Note grab, composite, and undisturbed sample designations in the field logbook.

Table I-A-8-1: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
SS	Surface Soil	Soil
IS	Surface Soil (ISM)	Soil
IB	Subsurface Soil (ISM)	Soil
BS	Subsurface Soil	Soil
BG	Subsurface Soil (Geotechnical)	Soil
SD	Sediment	Sediment
GW	Groundwater	Water
SW	Surface Water	Water
FP	Free Product	Oil
WQ	Water Blanks	Water
SG	Soil Gas	Soil gas
CC	Concrete Chips	Concrete

Identifier	Sample Type	Matrix
WS	Waste (IDW)	Soil
WW	Waste (IDW)	Water

IDW investigation-derived waste
ISM incremental sampling methodology

Table I-A-8-2 describes the field QC designator types. These field QC designators clarify the type of sample collected.

Table I-A-8-2: Field QC Sample Type Identifiers

Identifier	QC Sample Type	Description
S	Normal (Primary) Sample	All non-field QC samples
D	Duplicate	Collocate (adjacent liners)
R	Triplicate	Replicate
E	Equipment Rinsate	Water
B	Field Blank	Water
T	Trip Blank	Analytical-laboratory-prepared sample -Water
M	Trip Blank	Analytical-laboratory-prepared sample – Methanol
L	Batch Test Sample	Batch Test Leaching Model Sample
P	Blind Spike	Performance testing sample

6. Records

Sample identifiers (and COC sample numbers, if appropriate) shall be identified in advance if the exact numbers of samples to be collected are known; these numbers may be listed on a spreadsheet along with requested analyses to be used as a reference by field sampling personnel.

The COC/analytical request form must be used to track all sample names. Copies of each COC form shall be sent daily to the CTO Laboratory Coordinator and with the samples to the analytical laboratory. An example of a COC form is included as Attachment III-E-2 of Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

In the field, personnel shall record in the field logbook the COC sample number of each sample collected, as well as additional information, such as the sampling, date, time, and pertinent comments.

7. Health and Safety

Not applicable.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

None.

Soil Sampling

1. Purpose

This section sets forth the standard operating procedure for soil sampling (surface samples, trench samples, and boring samples) to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil sampling procedures are followed during projects conducted under the NAVFAC Pacific ER Program, and that they are conducted or supervised by a qualified individual. A qualified individual for subsurface sampling is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience in the supervision of soil boring construction. A qualified individual for trenching, excavation (e.g., pit), or surface sampling supervision is one who has sufficient training and experience to accomplish the objectives of the sampling program. The CTO Manager shall also ensure that a qualified person, as defined in Procedure I-E, *Soil and Rock Classification,* conducts soil classification during all types of soil sampling. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 CONSIDERATIONS FOR MUNITIONS AND EXPLOSIVES OF CONCERN

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission (ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 SUBSURFACE SOIL SAMPLING

The purpose of subsurface soil sampling is to acquire accurate, representative information about subsurface materials penetrated during drilling or trenching. This is accomplished by logging lithologic information, classifying lithologic materials, and collecting lithologic samples for analysis using geotechnical or chemical methods.

5.2.1 Inspection of Equipment

The collection of reliable samples of subsurface materials depends partly on the types of samples that can be collected when using various subsurface exploration techniques. These procedures are described in Section 5.2. In all cases, the equipment shall be inspected prior to commencement of drilling for signs of fluid leakage, which could introduce contaminants into the soil. If, at any time during subsurface exploration, fluid is observed leaking from the rig, operations shall cease and the leak shall be immediately repaired or contained. All soil and other materials affected by the leak will be collected, containerized, and labeled for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

5.2.2 Preparation of Site

Proper preparation of the site prior to the commencement of subsurface exploration is essential for smooth drilling operations. It is required to protect the health and safety of site personnel. First, the site shall be inspected to ensure that there are no overhead hazards that could affect subsurface exploration. Then, all subsurface sampling locations shall be assessed using geophysical methods to identify subsurface utilities or hazards. If possible, the area shall be excavated by hand to a depth of 2 to 3 feet before beginning drilling. If surface or shallow samples are required, it is suggested that the hand excavation be done as close to the actual subsurface exploration as possible. The drill rig must have a means to guard against employee contact with the auger (e.g., guard around the auger; barricade around the perimeter of the auger; electronic brake activated by a presence-sensing device). All members of the field crew shall know the location of the kill switch, which must be readily accessible, for the equipment.

The equipment shall be situated upwind or side-wind of the borehole. The area surrounding, and in the vicinity of, the borehole shall be covered with plastic, including the area where cuttings are placed into 55-gallon drums and the equipment decontamination area. The required exclusion zones shall be established by using plastic tape or cones to designate the various areas.

5.2.3 Equipment Decontamination

To avoid cross-contamination, all sampling equipment utilized for borehole drilling and soil sampling that may potentially come into contact with environmental samples shall be thoroughly decontaminated as described in Procedure I-F, *Equipment Decontamination*. All sampling tools shall be decontaminated between each sampling event and between each borehole or trench. At a minimum, all equipment shall be steam-cleaned or undergo the wash-and-rinse process. All wash-and-rinse water shall be collected, containerized, and labeled for proper disposal. Clean equipment (e.g., augers and samplers) shall be protected from contact with contaminated soils or other contaminated materials prior to sample collection. Equipment shall be kept on plastic or protected in another suitable fashion. After a borehole is completed, all augers and contaminated downhole equipment shall be stored on plastic sheeting.

5.2.4 Handling of Drill Cuttings

All soil cuttings from borehole drilling shall be placed into 55-gallon U.S. Department of Transportation (DOT)-approved drums or other appropriate containers, such as a roll-off bin. The containerized cuttings shall be stored in a centralized area pending sample analysis to determine their final disposition. The procedure on investigation-derived waste (IDW) (see Procedure I-A-6, *Investigation-Derived Waste Management*) details drum handling and labeling procedures.

5.3 Subsurface Soil Sample Collection Methods

Table I-B-1-1 describes the characteristics of the sampling methods for the drilling techniques frequently used for soil borings and monitoring well installation, as described in Procedure I-C-1, *Monitoring Well Installation and Abandonment*. The split-spoon sampling method is the most commonly used soil sampling technique. However, in certain circumstances, other methods may have to be used to obtain optimal soil sampling results.

Sampling and handling procedures for samples submitted for volatile organic compound (VOC) analyses are provided in Attachment I-B-1-1. Considerations when using incremental sampling (IS) methods are provided in Attachment I-B-1-1.

Table I-B-1-1: Characteristics of Common Subsurface Formation-Sampling Methods

Type of Formation	Sample Collection Method	Sample Quality	Potential for Continuous Sample Collection?	Samples Suitable for Analytical Testing?	Discrete Zones Identifiable?
Unconsolidated	Bulk Sampling (Cuttings)	Poor	No	No	No
	Thin Wall	Good	Yes	Yes	Yes
	Split Spoon	Good	Yes	Yes	Yes
	Trench	Good	No	Yes	Yes
	Core Barrels	Good	Yes	Yes	Yes
Consolidated	Cuttings (direct rotary)	Poor	No	No	No
	Core Barrels	Good	Yes	Yes	Yes

The following text describes the primary soil sampling methods used for the NAVFAC Pacific ER Program.

5.3.1 Split-Spoon Samples

Split-spoon sampling is usually used in conjunction with the hollow-stem or solid-stem auger drilling method and can be used for sampling most unconsolidated and semi-consolidated sediments. It is used less frequently for air and mud rotary, and casing drive methods. It cannot normally be used to sample bedrock, such as basalt, limestone, or granite. The method can be used for highly unconsolidated sands and gravels if a stainless-steel sand catcher is placed in the lower end of the sampler.

The split-spoon sampler consists of a hardened metal barrel, 2 to 3 inches in diameter (2 to 2.5 inches inner diameter) with a threaded, removable fitting on the top end for connection to the drill rods and a threaded, removable "shoe" on the lower end that is used to penetrate the formation. The barrel can be split along its length to allow removal of the sample.

The following steps are required to obtain a representative soil sample using a split-spoon sampler:

- Advance the borehole by augering until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Equip the sampler with interior liners that are composed of materials compatible with the suspected contaminants if samples are to be retained for laboratory analytical analysis. Generally, these liners consist of brass or stainless steel and are slightly smaller than the inner diameter of the sampler. It is recommended to use stainless-steel liners rather than

brass if samples are to be analyzed for metals. Always evaluate the composition of the liners with respect to the types of contaminants that are suspected.

- Attach the properly decontaminated split-spoon sampler (equipped with liners) either to the drill rods or to a cable system and lower it to the bottom of the borehole through the augers.
- Drive the sampler into the formation by either a manual or automatic hammer (usually a 140-pound weight dropped through a 30-inch interval). Record the number of blows required to drive the sampler at 6-inch intervals in the boring log since blow counts provide an indication of the density/compaction of the soils being sampled. The field geologist, hydrogeologist, or geotechnical engineer shall carefully observe the internal measuring technique of the driller and keep track of sampling materials to ensure the accurate location of samples. Continuous samples can be collected with the split-spoon method by augering or drilling to the bottom of the previously sampled interval and repeating the operation. Whether continuous or intermittent, this collection method disturbs samples and cannot be used for certain geotechnical tests that require undisturbed samples.
- Bring the split-spoon sampler to ground surface and remove it from the drill rods or cable system following sample acquisition. Loosen the upper and lower fittings and take the sampler to the sample handling area. At the sample handling area, remove the fittings, split the barrel of the sampler, and remove one side of the sampler. At this time, it is important to observe and record the percentage of sample recovery.

Liners—Sampler liners can be used to collect and store samples for shipment to laboratories, for field index testing of samples, and for removing samples from solid barrel type samplers. Liners are available in plastic, Teflon, brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 inches (152.4 millimeters) to 5.0 feet (1.53 meters). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short-term as samples are subsampled and preserved immediately on site. Teflon may be required for mixed wastes and for long-term storage. Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners with less tolerance may be required and a shortened sample interval used to reduce friction in the liner. Metal liners can be reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use (ASTM 2005).

Immediately remove the liners containing the soil samples from the sampler. Generally, the lowermost liner is considered the least disturbed and shall be retained as the analytical laboratory sample. However, in certain circumstances (such as with the use of a sand catcher), other liners may be more appropriate for retention as the laboratory sample. If liners containing the sample material are to be submitted to the laboratory, then cover the ends of the sample liner to be retained as the analytical laboratory sample with Teflon film and sealed with plastic caps. While currently not preferred by the State of Hawaii, if liners are submitted, the laboratories should be instructed to prepare the soil from the liner as an incremental sample to prevent biasing the results that can occur when discretely collecting the analytical volume. The site geologist, hydrogeologist, or geotechnical engineer shall observe the ends of the liner destined for analytical sampling and describe the physical nature of the sample (e.g., soil or rock type, grain size, color, moisture, as indicated in Procedure I-E, *Soil and Rock Classification*.) Then label the sample according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately place it on ice in a cooler as described in Procedure III-F, *Sample Handling, Storage, and Shipping*.

- Collect split-spoon soil samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.
- Collect split-spoon soil samples submitted for non-VOC analysis using the IS procedure found in Attachment I-B-1-1
- Any remaining liners collected from the sample can then be used for other purposes, such as providing a duplicate sample for field quality control or material for lithologic logging. These samples can also be used for headspace analysis as described in Section 5.4.
- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1. In most instances, an additional liner full of material is available for this purpose. Check to ensure that all liners contain similar material. If an extra liner full of material is not available, then log by collecting the extra material present in the end of the sampler shoe. Make a comparison to the material visible at the end of the sample liner destined for laboratory analysis to ensure that the entire sample consists of similar material. If not, then describe the different material to the extent possible by relating it to similar material that was encountered previously.
- If VOCs are suspected to be present, screen the sample with an organic vapor monitor (OVM) or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

5.3.2 Thin-Wall Samples

The thin-wall or Shelby tube sampler is usually used in conjunction with the hollow-stem and solid-stem auger drilling methods and is most useful when sampling clay- and silt-rich sediments. It can also be used with air and mud rotary and casing drive drilling techniques. It is amenable only to lithologies that are relatively soft and, in some cases, is not capable of penetrating hard clays or compacted sands. In addition, samples of unconsolidated sands cannot normally be acquired because they cannot be retained within the sampler, although a sand catcher can be utilized, in some cases, with moderate success.

The thin-wall sampler often consists of a single thin tube that is 3 to 4 inches in outer diameter and 1 to 3 feet in length. The upper end of the sampler has a solid metal section with a fitting for drill rods. There is no fitting for the lower end of the sampler, and it is usually open to allow sample acquisition; however, when sampling in poorly consolidated materials, a sand catcher may be placed in the lower end to ensure retention of the sample.

The following steps are required to obtain a representative soil sample using a thin-wall sampler:

- Advance the borehole by augering or drilling until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Place the sampler on the end of the drill rods and lower it to the bottom of the borehole.
- Instead of driving the sampler, use the hydraulic apparatus associated with the kelly bar on the drilling rig to press the sampler into the undisturbed formation. The thin-wall sampler may lack sufficient structural strength to penetrate the materials, in which case another sampling technique may be required. The samples obtained using this method cannot be used for certain geotechnical tests where undisturbed samples are required.
- Thin-wall samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.
- Following sample acquisition, bring the thin-wall sampler to the ground surface, remove it from the drill rods, and take it to the sample handling area.
- Immediately cover the ends of the sample with Teflon film and sealed with plastic caps if the sample is to be retained as a laboratory sample. Then label the sample according to Procedure III-E*, Record Keeping Sample Labeling, and Chain of Custody* and immediately place it on ice in a cooler. Extrude the sample from the sampler and inspect it if the sample is to be used only for lithologic logging.
- Conduct lithologic logging of each sample in accordance with Procedure I-E*, Soil and Rock Classification* and enter each sample into the boring log presented in Figure I-B-1-1. If the sample is contained in a sleeve, observe the ends of the sample in the sleeve to assess lithologic and stratigraphic characteristics.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination.*

5.3.3 Cores

A core barrel is often used to obtain core samples from harder lithologic materials, such as basalt, granite, and limestone, in instances where undisturbed samples are required for geotechnical testing, and in cases where completely continuous sampling is required. Complete recovery of samples during coring is often difficult when sampling unconsolidated and semi-consolidated lithologies, such as clays, silts, and sands.

Field Log of Boring

BORING NUMBER	SHEET ____ OF _____

PROJECT NAME	PROJECT NUMBER	ELEVATION AND DATUM			LOCATION	
DRILLING COMPANY	DRILLER	DATE AND TIME STARTED			DATE AND TIME COMPLETED	
DRILLING EQUIPMENT	DRILLING METHOD	COMPLETION DEPTH			TOTAL NO. OF SAMPLES	
SIZE AND TYPE OF BIT	HOLE DIAMETER	NO. OF SAMPLES	BULK	SS	DRIVE	PITCHER
DRILLING FLUID	DRILLING ANGLE	WATER LEVEL	FIRST		AFTER _______ HOURS	
SAMPLE HAMMER TYPE DRIVING WT. DROP		HYDROGEOLOGIST/DATE			CHECKED BY/DATE	

LITHOLOGY	DEPTH (FEET)	SAMPLES	RECOVERY	BLOW COUNT	DESCRIPTION	USCS SYMBOL	ESTIMATED PERCENT OF GR	ESTIMATED PERCENT OF SA	ESTIMATED PERCENT OF FI	COMMENTS

Figure I-B-1-1: Field Log of Boring

ASTM International (ASTM) has standardized rock coring methods (D-2113) (ASTM 2006). Several standardized core sizes for bits, shells, and casings have been established (e.g., RX, NX, SW). Table I-B-1-2 summarizes the various size standards for core barrels and bits.

Table I-B-1-2: Standard Core Barrel Sizes (in inches)

Description	RX or RW	EX or EW	AX or AW	BX or BW	NX or NW	HX or HW	PX or PW	SX or SW	UX or UW	ZX or ZW
Bit Set Normal I.D.	0.750	0.845	1.185	1.655	2.155	3.000	—	—	—	—
Bit Set Normal and Thin-wall O.D.	1.160	1.470	1.875	2.345	2.965	3.890	—	—	—	—
Bit Set Thin-wall. I.D	0.735	0.905	1.281	1.750	2.313	3.187	—	—	—	—
Shell Set Normal and Thin-wall O.D.	1.175	1.485	1.890	2.360	2.980	3.907	—	—	—	—
Casing Bit Set I.D.	1.000	1.405	1.780	2.215	2.840	3.777	4.632	5.632	6.755	7.755
Casing Bit Set and Shoe O.D.	1.485	1.875	2.345	2.965	3.615	4.625	5.650	6.780	7.800	8.810

I.D. Inner Diameter
O.D. Outer Diameter

The selection of the most practical core barrel for the anticipated bedrock conditions is important. The selection of the correct drill bit is also essential to good recovery and drilling production. Although the final responsibility of bit selection usually rests with the drilling contractor, there is a tendency in the trade to use “whatever happens to be at hand.” The selection of the diamond size, bit crown contour, and number of water ports depends upon the characteristics of the rock mass. The use of an incorrect bit can be detrimental to the overall core recovery. Generally, fewer and larger diamonds are used to core soft formations, and more numerous, smaller diamonds, which are mounted on the more commonly used semi-round bit crowns, are used in hard formations. Special impregnated diamond core bits have been developed recently for use in severely weathered and fractured formations where bit abrasion can be very high.

Core barrels are manufactured in three basic types: single tube, double tube, and triple tube. These basic units all operate on the same principle of pumping drilling fluid through the drill rods and core barrel. This is done to cool the diamond bit during drilling and to carry the borehole cuttings to the surface. A variety of coring bits, core retainers, and liners are used in various combinations to maximize the recovery and penetration rate of the selected core barrel.

The simplest type of rotary core barrel is the single tube, which consists of a case hardened, hollow steel tube with a diamond drilling bit attached at the bottom. The diamond bit cuts an annular groove, or kerf, in the formation to allow passage of the drilling fluid and cuttings up the outside of the core barrel. The single tube core barrel cannot be employed in formations that are subject to erosion, slaking, or excessive swelling, as the drilling fluid passes over the recovered sample during drilling.

The most popular and widely used rotary core barrel is the double tube, which is basically a single tube barrel with a separate and additional inner liner that is available in either a rigid or swivel type of construction. In the rigid types, the inner liner is fixed to the outer core barrel so that it rotates with the outer tube. In contrast, the swivel type of inner liner is supported on a ball-bearing carrier, which allows the inner tube to remain stationary, or nearly so, during rotation of the outer barrel. The sample, or core, is cut by rotation of the diamond bit. The bit is in constant contact with the drilling fluid as it flushes out the borehole cuttings. The addition of bottom discharge bits and fluid control valves to the core barrel system minimizes the amount of drilling fluid and its contact with the sample, which further decreases sample disturbance.

The third and most recent advancement in rotary core barrel design is the triple tube core barrel, which adds another separate, non-rotating liner to the double tube core barrel. This liner, which retains the sample, consists of a clear plastic solid tube or a split, thin metal liner. Each type of liner has its distinct advantages and disadvantages; however, they are both capable of obtaining increased sample recovery in poor quality rock or semi-cemented soils, with the additional advantage of minimizing sample handling and disturbance during removal from the core barrel.

The rotary core barrels that are available range from 1 to 10 inches in diameter, and the majority may be used with water, drilling mud, or air for recovering soil samples. Of the three basic types of core barrels, the double tube core barrel is most frequently used in rock core sampling for geotechnical engineering applications. The triple tube core barrel is used in zones of highly variable hardness and consistency. The single tube is rarely used because of its sample recovery and disturbance problems.

Coring to obtain analytical samples requires only filtered air as the drilling fluid. The core barrel operates by rotating the outer barrel to allow the bit to penetrate the formation. The sample is retained in the inner liner, which in most samplers does not rotate with the outer barrel. As the outer barrel is advanced, the sample rises in the inner liner. In general, a secondary liner consisting of plastic or metal is present within the inner liner to ensure the integrity of acquired samples.

Obtain soil or rock core samples with a core barrel or a 5-foot split-spoon core barrel using the following procedure:

- Drill the core barrel to the appropriate sampling depth. It is important to use only clean, filtered air (i.e., particulate- and petroleum-free) as drilling fluid while coring to obtain samples for laboratory analysis. If necessary, distilled water may be added through the delivery system of the coring device by the driller, provided that the drilling returns cannot be brought to the surface by air alone.
- Retrieve the core barrel from the hole. Use care to ensure that the contents of the core barrel do not fall out of the bottom during withdrawal and handling.
- Open the core barrel by removing both the top and bottom fittings. Then remove the sample within the inner liner from the core barrel and take it to the sample handling area.

- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.

Collect core samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.

- If rock core samples are to be recovered for analytical laboratory or geotechnical analyses, the core barrel will either be lined with a sample container (e.g. stainless steel or acrylic liner), or the samples will be transferred to an appropriate sample container (e.g. stainless steel / acrylic liner, glass jar). Samples collected or placed in stainless steel or acrylic liners shall have the ends of the liners covered with Teflon film and sealed with plastic end caps. The sample containers shall be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and Procedure III-F, *Sample Handling, Storage, and Shipping*, and immediately placed on ice in a cooler.
- Place the samples in core boxes if samples are to be catalogued and stored. Affix the CTO number; site name; borehole number; start depth; end depth; date; and name of the geologist, hydrogeologist, or geotechnical engineer to the core box. Store the samples in a clean, dry area on site during the duration of field sampling; samples shall not be brought back to the office or equipment storage area. Document proper disposal at the completion of field sampling.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

5.3.4 Bulk Samples

The term "bulk sample" represents a sample collected from borehole cuttings either from the hollow-stem auger flights or the discharge of any of the rotary or cable tool drilling techniques. This type of sample is useful for describing soils or consolidated materials, where no undisturbed samples representative of a specific depth are being collected. It should be noted that this type of sample is generally considered to be the least acceptable of the types of samples previously described in this section and shall be used only when detailed lithologic data are not needed.

Handling and lithologic logging of bulk samples should be performed in a manner consistent with that used for split-spoon samples. An estimate of the depth (or range of depths) from which the sample was obtained, and date and time of collection should be recorded on the boring log. Samples are usually collected every 5 feet, preferably at several different times during a 5-foot drilling run so that lithologic variations occurring over the drilling interval can be noted. Rock fragments commonly range in size from 1/16 to 1/2 inch, with many fragments larger than 1/4 inch. Larger fragments can often be obtained with reverse circulation rotary drilling. Rotary-tool samples usually contain some caved materials from above and, when drilling with mud or water rotary, the cuttings may contain soil and rock recirculated by the mud/water pump; therefore, care must be exercised when interpreting lithologic logs completed using data from this type of sample.

Because the collection of samples at the surface lags behind the actual drilling of a given lithologic bed at depth, the samples usually represent a depth less than that of the current depth of the drill bit. The amount of lag may be significant in deeper boreholes, but can be eliminated by collecting samples after circulating for a period of time sufficient to permit the most recently drilled materials to reach the surface.

5.3.5 Borehole Abandonment

Following completion of soil sampling, the borehole shall be properly abandoned unless a monitoring well is to be installed. Abandonment shall occur immediately following acquisition of the final sample in the boring and shall consist of the placement of a bentonite-cement grout from the bottom of the boring to within 2 feet of ground surface. The grout mixture shall consist of a mix of 7 to 9 gallons of water per 94-pound bag of Portland Type I or II cement with 3 to 5 percent by weight of powdered bentonite. Other commercial products such as Volclay are also acceptable with approval of the CTO Manager and QA Manager or Technical Director. The bentonite-cement grout shall be placed in one continuous pour from the bottom of the boring to within at least 0.5 foot to 2 feet of ground surface through a tremie pipe or hollow-stem augers. Additional grout may need to be placed if significant settlement occurs. The remaining portion of the boring can be filled with topsoil.

5.3.6 Trenching and Pit Sampling

Trenching is used in situations where the depth of investigation generally does not exceed 10 to 15 feet and is most suitable for assessing surface and near-surface contamination and geologic characteristics. In addition, trenching allows detailed observation of shallow subsurface features and exposes a wider area of the subsurface than is exposed in borings. Pit sampling is typically conducted in conjunction with a removal or remedial action.

A backhoe is usually used to excavate shallow trenches to a depth of no greater than 15 feet. Front-end loaders or bulldozers are used when it is not possible to use a backhoe; for example, when materials lack cohesion or are too stiff, or the terrain is too steep for a backhoe. Larger excavations (i.e., pits) may require additional equipment as described in the CTO work plan (WP) or equivalent document.

Typically, trenches have widths of one to two backhoe buckets and range in length from 5 to 20 feet, although larger trenches can be dug depending on the objectives of the study. Pits will vary in size depending upon the scope of the removal/remedial action. Soils removed from the trench/pit shall be carefully placed on plastic sheeting or other appropriate materials in the order of removal from the trench or excavation. The shallow excavated materials can be placed on one side of the trench/excavation and deeper materials on the other side to allow better segregation of shallow and deep materials.

Soil sampling locations within each trench or pit shall be chosen on the basis of visual inspection and any VOC screening results. Samples shall be collected from either the sidewalls or the bottom of the trenches/excavations. Soil sampling should be conducted outside the trench/excavation, and personnel generally should not enter a trench or pit if there is any other means (e.g., backhoe buckets, hand augers, shovels, or equivalent) to perform the work. If entry is unavoidable, then a competent person shall first determine acceptable entry conditions including sloping, shoring, and air monitoring requirements, personal protective equipment (PPE), and inspections. In addition, the site-specific health and safety plan must be amended to include applicable requirements of 29 Code of Federal Regulations (CFR) 1910.146.

Equipment used for trench/pit sampling may include hand augers, core samplers (slide hammer), liners inserted manually into the soil, or hand trowels. In addition, samples may be obtained directly from the trench or from the backhoe bucket. All samples shall be properly sealed and labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. Sample locations and descriptions shall be described and recorded on the field trench/pit log.

Trench or pit samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.

The exposed materials shall be observed for lithologic and contaminant characteristics following completion of the excavation activities. Detailed mapping of the exposed walls of the trench shall be conducted, although in no instance shall personnel enter a trench without first determining acceptable entry conditions including sloping, shoring, and air monitoring requirements, PPE, and inspections as defined in 29 CFR 1910.146. A useful mapping technique for extremely long trenches or large pits is to examine the vertical profile of the excavation at horizontal intervals of 5 to 10 feet, in a manner similar to the method typically used for preparation of a geologic cross-section using soil borings. Field observations shall be noted in the field logbook and described in detail on a trench/pit log. An example of a field trench/pit log is presented in Figure I-B-1-2. The lithologic description shall include all soil classification information listed in Procedure I-E, *Soil and Rock Classification*. A cross-section of the trench or pit should also be included on the field trench/pit log. Photographs of the trench/pit are also an excellent way to document important subsurface features.

During backfilling of the excavation, the materials excavated from the greatest depth should be placed back into the excavation first. Lithologic materials should be replaced in 2- to 4-foot lifts and recompacted by tamping with the backhoe bucket. For certain land uses or site restoration, more appropriate compaction methods may be required. These methods shall be described in the CTO WP and design documents. The backfilled trench/pit shall be capped with the original surface soil. If materials are encountered that cannot be placed back in the excavation, they should be placed either in DOT-approved open-top drums or placed on and covered with visqueen or equivalent material and treated as IDW in accordance with Procedure I-A-6, *Investigation-Derived Waste Management.*

5.4 SURFACE SOIL SAMPLING

All surface soil samples shall be accurately located on field maps in accordance with Procedure I-I, *Land Surveying*. Detailed soil classification descriptions shall be completed in accordance with

Procedure I-E, *Soil and Rock Classification* and recorded on the surface and shallow soil sample log (Figure I-B-1-3).

In general, surface soil samples are not to be analyzed for VOCs unless there is sufficient evidence to suggest the presence of such compounds.

Methods commonly used for collection of surface soil samples are described below. Considerations when using IS methods are provided in Attachment I-B-1-1.

5.4.1 Hand Trowel

A stainless-steel or disposable hand trowel may be used for sampling surface soil in instances where samples are not to be analyzed for volatile organics. The hand trowel is initially used to remove the uppermost 2 inches of soil and is then used to acquire a representative sample of deeper materials to a depth of 6 inches. Generally, only samples within the upper 6 inches of soil should be sampled using these methods. The depth of the sample shall be recorded in the surface and shallow soil sample log (Figure I-B-1-3). The soil classification shall include all the information outlined in Procedure I-E, *Soil and Rock Classification*.

Soil samples collected using a hand trowel are usually placed into pre-cleaned, wide-mouth glass jars. The jar is then sealed with a tight-fitting cap, labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and placed on ice in a cooler in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping*. All sampling equipment must be decontaminated prior to each use according to the methods presented in Procedure I-F, *Equipment Decontamination.*

5.4.2 Hand Auger

A soil recovery hand auger consisting of a metal rod, handle, detachable stainless-steel core barrel, and inner sleeves can be used to obtain both surface soil and trench samples. Multiple extensions can be connected to the sampler to facilitate the collection of samples at depths up to 15 feet below the existing ground surface.

Pre-cleaned sample liners are loaded into the core barrel prior to sampling. In general, these liners are used not only to collect samples, but also to serve as the sample container. Alternatively, in instances where VOCs are not to be analyzed or where not enough samples can be collected to completely fill a liner, samples can be transferred to wide-mouth glass jars. In either case, the sample shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. To minimize possible cross-contamination, the soil recovery hand auger and sample liners shall be decontaminated prior to each use according to the procedures described in Procedure I-F, *Equipment Decontamination*.

5.4.3 Slide Hammer Sampling

In instances where the soil type precludes the collection of soil samples using the soil recovery hand auger, a manually operated slide hammer can be used to collect relatively undisturbed soil samples from excavations and surface soils. The slide hammer consists of a 6- to 12-inch core barrel that is connected to the slide hammer portion of the device using detachable extensions.

The core sampler is typically loaded with two to four sample liners, depending on the liner length, which are not only used to acquire the samples, but also serve as the sample container. Immediately following acquisition, samples shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*.

All of the sampling equipment that comes into contact with the sample medium shall be decontaminated in accordance with Procedure I-F, *Equipment Decontamination*. Split-barrel slide hammer core samplers, which have recently become available, are much easier to decontaminate than the older, single-piece core barrel, and should be used in place of the older core barrels where possible.

FIELD LOG OF TRENCH/PIT

Project Name							
Trench Number		Project Number	Elevation and Datum			Location	
Equipment Supplier		Operator	Date and Time Started			Date and Time Completed	
Equipment Type		Trench Orientation	Total Depth			Total Number of Samples	
Bucket Width	Trench Length	Trench Width	No. Of Samples	Bulk	Ss	Drive	Hand Auger
Geologist or Hydrogeologist/Date			Check by/Date				

SOIL DESCRIPTION

LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	Est. % of G	S	F	COMMENTS
							Description taken _______ feet
							from ______ end of trench.

Figure I-B-1-2: Field Log of Trench/Pit

SURFACE AND SHALLOW SOIL SAMPLE LOG

Project Number	Project Name	Date	Time
Sample Identification Number and Time		Checked by	
Sampled by		Recorded by	
Method of Collection			
Surface Description			
Notes			

Soil Sample Data

Location	
Coordinates	Elevation

LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	Est. % of G	Est. % of S	Est. % of F	COMMENTS

Figure I-B-1-3: Surface and Shallow Soil Sample Log

5.4.4 Hand Sampling Using Sample Liners

Surface soil samples can sometimes be collected by hand using just the sample liners. This method can be used in cases where the surface soils are soft or where it is advantageous to minimize the disturbance of the sample (such as when sampling for volatiles). Obtaining surface soil samples with this method consists merely of pushing or driving the sample tube into the ground by hand.

The sample liner (with the collected sample inside) is then removed from the ground and capped with Teflon film and plastic end caps. The sample is labeled according to Procedure III-E, *Record Keeping, Sampling Labeling, and Chain-Of-Custody* and immediately placed on ice in a cooler. All liners shall be decontaminated prior to use in accordance with Procedure I-F, *Equipment Decontamination*. Since the only pieces of equipment used are the sample liners, this method helps to minimize the required amount of equipment decontamination.

5.5 Volatile Organics Screening and Headspace Analysis

Volatile organics screening and headspace analysis is performed to preliminarily assess if the sample contains VOCs. Volatile organics screening and headspace analysis of samples shall be performed using a portable organic vapor analyzer (OVA), a portable photoionization detector (PID), or other similar instrument.

Volatile organics screening and headspace analysis is intended as a field screen for the presence of VOCs. The method measures the presence or absence of VOCs in the headspace (air) above a soil sample. Various factors affect the level of VOCs volatilizing from soils, such as concentration in the soil, temperature of the soil and air, organic carbon content of the soil, equilibration time, moisture content of the soil, and the chemical and physical characteristics of the VOCs. Therefore, headspace readings can only be regarded as qualitative assessments of volatiles, and caution should be exercised if using this technique to select samples for analytical testing. OVA and PID readings can vary because the two instruments have different sensitivities to the various VOCs and are usually calibrated relative to different gas standards (i.e., methane for the OVA and isobutylene for the PID).

In order to screen samples for VOCs, the instrument probe shall be inserted into the top of the sample liner immediately after the sampler is opened. The instrument response (normally in parts per million) is then recorded in the field notebook and/or the field log.

For headspace analysis, a portion of the sample is transferred into a zipper storage bag or pre-cleaned glass jar, which is then sealed and agitated. The VOCs are allowed to volatilize into the headspace and equilibrate for 15 to 30 minutes. Next, the instrument probe is then inserted into the container to sample the headspace, and the instrument response is recorded in the field notebook and/or the field log.

6. Records

Soil classification information collected during soil sampling should be documented in borehole, trench, and surface soil log forms. All log entries shall be made in indelible ink. Information concerning sampling activities shall be recorded on sample log forms or in the field logbook. The CTO Manager or designee shall review all field logs on at least a monthly basis. Procedures for these activities are contained in this manual. Copies of this information should be sent to the CTO Manager and to the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

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Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-E, *Soil and Rock Classification*.

Procedure I-F, *Equipment Decontamination.*

Procedure I-I, *Land Surveying.*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

Procedure III-F, *Sample Handling, Storage, and Shipping.*

9. Attachment

Attachment I-B-1-1: Sampling and Handling Procedure: Analysis of Soil for Volatile Organic Compounds

Attachment I-B-1-1
Sampling and Handling Procedure:
Analysis of Soil for Volatile Organic Compounds

1. Laboratory Requirements

The laboratory must be capable of performing (1) United States (U.S.) Environmental Protection Agency (EPA) Solid Waste (SW)-846 Method 5035 and (2) Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives (EPA 2007). The laboratory must have method performance data to verify this capability.

Sampling and handling procedures for the analysis of soil for volatile organic compounds (VOCs) will depend on the project objectives and the sampling approach. The laboratory is responsible for providing the necessary sample containers with preservatives (if applicable) that meet consumable certification requirements. The following section describes the consumable options for VOC soil sampling. In addition, sample containers must have a sample label and be weighed prior to shipment to the field for use. The laboratory is responsible for recording the weight of each container before and after sampling. Alternately, EnCore-type samplers may be employed.

The laboratory must provide a minimum of three prepared containers, or EnCore-type samplers, for each soil sample analyzed for VOCs.

2. Supplies

- Disposable coring devices (hereafter referred to as coring devices): either vendor-calibrated sample coring devices, or EnCore-type samplers. One coring device sampler per sampling location, plus additional coring devices (5 percent) in case of breakage.
- The number and type of laboratory prepared sample containers will depend upon the sampling scheme employed.
- For discrete soil VOCs, two 40 milliliter (mL) volatile organic analyte (VOA) vials with 5 mL of ASTM International (ASTM) Type II water, single-use magnetic stir bar with Teflon lined septa cap, one VOA vial with 5 mLs of methanol with a Teflon lined septa cap, and sample label, or three EnCore-type samplers.
- For incremental soil VOC samples, the total number of sample containers will depend upon the number of increments collected. The laboratory shall provide containers which contain a maximum of 30 mL of methanol (or as dictated by Federal Laws for transporting Exempted Limited Quantities of Dangerous Goods (49 CFR 100-185) with a Teflon lined septa cap, and sample label.
- Reagent/trip blanks: laboratory-prepared in identical fashion to sample vials.
- Temperature blanks: laboratory-prepared.
- 2-ounce glass jars with Teflon-lined lid: for dilution purposes and percent moisture determination.
- Nitrile or equivalent gloves.

3. Field Sampling

The following directions apply to all sampling techniques for soil coring devices: For reasons stated in section 3.4of this attachment and explained in detail in Sections 8.2.1.8 and A7.2 of EPA Method 5035, core-type (i.e., Terra Core, EnCore, etc.) samplers are recommended for sample collection, not sample collection and transport (EPA 2007).

- Always wear clean gloves while handling sample containers to help prevent soil and other debris from adding to the weight of the vial. Always don a new pair of gloves and use a new core sampler for each sampling location.
- Whenever possible, collect the soil samples for VOC analysis in place. If this is not possible, practical, or safe, collect the sample from a sample liner, or if absolutely necessary, from a backhoe bucket. Avoid having particles of soil adhering to the grooves of the screw cap or the container threads.
- Collect VOA samples as quickly as possible to avoid unnecessary VOC losses. EPA Region 9 recommends total exposure of the soil sample to ambient conditions should not exceed 10 seconds.
- Once the soil has been transferred to the sample container, screw the cap back on and mark the sample ID on the label with a ballpoint pen. Do not use a pen that has high solvent concentrations in the ink such as a Sharpie.
- Place the VOA vial inside a cooler containing either wet ice in sealed bags or gel ice.
- Collect the number of sample containers as describe in Section 2 of this standard operating procedure at each sampling location. The same core sampler may be used to prepare all containers. Duplicate samples require collecting additional sample containers. For percent moisture purposes, soil must also be collected in 2-ounce or greater glass jars with Teflon-lined lids at each sampling location. If other analyses are being conducted for the sampling location, then the percent moisture may be obtained from other sample containers. The 2-ounce jar will be completely filled with zero headspace. If other analyses are not being conducted at the sampling location, then an additional sample must be collected in another 2-ounce glass jar for percent moisture.
- When incrementally collecting samples from a liner for non-VOC analysis, a core sampler may be used to obtain equal incremental sample volumes. The liner will have been sliced open prior to incremental sample collection for access to the entire length of the sample.
- Depending on the 1) pre-selected volume to be collected per sample, 2) the sample/liner length available for incremental sampling, and 3) the size of the core tool, collect as many cores from the entire soil sample/liner section that will total to the required sample volume. For example, if 30 grams is the volume to be collected per sample location, the sample/liner length is 6 inches, and a 5 gram core tool is used, then 6 incremental samples, located throughout the sample length to provide adequate, representative coverage of the entire

6 inches of sample, would be collected (i.e., 6 incremental samples could be taken at equally spaced locations across the sample length, totaling 30 grams of sample).

- Collect one equipment blank per laboratory or vendor shipment of Terra Core, as described in Procedure III-B, *Field QC Samples (Water, Soil)*, unless the syringes are certified clean (e.g., certificate of analysis or equivalent documentation) by the vendor.
- Place samples in bubble wrap or other protective covering. Place custody seals on the covering. Custody seals or tape must not be placed directly on the sample vials, as this will interfere with the analytical instrumentation, final weight of the sample, and ultimate sample VOC concentration.

The following additional directions for VOC soil sample collection are taken from EPA SW-846 Method 5035A Appendix A7.0 (EPA 2002).

Collection of Samples for Analysis

After a fresh surface of the solid material is exposed to the atmosphere, the subsample collection process should be completed in the least amount of time to minimize the loss of VOCs due to volatilization. Removing a subsample from a material should be done with the least amount of disruption (disaggregation) as possible. Additionally, rough trimming of the sampling location's surface layers should be considered if the material may have already lost VOCs (been exposed for more than a couple of minutes) or if it might be contaminated by other waste, different soil strata, or vegetation. Removal of surface layers can be accomplished by scraping the surface using a clean spatula, scoop, knife, or shovel (ASTM 2005, Hewitt et al. 1999).

Subsampling of Cohesive Granular but Uncemented Materials Using Devices Designed to Obtain a Sample Appropriate Analysis

Collect subsamples of the appropriate size for analysis using a metal or rigid plastic coring tool. For example, coring tools for the purpose of transferring a subsample can be made from disposable plastic syringes by cutting off the tapered front end and removing the rubber cap from the plunger or can be purchased as either plastic or stainless-steel coring devices. These smaller coring devices help to maintain the sample structure during collection and transfer to the VOA vials, as do their larger counterparts used to retrieve subsurface materials. When inserting a clean coring tool into a fresh surface for sample collection, air should not be trapped behind the sample. If air is trapped, it could either pass through the sampled material causing VOCs to be lost or push the sample prematurely from the coring tool.

The commercially available EasyDraw Syringe, Powerstop Handle, and Terra Core sampler coring devices are designed to prevent headspace air above the sample contents. For greater ease in pushing into the solid matrix, sharpen the front edge of these tools. The optimum diameter of the coring tool depends on the following:

- Size of the opening on the collection vial or bottle (tool should fit inside mouth)
- Dimensions of the original sample, particle size of the solid materials (e.g., gravel-size particles would require larger samplers)
- Volume of sample required for analysis

For example, when a 5-gram (g) subsample of soil is specified, only a single 3-cubic-centimeter (cm^3) volume of soil has to be collected (assuming the soil has density of 1.7 g/cm^3). Larger subsample masses or more subsample increments are preferred as the heterogeneity of the material increases. After an undisturbed sample has been obtained by pushing the barrel of the coring tool into a freshly exposed surface and then removing the filled corer, quickly wipe the exterior of the barrel with a clean disposable towel.

The next step varies depending on whether the coring device is used for sample storage and transfer or solely for transfer. If the coring tool is used as a storage container, cap the open end after ensuring that the sealing surfaces are cleaned. If the device is to be solely used for collection and not for storage, immediately extrude the sample into a VOA vial or bottle by gently pushing the plunger while tilting the VOA vial at an angle (to avoid splashing any deionized water or methanol). The volume of material collected should not cause excessive stress on the coring tool during intrusion into the material, or be so large that the sample easily falls apart during extrusion. Obtain and transfer samples rapidly (<10 seconds) to reduce volatilization losses. If the vial or bottle contains ASTM reagent Type II water, hold it at an angle when extruding the sample into the container to minimize splashing. Just before capping, visually inspect the lip and threads of the sample vessel, and remove any foreign debris with a clean towel, allowing an airtight seal to form.

Devices that Can Be Used for Subsampling a Cemented Material

The material requiring sampling may be so hard that even metal coring tools cannot penetrate it. Subsamples of such materials can be collected by fragmenting a larger portion of the material using a clean chisel to generate aggregate(s) of a size that can be placed into a VOA vial or bottle. When transferring the aggregate(s), precautions must be taken to prevent compromising the sealing surfaces and threads of the container. Losses of VOCs by using this procedure are dependent on the location of the contaminant relative to the surface of the material being sampled. Therefore, take caution in the interpretation of the data obtained from materials that fit this description. As a last resort, when this task cannot be performed on site, a large sample can be collected in a vapor-tight container and transported to the laboratory for subsampling. Collect, fragment, and add the sample to a container as quickly as possible.

Devices that Can Be Used for Subsampling a Non-cohesive Granular Material

As a last resort, gravel, or a mixture of gravel and fines that cannot be easily obtained or transferred using coring tools, can be quickly sampled using a stainless-steel spatula or scoop. If the collection vial or bottle contains ASTM reagent Type II water, transfer samples with minimal splashing and without the spatula or scoop contacting the liquid contents. For some solids, a wide-bottom funnel or similar channeling device may be necessary to facilitate transfer to the container and prevent compromising the sealing surfaces of the container. Take caution when interpreting the data obtained from materials that fit this description. Loss of VOCs is likely due to the nature of the sampling method and the non-cohesive nature of the material, which exposes more surface area to the atmosphere than other types of samples. During the sampling process, non-cohesive materials also allow coarser materials to separate from fines, which can skew the concentration data if the different particle sizes, which have different surface areas, are not properly represented in the sample.

Use of the EnCore Sampler (or Equivalent) for Sample Transport and Storage

The EnCore sampler is a sampling device that can be used as both a simultaneous coring tool for cohesive soils and a transport device to a support laboratory (field or off site). The EnCore sampler is intended to be a combined sampler-storage device for soils until a receiving laboratory can initiate either immediate VOC analysis, or preserve extruded soil aliquots for later VOC analysis. It is meant to be disposed of after use. The commercially available device is constructed of an inert composite polymer. It uses a coring/storage chamber to collect either a 5-gram or 25-gram sample of cohesive soils. It has a press-on cap with hermetically a vapor-tight seal and locking arm mechanism. It also has a vapor-tight plunger for the non-disruptive extrusion of the sample into an appropriate container for VOC analysis of soil.

An individual disposable EnCore sampler (or equivalent) is needed for each soil aliquot collected for vapor partitioning or ASTM reagent Type II water sample preparation. Upon soil sample collection, store the EnCore sampler is at 4 ±2 degrees centigrade (°C) until laboratory receipt within 48 hours. Upon laboratory receipt, soil aliquots are extruded to appropriate tared and prepared VOA vials.

Validation data have been provided to support use of the EnCore sampler for VOC concentrations in soil between 5 and 10 parts per million, for two sandy soils, with a 2-day holding time at 4 ±2°C. Preliminary data (Soroni et al. 2001) demonstrate an effective 2-day (48-hour) holding time at 4 ±2°C for three sandy soil types with VOC concentrations at 100 parts per billion (ppb) (benzene and toluene at 300 ppb), as well as an effective 1- or 2-week holding time at <-7°C (freezing temperature). Recent published work (EPA 2001) neither definitively supports nor shows the EnCore device to be ineffective for sample storage at these preservation temperatures. Soils stored in the EnCore device for 2 calendar days at 4 ± 2°C are subject to loss of benzene, toluene, ethylbenzene, and xylene (BTEX) compounds by biodegradation if the soil is an aerated, biologically active soil (e.g., garden soil) (Soroni et al. 1999), but this BTEX loss is eliminated for up to 48 hours under freezing conditions (Hewitt 1999).

Further details on the EnCore sampler can be found in ASTM D4547-09 (ASTM 2009) or other publications.

Since Naval Facilities Engineering Command, Pacific action levels for VOCs in soil are typically associated with EPA Region 9 preliminary remediation goals for residential exposure scenarios, it is recommended that if EnCore samplers are used, they be frozen on site prior to shipment to the laboratory or extruded into a 40-mL VOA vial before shipment.

4. Sample Shipping and Holding Times

Samples preserved with water may be shipped either at 4 ±2°C or frozen at –7°C. The primary difference between the two shipping temperatures is the allowable holding time of the sample between sample collection and sample analysis. Samples shipped at 4 ±2°C must either be received and analyzed by the laboratory within 48 hours of sample collection or be received by the laboratory within 48 hours, frozen upon receipt, and analyzed within 14 days of sample collection. Samples shipped at –7°C and received/maintained by the laboratory in a frozen state must be analyzed within 14 days of sample collection.

If soil samples are to be field frozen, place the frozen samples in a cooler containing fresh, frozen gel packs or an ice and rock salt mixture, and ship the cooler using an overnight carrier. Dry ice may be used as a refrigerant for sample shipment, but must be coordinated with the overnight carrier in advance. The sample vials and caps must never be placed in direct contact with the dry ice since cracking may occur.

Soil or sediment samples contained in methanol and 2-ounce glass jars may be shipped in standard coolers using conventional shipping protocols described in Procedure III-F, *Sample Handling, Storage, and Shipping*, if the sample appears to have a moisture content that might cause the sample to expand and the glass jar to break due to freezing. If soil samples contained in 2-ounce glass jars are shipped in this manner, then trip blanks must accompany them during shipment.

Reagent/trip blanks that contain the same volume of ASTM Type II water and sample label used in the sample VOA vials must be included in each shipment. The reagent/trip blanks will be packaged, shipped, and analyzed in the same manner as field samples. Reagent/trip blanks will be analyzed to evaluate cross-contamination during shipment and to identify potential reagent contamination issues.

5. Laboratory Receipt

Upon receipt by the analytical laboratory, the sample temperature must be measured and recorded. The laboratory should note whether the samples are frozen. The samples must be logged in and assigned an analysis date to ensure that samples are analyzed within the 14-day holding time.

Once the samples have been logged in, they are placed in a freezer at 0°C or colder until they are analyzed. Samples arriving in a non-frozen state (greater than 0°C) are to be frozen upon receipt or analyzed within 48 hours of sample collection. If the duration of sample shipment exceeds 48 hours, the non-frozen samples should be analyzed on the day of laboratory receipt.

The laboratory will prepare the samples for analysis as dictated by laboratory standard operating procedures and SW-846 Method 5035, and analyzed by Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives.

6. References

49 Code of Federal Regulations (CFR) 100-185. *Hazardous Materials and Oil Transportation*.

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Hewitt, Alan. D. and K. F. Myers. 1999. *Sampling and On-Site Analytical Methods for Volatiles in Soil and Groundwater—Field Guidance Manual*; Special Report 99-16. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. November.

Soroni, S. S. and J. F. Schaborn. 1999. *Performance of the Disposable EnCore Sampler for Storing Soil for Volatile Organic Analysis*. Proceedings of the 15th Annual Waste Testing and QA Symposium, EPA. Washington. pp. 129-134.

Soroni, S. S., J. F. Schaborn and J. F. Rovani. 2001. *Validation of a New Soil VOC Sampler: Performance of the En Core Sampler for Storage of Low VOC Concentrations and EPA Method 1311 Volatile Organic Analytes*. Topical Report WRI-01-R005; Laramie, WY: Western Research Institute.

Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-F, *Sample Handling, Storage, and Shipping.*

Surface Water Sampling

1. Purpose

The purpose of this standard operating procedure is to establish standard protocols for use in sampling surface water by all United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most current version of the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e. Remedial Project Manager or QA manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that all project field personnel follow these procedures when sampling surface water. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

Surface water bodies that could be affected by a release from an investigation site may be selected for sampling. This procedure describes sample collection methods for a surface water sampling program.

5.1 SELECTION OF SAMPLING TECHNIQUES

Proper selection of sampling points and collection methodology are essential to meeting the objectives of a surface water sampling program. The data quality objectives and the conceptual site model should be used to determine all sampling methods and parameters. Sampling points should be selected for collection of surface water samples on the basis of characteristics of the surface water body to be monitored, the location of the body of surface water, and its hydrologic boundaries with respect to the site. Other considerations include the contaminants of concern, logistical considerations, such as access to the surface water body, the direction of flow, and determination of a background location.

Methods of collecting surface water samples vary from hand sampling procedures at a single point to sophisticated, multipoint sampling techniques. The number and type of samples to be collected depends on the characteristics of the body of water, the amount of suspended sediment that a moving body carries, the size of the discharge area at the site, and other factors. Multipoint sampling techniques apply to larger bodies of water; the samples are composited to provide a more representative sample.

Whenever possible, the sampling device, either disposable or constructed of a nonreactive material, should hold at least 500 milliliters to minimize the number of times the liquid must be disturbed, thus reducing agitation of any sediment layers. A 1-liter polypropylene or stainless steel beaker with a pour spout and handle works well. Any sampling device might contribute contaminants to a sample. The correct sampling device will not compromise the integrity of the sample and will give the desired analytical results.

5.1.1 Shallow Water Body Surface Water Sample Collection

A dip or grab sample is appropriate for a small body of water, or for collecting near-surface samples in a larger surface water body. The sampling method involves filling a sample container by submerging it either just below the surface, or by lowering the container to a desired depth by using a weighted holder. For shallow bodies of surface water, hold the sample container carefully just beneath the water surface to avoid disturbing the streambed and stirring the sediment. Position the container’s mouth so that it faces upstream, while the sampling personnel are standing downstream. Any preservative added to the sample should be added after sample collection to avoid loss of preservative. Alternatively, a transfer device may be dipped into the water, and then the contents transferred to the appropriate container containing the preservative. For near-surface sample collection in a large surface water body, a pond sampler may be used if an extended reach is required to collect a representative sample. A pond sampler consists of a single use sample container attached to a telescoping, heavy-duty, aluminum pole via an adjustable clamp attached to the end. The collection technique for shallow surface water samples can be used for near-surface samples in a large surface water body.

5.1.2 Deep Surface Water Sample Collection

For deeper surface water bodies, either sample containers or transfer devices may be used to collect a sample. A weighted holder that allows either a sample transfer device or a sample container to be lowered, opened for filling, closed, and returned to the surface is suggested for sampling deeper surface water bodies. This is because concentrations of constituents near the surface of a deeper body of surface water might differ from the total concentration distributed throughout the water column cross section and thus a surface sample would not be representative of the water body. An open container that is lowered and raised to the surface at a uniform rate so that the bottle is just filled on reaching the surface is appropriate for deeper stagnant water bodies, however this method does not collect a truly representative sample in deeper flowing surface water bodies.

Kemmerer Samplers. Collect samples near the shore unless sampling from a boat is feasible and permitted. If a boat is used, the body of water should be cross-sectioned, and samples should be collected at various depths across the water in accordance with the specified work plan. For this type of sampling, use a weighted-bottle sampler to collect samples at any predetermined depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. The sampler can be either fabricated or purchased. The general procedure for using the sampler is as follows:

1. Assemble the weighted bottle sampler.
2. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely.
3. Pull out the stopper with a sharp jerk of the sampler line.
4. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
5. Raise the sampler and cap the bottle.
6. Wipe the bottle clean. The bottle can also be used as the sample container.

Teflon Bailers: Teflon bailers have also been used to collect samples in deep bodies of water. When the use of Teflon bailers is deemed appropriate for sampling water from a specific depth, the bailers shall be equipped with a check valve that closes during sample retrieval.

Peristaltic Pump: Another method of extending the reach of sampling efforts is to use a small peristaltic pump. In this method, the sample is drawn through heavy-wall Teflon tubing and pumped directly into the sample container. This system allows the operator to reach into the liquid body, sample from depth, or sweep the width of narrow streams. However, use of the peristaltic pump is restricted to a maximum depth of 20 to 24 feet due to the physical constraints associated with vacuum pumps.

If medical-grade silicon tubing is used in the peristaltic pump, the system is suitable for sampling almost any analyte, including most organics. Some volatile stripping may occur; due to the relatively high flow rate of the pump. Therefore, avoid pumping methods for sampling volatile organics. Battery-operated peristaltic pumps are available and can be easily carried by hand or with a shoulder sling, as needed. It is necessary in most situations to change both the Teflon suction line and the silicon pump tubing between sampling locations to avoid cross contamination. This action requires maintaining a sufficiently large stock of material to avoid having to clean the tubing in the field.

Peristaltic pumps work especially well for sampling large bodies of water when a near-surface sample will not sufficiently characterize the body as a whole. It is capable of lifting water from depths in excess (but not much in excess) of 21 feet. This lift ability decreases somewhat with higher-density fluids and with increased wear on the silicone pump tubing. Similarly, increases in altitude will decrease the pump’s ability to lift from depth. When sampling a liquid stream that exhibits a considerable flow rate, it may be necessary to weight the bottom of the suction line.

Use the following procedures for collecting samples using peristaltic pumps:

1. Install clean, medical-grade silicone tubing in the pump head, per the manufacturer's instructions. Allow sufficient tubing on the discharge side to facilitate convenient dispensation of liquid into sample bottles but only enough on the suction end for attachment to the intake line. This practice will minimize sample contact with the silicone pump tubing. (Some types of thinner Teflon tubing may be used.)
2. Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the tubing on the intake side of the pump. If necessary, a small weight composed of relatively inert material, which will not react with anticipated chemicals, may be used to weight the intake tubing. Heavy-wall Teflon of a diameter equal to the required pump tubing will suit most applications. (A heavier wall will allow for a slightly greater lateral reach.)
3. If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume, and then return it to the source (i.e., surface water) after the sample aliquot has been collected.
4. Fill necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as it is filled.
5. Preserve the sample, if necessary, following guidelines in the work plan. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
6. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly. Tape the cap to the bottle, and then date and initial the tape. The tape will serve as a custody seal.
7. Label the sample bottle with an appropriate tag using a solvent-free marker. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Record the information in the field logbook, and complete the chain-of-custody documents.
8. Place the properly labeled sample bottle in an appropriate carrying container.
9. Allow the system to drain thoroughly, and then disassemble and decontaminate it.

5.2 TRANSFER DEVICES

Samples from various locations and depths can be composited if project quality objectives indicate that it is appropriate; otherwise, collect separate samples. Identify approximate sampling points on a sketch of the water body. Use the following procedures for collecting samples using transfer devices:

1. Submerge a stainless steel dipper or other suitable device, causing minimal disturbance to the surface of the water. Note the approximate depth and location of the sample source (e.g., 1 foot up from bottom or just below the surface).
2. Allow the device to fill slowly and continuously.
3. Retrieve the dipper or device from the surface water with minimal disturbance.
4. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper or device edge.
5. Empty the dipper or device slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.

6. Continue delivery of the sample until the bottle is almost filled. Check all procedures for recommended headspace for expansion.
7. If necessary, preserve the sample according to guidelines in the work plan. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
8. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly. Tape the cap to the bottle using solvent-free tape, and then date and initial the tape. The tape will serve as a custody seal.
9. Label the sample bottle with an appropriate sample tag using a solvent-free marker. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Record the information in the field logbook, and complete the chain-of-custody form.
7. Dismantle the sampler, wipe the parts with terry towels or rags, and store them in plastic bags for subsequent disposal. Follow all instructions for proper decontamination of equipment and personnel.

Use the following procedures for collecting samples using peristaltic pumps:

1. Install clean, medical-grade silicone tubing in the pump head, per the manufacturer’s instructions. Allow sufficient tubing on the discharge side to facilitate convenient dispensation of liquid into sample bottles but only enough on the suction end for attachment to the intake line. This practice will minimize sample contact with the silicone pump tubing. (Some types of thinner Teflon tubing may be used.)
2. Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the tubing on the intake side of the pump. If necessary, a small weight composed of relatively inert material, which will not react with anticipated chemicals, may be used to weight the intake tubing. Heavy-wall Teflon of a diameter equal to the required pump tubing will suit most applications. (A heavier wall will allow for a slightly greater lateral reach.)
3. If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume, and then return it to the source (i.e., surface water) after the sample aliquot has been collected.
4. Fill necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as it is filled.
5. Preserve the sample, if necessary, following guidelines in the work plan. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
6. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly. Tape the cap to the bottle, and then date and initial the tape. The tape will serve as a custody seal.
7. Label the sample bottle with an appropriate tag using a solvent-free marker. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Record the information in the field logbook, and complete the chain-of-custody documents.
8. Place the properly labeled sample bottle in an appropriate carrying container.
9. Allow the system to drain thoroughly, and then disassemble and decontaminate it.

Multipoint sampling techniques that represent both dissolved and suspended constituents and both vertical and horizontal distributions are applicable to larger bodies of water. Subsequent to sample collection, multipoint sampling techniques may require a compositing and sub-sampling process to homogenize all the individual samples into the number of subsamples required to perform the analyses of interest. Homogenizing samples is discouraged for samples collected for volatile organic analysis, because aeration causes a loss of volatile compounds. If collection of composite samples is required, then include the procedure for compositing in the project-specific work plan.

The sampling devices selected must not compromise sample integrity. Collect samples with either disposable devices, or devices constructed of a nonreactive material, such as glass, stainless steel, or Teflon. The device must have adequate capacity to minimize the number of times the liquid must be disturbed, reducing agitation of any sediment layers. Further, the device must be able to transfer the water sample into the sample container without loss of volatile compounds. A single- or double-check valve or stainless steel bailer made of Teflon equipped with a bottom discharging device may be used.

All equipment used for sample collection must be decontaminated before and after use in accordance with Procedure I-F, *Equipment Decontamination*.

5.3 TYPICAL FIELD SAMPLING SUPPLIES AND EQUIPMENT/APPARATUS

Sampling supplies

- Work Plan
- Maps/Plot plan
- Tape measure
- Survey stakes, flags, or buoys
- Camera
- Stainless steel, plastic, or other appropriate composition (e.g., Teflon) bucket
- Laboratory supplied sampling containers
- Ziploc plastic bags for samples, and sample jars
- Logbook
- Labels
- Chain of Custody forms
- Site description forms
- Cooler(s)
- Ice

Equipment/Apparatus

- Decontamination supplies/equipment
- Spade or shovel

- Spatula
- Scoop
- Trowel
- Task-specific surface water sampling equipment

6. Records

During the completion of sampling activities, fill out the sample logbook and transmit forms to the CTO Manager for storage in project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Procedure I-F, *Equipment Decontamination.*

9. Attachments

None.

Monitoring Well Installation and Abandonment

1. Purpose

This standard operating procedure describes the methods to be used by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel during the installation of groundwater monitoring wells. It describes the components of monitoring well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Filter Pack

Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.2 Annulus

The annulus is the downhole space between the borehole wall and the well casing and screen.

3.3 Bridge

An obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.4 Grout

Grout is a fluid mixture of cement and water that can be forced through a pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 Sieve Analysis

Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4. Responsibilities

CTO Managers are responsible for issuing WPs that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and, possibly, state regulatory agencies enforce regulations that may include well construction and installation requirements. The CTO Manager shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The CTO Manager or designee shall review all well construction logs on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well installation and abandonment have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications are implemented in the field. The qualifications for the FM include a degree in geology, hydrogeology, civil/geotechnical/environmental engineering, or equivalent with at least 2 years of field experience in the installation of monitoring wells.

Field sampling personnel are responsible for the implementation of this procedure.

The onsite geologist/hydrogeologist/engineer is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within Procedure I-B-1, *Soil Sampling.*

5. Procedures

5.1 Considerations For Munitions and Explosives of Concern

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission

(ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 BACKGROUND INFORMATION

The primary objectives of installing a monitoring well at a site are: to observe groundwater levels and flow conditions; to obtain samples for determining groundwater quality; and to evaluate the hydraulic properties of water-bearing strata. To achieve these objectives, it is necessary to satisfy the following criteria:

- Construct the well with minimum disturbance to the formation.
- Construct the well with materials that are compatible with the anticipated geochemical environment.
- Properly complete the well in the desired zone.
- Adequately seal the well with materials that will not interfere with the collection of representative water samples.
- Sufficiently develop the well to remove drilling fluids or other additives or conditions associated with drilling, and provide unobstructed flow to the well.

The proper design and construction of monitoring wells requires an understanding of site geology and hydrogeology, and knowledge of contaminant transport in subsurface materials.

A significant difference between monitoring wells and production or “water” wells is that the intake section of monitoring wells is often purposely completed in a zone of poor water quality and/or poor yield. The quality of water entering a monitoring well can vary from drinking water to a hazardous waste or leachate. In contrast, production wells are normally designed to efficiently obtain water from highly productive zones containing good quality water. The screen of a monitoring well often extends only a short length (typically 10 feet or less) to monitor hydraulic conditions within, and obtain water samples from, selected water-bearing intervals. In contrast, water wells are often designed to obtain economic quantities of water from multiple zones of water-bearing strata.

5.3 MONITORING WELL DESIGN CONSIDERATIONS

The following information was compiled from a number of technical references. For additional information related to monitoring well installation, consult the references listed in Section 8.

5.3.1 Well Placement

Select the location of a monitoring well according to the purpose of the monitoring program, which will vary among different sites and may include detection of contaminants in groundwater, verification of contaminant migration predictions, the monitoring of leachate at a landfill site, or remediation of a contaminated site. Each of these purposes will require a specialized array of monitoring locations and completion intervals, and a specific sampling program. Therefore, design the monitoring well network to satisfy the needs of the particular situation.

Determine the position of a monitoring well in a contaminant flow path for a monitoring effort based on the interpretation of preliminary data. These data shall be sufficient to facilitate identification of potential contaminant sources. Also consider site history, topography, climate, surface hydrology, and the location of nearby pumping wells.

Design the layout of the groundwater monitoring network following preliminary evaluation of the approximate direction of groundwater flow. A minimum of three wells is necessary to estimate local hydraulic gradients. Ideally, at least one well will be located hydraulically upgradient, and two or more wells strategically located hydraulically downgradient of each potential contaminant source. Determination of the horizontal and vertical extent of a contaminant plume is often an iterative process requiring the installation and sampling of wells in several phases.

Install monitoring wells hydraulically downgradient and as close as physically possible to the areas of suspected contamination in order to immediately detect releases from a hazardous waste site. Locate additional monitoring wells based on the interception of potential groundwater flow paths and direction of contaminant migration.

The placement of groundwater monitoring wells shall also consider the three-dimensional nature of groundwater flow. Significant vertical gradients and heterogeneous and/or anisotropic hydraulic conditions may exist at a site. Thus, the direction of groundwater flow may not necessarily coincide with the apparent horizontal gradient observed by the triangulation provided by three monitoring wells. Determine the completion intervals of existing wells prior to the calculation of groundwater gradient directions. Consider temporal/seasonal groundwater flow conditions if the monitoring well network is located near existing active well fields, near tidal zones, or near ephemeral surface water (e.g., canals, dry river beds).

5.3.2 Well Depth and Screened Interval

A detailed understanding of the site stratigraphy, including both horizontal and vertical extent of geologic formations, is necessary to identify zones of different permeabilities, and discontinuities, such as bedding planes, fractures, or solution channels. Groundwater flow and/or contaminant transport beneath the site preferentially occur in the more permeable zones. Equally important is the identification of relatively low permeability zones that may impede migration of contaminants. The occurrence and movement of groundwater in the subsurface is closely related to lithology. Thus, geologic conditions will influence the location, design, and methods used to locate and install monitoring wells.

The depth of a monitoring well is determined by the depth of one or more water-bearing zones that are to be monitored. For example, if preliminary soil borings indicate that multiple water-bearing zones are present at a site, and it is believed that zones other than the uppermost zone may be impacted by surface contamination, a well should be completed in each individual water-bearing zone encountered. Where two or more saturated zones occur beneath a site, and the intent of the monitoring program is to monitor water quality in the lower zone, the monitoring well will generally require surface casing to isolate the upper water-bearing zone from the deeper zone prior to drilling into the deeper zone.

In multiple aquifer systems, highly variable conditions may occur. For example, an overlying unconfined aquifer may be contaminated, whereas the underlying confined aquifer may not contain contaminants. Exercise extreme care to ensure that the installation/completion of monitoring wells does not cause cross-contamination of the aquifers. In these cases, it may be preferable to install surface casing through the contaminated aquifer to minimize the possibility of cross-contamination to the lower aquifer system.

Characteristics of lithologic materials encountered at the site, such as the degree of consolidation and grain size, also influence the type of well completion. In unconsolidated alluvial deposits, screened well intakes are typically used. An emplaced filter pack, consisting of well-sorted, clean, inert silica sand with a grain size and well screen slot size appropriate for the formation, typically is used to filter out fine-grained materials present within formations encountered in the borehole. Where permeable, consolidated formations are present, casing may be extended through overlying unconsolidated deposits and the well may be completed with a section of open borehole in the consolidated water-bearing zone. Even in these cases, however, fine-grained materials may enter the well through fractures, and if severe enough, an artificial filter pack and screened intake may be required. Also, many regulatory agencies require a screened interval installed with filter pack for all well completions.

Placement of the screened interval depends primarily on two factors: the interval to be monitored and the type of contaminants. The desired interval to be monitored shall dictate the interval to be screened. Determine which stratigraphic horizons represent potential pathways for contaminant migration by the site characterization. Short screened sections provide more specific data on the vertical distribution of contaminants and hydraulic head, while long screen intervals can result in a cumulative dilution of contamination in one zone with uncontaminated groundwater in another zone, as well as less specific information on hydraulic head. In addition, a long screened interval could potentially create vertical conduits that might result in cross-contamination.

Consider the type of contaminants involved prior to well installation. Contaminants that have a density less than water migrate differently than contaminants with a density equal to or greater than water. For example, if the contaminant in an unconfined aquifer has a density lower than water, such as diesel or gasoline, it is important to ensure that the screened interval of the well extends above the maximum seasonal elevation of the water table. Doing so facilitates an accurate determination of apparent thickness of free product in a monitoring well. In general, the screen shall extend 3 to 5 feet above the highest anticipated level of the water table when monitoring the upper portions of an unconfined aquifer.

Conversely, if the contaminant of concern has a density higher than water, such as trichloroethene (TCE), the screened interval of one or more monitoring wells should be installed just above the lower confining bed of a potentially impacted aquifer. TCE may be transported at high concentrations as a dense, nonaqueous phase liquid (DNAPL) near the source area, and migrate along the top of a confining bed at the base of an impacted aquifer.

Give special attention to interpretation of site stratigraphy when assessing DNAPL, particularly with respect to dipping beds, as it is possible for DNAPLs to effectively move hydraulically upgradient if low permeability perching horizons dip in a direction opposite the hydraulic gradient. This type of situation is important to consider when selecting monitoring well locations.

If time and budget allow, correlate conventional borehole geophysical methods and continuous cores of soil samples to yield a more complete stratigraphic characterization. A continuous profile of borehole conditions is compared to field observations and is used to select screened intervals.

5.3.3 Well Permitting

All wells shall be permitted in accordance with the regulations of the jurisdiction where well installation is occurring, if this is Navy policy for the region of activity. Contact local authorities prior to establishing well construction requirements for the project.

The permit procedure may require permit fees, site inspections, and an application signed by a registered professional geologist or engineer. Permit requirements may impact field schedules and budgets. The driller may also be required by law to be licensed and bonded. Provide documentation that all legal requirements have been met to the appropriate agencies prior to the installation of a monitoring well.

5.4 SELECTION OF DRILLING METHOD

Monitoring well installation at hazardous waste sites may involve drilling through or near hazardous materials, in areas where the extent of contamination is unknown, or through more than one geologic material or aquifer. Use of any drilling method at a hazardous waste site involves an element of risk related to the potential spread of contamination or creation of a pathway through which contaminants can migrate. Selection of a method most appropriate for site-specific conditions is essential to minimize these risks. Table I-C-1-1 provides an interpretation of how geologic conditions may influence the selection of a particular drilling method.

Most drill rigs use gasoline or diesel fuel, as well as hydraulic fluid during operation. Because these fluids are all potential contaminants, it is important to protect the drill hole and immediate area from these substances. Whenever leaking fluid from the drill rig is detected, drilling operations shall cease as soon as practical following stabilization of the drill stem, and the rig shall be moved to a safe area to be repaired.

Table I-C-1-1: Relative Performance of Different Drilling Methods in Various Types of Geologic Formations; Commonly Utilized Drilling Methods

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Loose sand and gravel	G	P	P-G	NR	E	NR	E	NR	P-E	E	E
Loose boulders in alluvium	P	P-G	G	NR	E	NR	P	NR	P	G	NR
Clay, silt	E	G	E	NR	E	NR	E	P-G	E	E	G
Shale	P	NR	E	P	E	NR	NR	E	E	E	NR
Sandstone	P	NR	G	E	NR	NR	NR	E	G	E	P
Limestone with chert	NR	NR	G	E	NR	E	NR	E	G	G	NR
Limestone with and without fractures	NR	NR	G-E	E	NR	E	NR	E	P-E	E	P
Limestone, cavernous	NR	NR	P-G	P-G	NR	E	NR	E	NR	E	NR

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Dolomite	NR	NR	E	E	NR	E	NR	E	E	E	NR
Basalts-thin layers in sedimentary rocks	P	NR	G	E	NR	NR	NR	E	G	E	P
Tuff	P	NR	G	E	NR	E	NR	E	G	G	NR
Basalts-thick layers	NR	NR	P	G	NR	E	NR	E	G	G	NR
Basalts-highly fractured	NR	NR	NR	P	NR	G	NR	E	NR	G	NR
Metamorphic rocks	NR	NR	NR-P	G	NR	E	NR	E	G	G	NR
Granite	NR	NR	NR-P	E	NR	E	NR	E	G	G	NR

E Excellent
G Good
NR Not Recommended
P Poor
* Cannot be used for analytical soil sampling
** Procedure I-H, *Direct-Push Sampling Techniques* discusses protocol associated with direct push applications.

The following sections discuss commonly used drilling methods and their applicability to installation of monitoring wells. Regardless of the drilling method selected, decontaminate all drilling equipment using Procedure I-F, *Equipment Decontamination*. Follow these procedures before use and between borehole locations to prevent cross-contamination. In addition to selecting the proper drilling technique, take other precautions to prevent distribution of any existing contaminants throughout the borehole.

5.4.1 Hollow-stem Continuous-flight Auger

Hollow-stem continuous-flight auger (HSA) is the most frequently employed method used in the environmental industry for the drilling and installation of shallow monitoring wells in unconsolidated materials. Drilling with HSA is possible in loose sand and gravel, loose boulders in alluvium, clay, silt, shale, and sandstone. HSA drilling is usually limited to unconsolidated materials and depths of approximately 150 to 200 feet. HSA drill rigs are mobile, relatively inexpensive to operate, generally cause minimal disturbance to the subsurface materials, and have the additional advantage of not introducing drilling fluids (e.g., air, mud, or foam) to the formation.

Another advantage of the HSA method is that undisturbed samples are obtained by driving a split-spoon sampler below the lead auger. Soil samples can usually be easily collected in this manner with a minimum of tripping sampling tools into and out of the hole.

Moreover, in the HSA drilling method, the well is constructed inside the HSAs as the augers are gradually removed from the ground. This method decreases the possibility of the borehole collapsing before the well is installed. HSAs shall have a nominal outside auger-flight diameter of 10 to 12 inches and a minimum inside diameter of 8 inches. Larger inside diameter auger flights are sometimes available. Well casing diameter is usually limited to 4 inches or less when using the HSA method. The difference between the inner diameter (I.D.) of the auger and the outer diameter (O.D.) of the well casing shall be at least 4 inches (i.e., a minimum 2-inch annular space) to permit effective placement of filter pack, bentonite seal, and grout without bridging.

5.4.2 Rotary Bucket Auger

Rotary bucket auger drilling, or bucket auger drilling (BAD), utilizes a large-diameter bucket auger to excavate earth materials. Excavated material is collected in a cylindrical bucket that has auger-type cutting blades on the bottom of the bucket. The bucket is attached to the lower end of a kelly bar that passes through, and is rotated by, a large ring gear that serves as a rotary table.

The kelly bar is square in cross-section and consists of two or more lengths of square steel tubing, with each successive length of tubing telescoped inside the previous length. This design permits boring to a depth several times the collapsed length of the kelly bar before having to add a length of drill rod between the kelly and the bucket. In drilling with the telescoping kelly, the bucket is typically lifted and dumped without disconnecting, thereby speeding up the process when drilling deep holes. Depths of 75 to 100 feet are achievable with most telescoping kellys. It is possible to construct wells more than 250 feet deep by this method, although depths of 50 to 150 feet are more typical.

The BAD technique is most effective in semi-consolidated or clayey formations that stand open without caving. Drilling through unconsolidated materials within the saturated zone is difficult, but not impossible if the hole is kept full of water or mud (see direct rotary methods with foam or mud). Drilling mud may be necessary, particularly in loose formations consisting of unconsolidated fine- to medium-grained sands and silts. In the right conditions, a bucket auger bit will remove a cylinder of material 12 to 24 inches deep with each run. Therefore, samples obtained by the BAD method are representative of the formation being drilled, unless sloughing or caving of the borehole walls occurs.

Boreholes drilled with the BAD technique generally range from 18 to 48 inches in diameter. Because of the large diameter of the borehole drilled with this technique, and the common need to add either water or mud to maintain the borehole in unconsolidated, near-surface deposits, it is recommended to use this method only for the installation of surface casing through the first water-bearing unit at a hazardous waste site.

5.4.3 Direct Rotary with Foam or Mud

Direct rotary drilling (DRD) techniques involve the use of various types of drilling fluids, which typically include air, foam, and mud. In each of the DRD methods, drilling fluids are circulated down through the inside of the drilling pipe into the borehole, and then up through the annulus between the drilling pipe and the borehole wall to carry drill cuttings up to the surface. The drilling fluids may also be used for stabilizing the borehole wall, which may be especially useful in unconsolidated, caving formations. In this section, the DRD method and its use with either foam or mud are discussed.

A variety of bit types may be used with each of these drilling fluids, depending on the type of formational material encountered; however, typically, the tri-cone or roller bit is used. The drilling bit is attached directly to a heavy section of drill pipe called a drill collar, which is attached to help keep the borehole straight. The drill collar is in turn attached to the drill pipe and the kelly.

General types of drilling fluids available for use with the DRD method include water with clay additives, water with polymeric additives, water with clay and polymeric additives, and foams (comprised of air or water, surfactants, and occasionally clays or polymers). The drilling fluid density may be adjusted during drilling to improve or resume circulation within the borehole, or to attempt to stabilize the borehole wall. A major problem with the addition of these fluids is that it is almost impossible to estimate the amount introduced into the formation through the saturated and unsaturated zones. Additionally, it is also very difficult to estimate the magnitude and duration of the impact to groundwater quality by the use of these fluids.

The drilling fluids and associated cuttings shall not be allowed to flow over the site unrestricted. A downhole circulation system, or fluid diversion system shall be used to keep the fluids and cuttings contained in a reasonable manner, yet still allow the collection of grab samples for lithologic identification.

While in some geologic situations DRD may be the most efficient method of drilling a borehole, potential problems associated with the drilling fluids usually make DRD a last-resort drilling technique for environmental purposes; one that should be avoided whenever possible.

Potential Problems of DRD with Foam or Mud

- The chemistry of the drilling fluid could adversely affect the chemistry of groundwater samples, soil samples, or the efficiency of the well (when using mud).
- Bentonite mud reduces the effective porosity of the formation around the well, thereby compromising the estimates of well recovery. Bentonite may also affect groundwater pH. Additives to adjust viscosity and density may introduce contaminants to the system or force irrecoverable quantities of mud into the formation.
- Some organic polymers and compounds provide an environment for bacterial growth, which in turn, reduces the reliability of sampling results.
- Uncontained drilling foam and/or mud may create unsafe working conditions at the surface around the rig.

Solutions

- DRD should only be utilized as a last resort.
- The hydrogeologist should ensure that the fluids used will not affect the chemistry of the soil samples and groundwater samples. One possibility is to collect samples of the drilling fluid for laboratory analysis.
- The hydrogeologist shall keep track of the amount of water and fluids introduced to the borehole in order to purge this quantity during well development.
- Provisions to contain drilling mud and foam shall be discussed in the drilling contractor scope of work.

5.4.4 Air Rotary and Air Rotary with Casing Hammer

Air rotary drilling (ARD) and air rotary with casing hammer (ARCH) force air down the drill pipe and back up the borehole and remove drill cuttings in the same manner as DRD with foam or mud. Without a casing hammer, the use of ARD techniques is best suited to hard-rock formations where the borehole will stand open on its own and circulation loss is not a major concern. ARCH is most useful in unconsolidated sediments of all types due to the use of a hardened steel casing that is driven behind the bit with a pneumatic casing hammer to keep the hole open. A combination of these two drilling techniques is very useful where unconsolidated overburden overlies consolidated rock. In this case, the casing hammer attachment would be used to set the surface casing at the top of the consolidated formation while continuing with ARD. As a well is being installed or the hole is being abandoned, the casing can be retrieved for use on another hole, or left in place to serve as surface casing.

Air from the compressor shall be filtered to ensure that oil or hydraulic fluid is not introduced into the soils and/or groundwater system to be monitored. In addition, foam or hydrocarbon-based lubricating joint compounds for the drill rods shall not be used with any rotary drilling method due to the potential for introduction of contaminants into the native materials and/or groundwater. Teflon-based joint lubricating compounds that are typically mixed with vegetable oil are available for this purpose.

Potential Problems of ARD and ARCH

- In the case of sampling with a split-spoon sampler to collect soil samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.
- Fine-grained saturated materials that may cause surging and heaving problems are common in many coastal areas. Heaving sediments may cause problems during sampling and well installation when drilling with ARD.
- Rocks and other drill cuttings may be ejected from the borehole at high velocities, creating a secondary hazard around the rig.

Solutions

- ARD and ARCH should not be used for soil sampling in shallow, unconsolidated situations where a HSA rig could be used as effectively.
- One method to compensate for heaving and surging aquifer materials is to over drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is being performed.
- Another method to control heaving sands is to add clean water to a level above the water table to create a downward pressure on the heaving materials. This additional volume of water should also be extracted during well development.
- Drill rigs shall be equipped with cyclones or equivalent devices designed to contain formation projectiles.

5.4.5 Dual Tube Casing Hammer with Reverse Air Circulation

Dual tube casing hammer with reverse air circulation (DTCH) is useful in unconsolidated sediments, but is most effective as a method for drilling through thick sequences of materials, such as coarse-grained sands and gravels. The DTCH system operates by simultaneously driving a pair of heavy gauge steel pipes into the ground while using high pressure reverse air circulation to blow air down the annulus of the two pipes and bring air and unconsolidated lithologic materials out through the inside of the inner pipe. The method does not employ a typical bit in that the formational materials are not ground up, sliced, nor cut into pieces. Instead, the bit consists of a special shoe that is used to funnel materials either into, or away from, the inner pipe, depending on whether the formational material is fine- or coarse-grained, respectively.

Typically, the method can drill through 200 feet of gravel in a day with relative ease. The inside diameter of the inner pipe is about 6 inches, with the borehole diameter being about 10 inches. Cobbles with long axes of up to 6 inches come up through the inner pipe easily. Larger conglomerate clasts must be either pushed aside or broken up using the pneumatic hammer to drive the heavy shoe down onto the clast.

Conversely, the method works poorly in clay-rich materials. The shoe acts as a large cookie cutter, forcing a plug of clay into the inner pipe, which then must be forced to the surface and physically removed from the diverter/shoe assembly with the hammer. This method should probably be avoided where large thicknesses of clay are expected to be encountered in the subsurface.

Typically, the DTCH method can drill to approximately 200 feet with standard equipment. Deeper holes will likely require a larger air volume for circulation via an additional compressor hooked up to the drilling rig. Additionally, a variation of the DTCH called “triple tube” can be used to install larger-diameter wells to depths of about 200 feet depending upon the site. This method can also be used to supply a temporary surface casing to avoid cross-contamination of deeper zones while extending the boring to greater depths.

Potential Problems of DTCH

- In the case of soil sampling with a split-spoon sampler to collect samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.

Solutions

- DTCH should not be used for sampling soil in shallow, unconsolidated situations where a HSA rig could be used as effectively.

5.5 MONITORING WELL DESIGN PROCEDURES

The designs of typical groundwater monitoring wells are depicted in Figure I-C-1-1 and Figure I-C-1-2. A discussion of the design of the individual components of a typical monitoring well is given in the following subsections.

5.5.1 Pre-installation Design Drawing

Develop a pre-installation design drawing after the borehole for the well has been completed and well-specific lithologic and hydrologic information are available. The pre-design drawing shall identify the anticipated depth of the well, the locations of the top and bottom of the screened interval, the anticipated top of the filter pack, the anticipated top of the bentonite seal, and the locations of centralizers (if applicable). In addition, calculate the volumes of sand, bentonite, and grout anticipated to be placed in the annular space of the well. Maintain the drawing as documentation of the well design.

5.5.2 Casing Selection

The cased section of a monitoring well is a pipe without slots or openings, which is installed to prevent the well from directly accessing formations above the screened interval. The casing isolates the screened interval.

The selection of appropriate casing materials must take into account several site-specific factors, such as: (1) geology, (2) geochemistry, (3) well depth, (4) size and type of equipment to be used in the well, and (5) the types and concentrations of suspected contaminants. In addition, consider several other logistical factors, including drilling method, cost, and availability.

Typical casing materials comprise polyvinyl chloride (PVC), chlorinated PVC, fiberglass reinforced plastic, Teflon, galvanized steel, carbon steel, Type 304 stainless steel, and Type 316 stainless steel. Casing materials must be compatible with the environment into which they will be placed. Metallic casings are most subject to corrosion, while thermoplastic casings are most subject to chemical degradation. Some thermoplastic materials are susceptible to sorption and desorption of chemicals. The extent to which these processes occur is related to water quality, the concentration of contaminants, and the type of casing materials. Choose casing material with knowledge of the existing or anticipated groundwater chemistry. If non-aqueous phase liquids (light non-aqueous-phase liquid or DNAPL) are potentially present at a site, careful consideration of the concentrations and types of chemicals that may come into contact with the casing must be made to insure the casing will not degrade over time. Table I-C-1-2 presents the relative compatibilities of some typical casing materials.Table I-C-1-2: Relative Chemical Compatibility of Rigid Well-Casing Material

	PVC [a] 1	Galvanized Steel	Carbon Steel	Low-Carbon Steel	Stainless [b] Steel 304	Stainless [b] Steel 316	Teflon [c]
Buffered weak acid	100	56	51	59	97	100	100
Weak acid	98	59	43	47	96	100	100
Mineral acid/high solids	100	48	57	60	80	82	100
Aqueous/organic mixtures	64	69	73	73	98	100	100
Percent overall rating [d]	91	58	56	59	93	96	100

[a] PVC casing shall not be installed in a groundwater environment containing chlorinated solvent or other destructive contaminants where the concentration of organics is greater than 1 part per million, and where the desired detection limit is less than 25 part per billion.
[b] Type 316 stainless steel screen and/or casing shall be used rather than type 304 when conditions are unknown and the lifespan of the monitoring well is to be greater than 5 years, or where the pH (indicates the hydrogen ion concentration – acidity or basicity) is less than 4.5, or where chloride concentration is greater than 1,000 part per million.
[c] Trademark of E.I. DuPont de Nemours
[d] Overall rating based on scale of 0 to 100 with 0 being the least compatible and 100 being the most compatible.

Besides chemical compatibility, a second consideration for specification of casing materials is the depth of the monitoring well. Well installations greater than 150 feet deep require casing materials of greater structural strength. In the case of PVC casing, Schedule 80 PVC rather than Schedule 40 may be required to prevent over-stressing of the casing couplings. The build-up of heat during grout setup might adversely affect some thermo-plastic materials.

Regardless of the type of casing materials, use only flush-threaded couplings. Flush-threaded couplings ensure that no screws, mechanical adapters, glues, or solvents are necessary to join individual sections. Steel conductor casing shall be welded at the joints, and the joint shall be at least as thick as the thickness of the casing wall. The weld shall be fully penetrating and shall meet the standards of the American Welding Society. Outside steel collars may be used to increase the strength of the welded joint. Do not use Teflon tape on PVC or stainless steel casing joints because it reduces the tensile strength of the joints.

The selection of an appropriate casing diameter is also important. The I.D. shall be 4 inches or greater to allow better access to the well and more rigorous well development than is commonly possible with smaller-diameter wells. Wells with casing smaller than 4-inch I.D. shall only be installed with the approval of the QA Manager or Technical Director. Wells greater than 150 feet in depth may require diameters larger than 4 inches to ensure that development and sampling equipment can be moved easily through the well. In addition, wells designed for groundwater extraction shall have a casing diameter large enough to accommodate a pump capable of achieving the appropriate pumping rate. The borehole in which the well is to be installed shall be a minimum of 4 inches larger in diameter than the O.D. of the well casing.

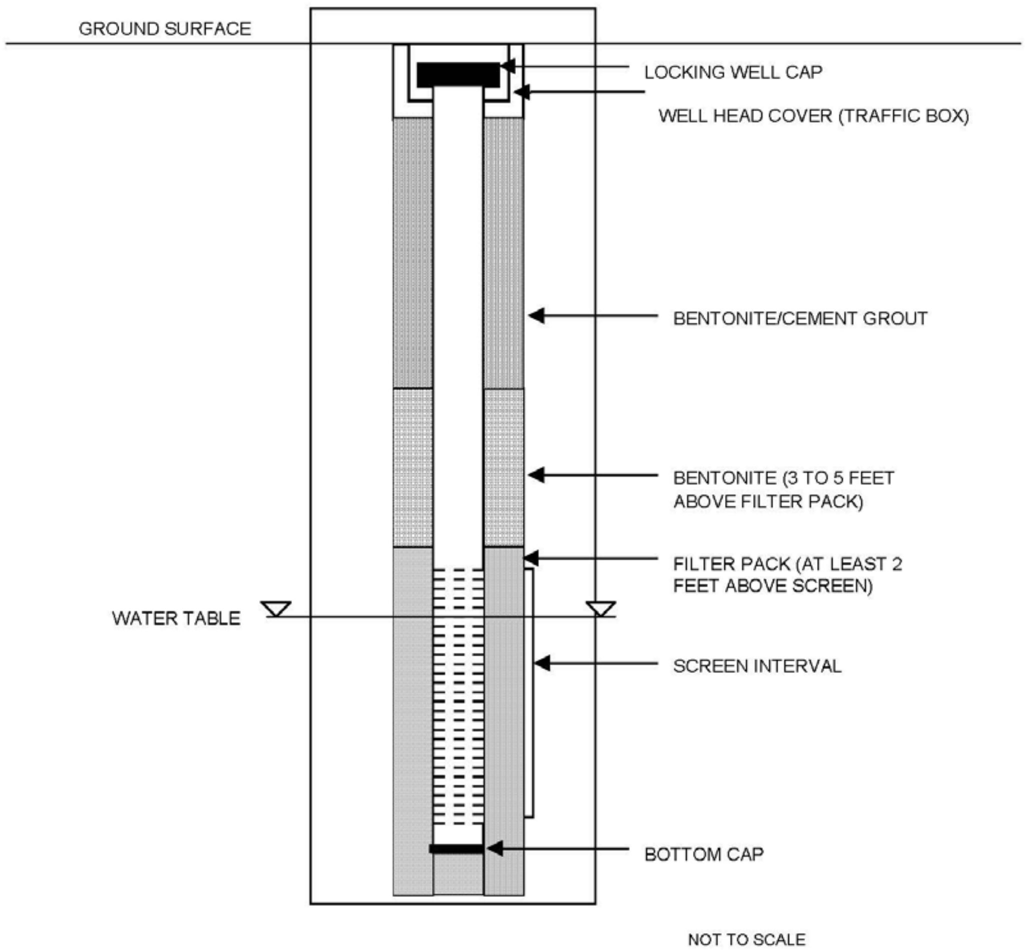


Figure I-C-1-1: General Cross Section of Monitoring Well, Unconfined Water Bearing Zone

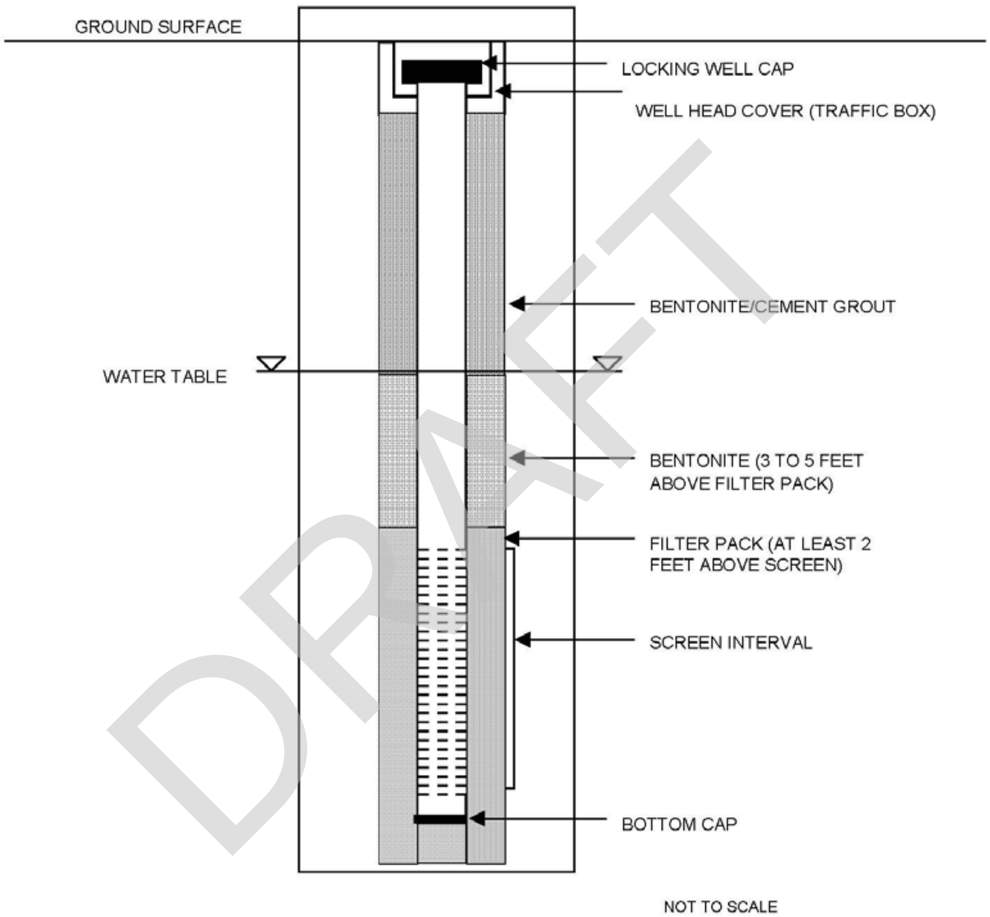


Figure I-C-1-2: General Cross Section of Monitoring Well, Confined Water Bearing Zone

5.5.3 Well Screen Selection

The screened section of the monitoring well allows groundwater to flow freely into the well, while retarding movement of fine-grained lithologic materials into the well. When designing a well screen, consider important factors, such as type of well screen material, length of the screened section, location of the screened section, the intake opening (slot) size, the type of intake opening, and size of filter pack to be utilized.

Five factors directly affect the performance of the monitoring well and are evaluated in the selection of an appropriate screen: (1) chemical resistance/interference, (2) screen length, (3) screen placement, (4) intended use of well (e.g., long-term groundwater extracted); and (5) intake opening size.

Selection of a screen material that provides chemical resistance and minimizes interference follows the same basic procedures as the selection of an appropriate casing material (see Table I-C-1-2). Some typical screen materials consist of PVC, Teflon, Type 304 stainless steel, and Type 316 stainless steel. Again, use only flush-threaded couplings. Screen sections constructed of different metals in the same well may cause electrochemical reactions that could rapidly degrade the casing or screen; therefore, do not use this type of composite well construction. In addition, construct wells intended for long-term groundwater extraction with well screen rather than slotted casing for facilitating redevelopment.

Selection of the screen length depends on its primary use(s). Most monitoring wells function as both groundwater sampling points and piezometers. Shorter-screened sections provide more specific data on vertically distributed contaminants, hydraulic head, and flow, and are generally preferred to longer-screened lengths. Saturated sections in groundwater monitoring wells shall be limited to between 5 and 10 feet in length; however, longer intervals may be justified in certain circumstances with approval of the QA Manager or Technical Director.

Placement of the screened interval within a groundwater monitoring well depends primarily upon two factors: the discrete interval and the type of contaminants to be monitored. The location of the discrete interval to be monitored will dictate the location of the screened interval within a monitoring well; however, also consider the characteristics of the contaminants to be monitored (i.e., light, non-aqueous phase liquid; dense, non-aqueous phase liquid) when choosing placement of the screened interval.

An additional consideration in the design of the screened section of the well is the hydraulic characteristics of the water-bearing zone that is to be monitored (i.e., confined or unconfined). If an unconfined zone is being monitored for contaminants that are less dense than water (e.g., gasoline, diesel, waste oil), place 3 to 5 feet of screened interval above the highest level of the water table to allow for evaluation of fluctuations in water level and to ensure that contaminant phases less dense than water can be observed. Conversely, if an unconfined zone is being monitored for contaminants that are denser than water (e.g., chlorinated solvents), place approximately 5 feet of screened interval (maximum) just above the confining unit at the base of the water-bearing zone to facilitate detection of the dense-phase contaminants. In the case of a confined water-bearing zone, use a maximum-screened interval of approximately 5 feet.

Selection of an appropriate intake opening size is critical to the performance of the monitoring well and to the integrity of groundwater samples obtained from the well. The size of the intake openings can only be determined following the selection of an appropriate filter pack, which itself is selected based upon the grain-size of the formation. An intake size is generally designed to hold back between 85 to 100 percent of the filter pack material. Figure I-C-1-3 can be used to select appropriate intake opening sizes. The screen slots shall be factory-made (or formed).

5.5.4 Filter Pack Design

Filter pack material shall be clean and chemically stable within the monitoring well environment to minimize addition to, or sorption from, the groundwater. Filter pack shall meet the following minimum specifications:

- Filter pack material shall be at least 95 percent silica, consisting of hard, durable grains that have been washed until free of dust and contamination, and graded.
- Filter pack material shall not be angular and non-uniform such that it will bridge in the annular space, leaving a void or poorly packed materials that can consolidate or settle after construction.
- Select filter pack to meet the grading specification determined from sieve analysis of the geologic formation to be screened, if available.
- Filter pack material shall be commercially packaged in bags that prevent the entrance of contaminants, and allow proper handling, delivery, and storage at the monitoring well site. Do not use material delivered in broken bags for monitoring well construction.

In investigations where there are limited data on site conditions prior to monitoring well installation, select the filter pack size prior to field activities based on available lithologic data. Use finer filter pack sizes if fine-grained formations are anticipated to be present, and use coarser-grained filter packs in coarser lithologies and consolidated formations.

In investigations where sieve analysis data exist for a site prior to field activities, base selection of a proper filter pack upon the grain size of the formation materials to be monitored. Use the sieve data for the finest lithology identified in the interval to be monitored for establishing filter pack size. The U.S. Environmental Protection Agency recommends that filter pack grain size be selected by multiplying the 70 percent retained grain size of the formation materials by a factor between 4 and 6. Use a factor of 4 if the formation materials are fine-grained and uniform, and use a factor of 6 if the formation materials are coarse-grained and non-uniform. In any case, the actual filter pack used should fall within the area defined by these two curves. An example of this technique is presented in Figure I-C-1-4.

5.5.5 Annular Seal

The annular seal is placed directly above the filter pack in the annulus between the borehole and the well casing. The annular space must be sealed to prevent the migration of water and contaminants through the annulus. The annular seal is also intended to hydraulically and chemically isolate discrete water-bearing zones.

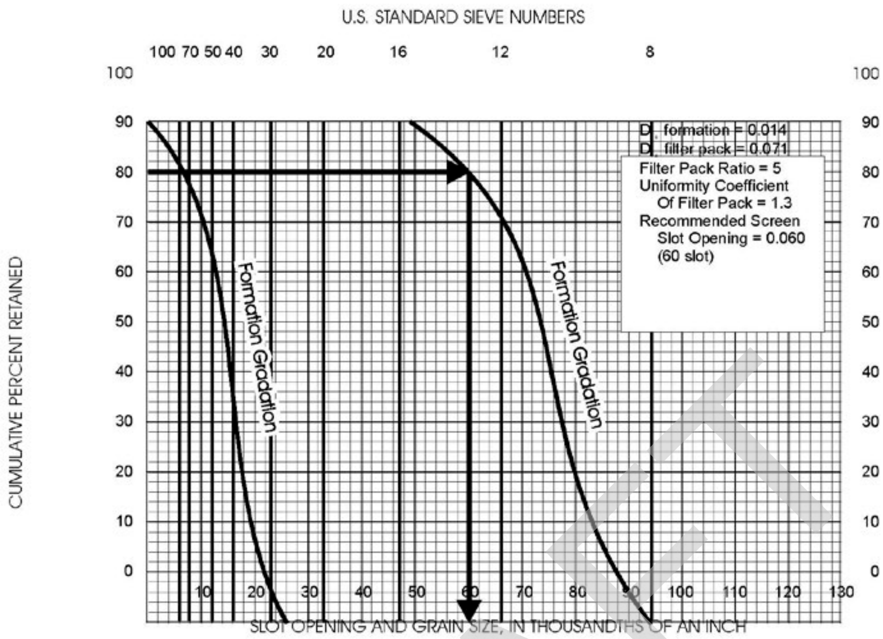


Figure I-C-1-3: Selecting Well Intake Slot Size Based on Filter Pack Grain Size

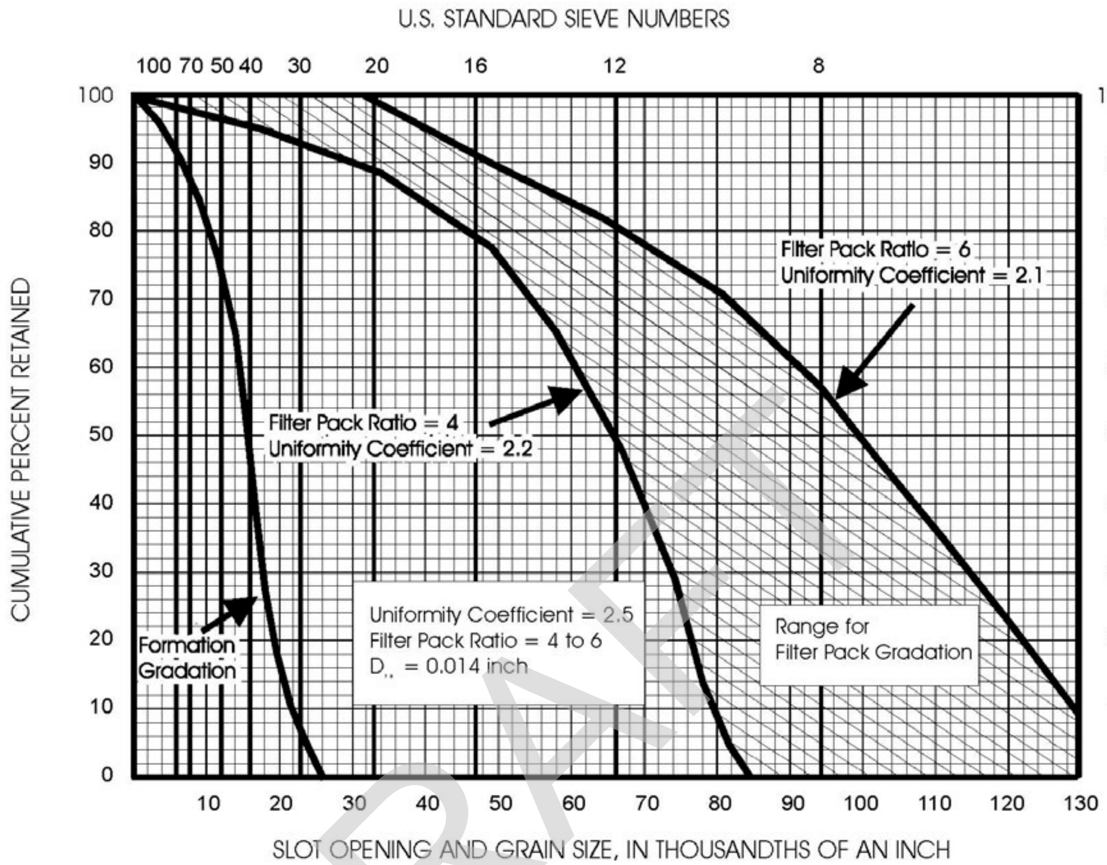


Figure I-C-1-4: Filter Pack Design Criteria

Typically, annular seals consist of two discrete sections. The first section, known as the bentonite seal, consists of a pure sodium bentonite seal. To be effective, the bentonite seal should be emplaced directly over the top of the filter pack and extend approximately 3 to 5 feet (no less than 3 feet thick). Typical materials for the seal consist of granular sodium bentonite, or sodium bentonite pellets or chips.

The second section of the annular seal typically contains grout slurry, which completely fills the remaining annular space from the bentonite seal to just below the ground surface. Grout consists of either sodium bentonite and Portland cement slurry or neat cement slurry. Give special consideration to the selection of annular seal material for wells installed in coastal areas where groundwater may contain elevated concentrations of sulfates. In this situation, use a sulfate resistant grout to prolong the usefulness of the well.

5.5.6 Surface Completion

The surface of the well shall be completed using either an above-grade (monument) style, or a flush-to-grade (traffic box) style. In either case, the protection of the wellhead at land surface is accomplished by means of a surface seal of concrete and a metal completion box surrounding the well casing. The surface seal serves to prevent infiltration of surface water and unauthorized entry, and where necessary, to provide protection from vehicular traffic.

5.6 MONITORING WELL INSTALLATION TECHNIQUES

The following general procedures describe the installation of groundwater monitoring wells.

5.6.1 General Casing and Screen Installation Techniques

Following completion of the borehole, the FM or designate will first measure the total depth of the hole to ensure that the desired depth has been attained. The lengths of casing and screen shall also be measured. These measurements shall be made with an accuracy of 0.01 feet using either a fiberglass or steel tape measure.

Installation of the casing and screen is normally accomplished by emplacing them into the well as an integral unit. Prior to installation, decontaminate individual lengths of the well casing and screen according to Procedure I-F, *Equipment Decontamination*, unless the casing and screen were certified by the manufacturer to have been properly pre-cleaned at the factory and sealed in plastic. Following decontamination, inspect each length to ensure that damaged or otherwise unsuitable sections are not used.

To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, suspend the casing and screen with a threaded hoisting plug and do not allow them to rest on the bottom of the boring unless the installation is less than 30 feet deep.

5.6.2 Centralizers

Install centralizers at the top and bottom of screened sections when using the air or mud rotary techniques for well installation. Also place centralizers at 20- to 40-foot intervals on blank casing; the FM will determine the spacing according to the depth of the well. Align the centralizers from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe. All devices used to affix centralizers to the casing shall not puncture the casing or contaminate the groundwater with which they come in contact. Centralizers shall be constructed of stainless steel.

5.6.3 Filter Pack Installation

Prior to the addition of any filter pack material, cover the top of the well casing to prevent filter pack material from entering it.

The filter pack is usually installed through HSAs, conductor casing, or a tremie pipe depending on the drilling technique used; however, if the depth to the bottom of the screened interval is less than 10 feet, and lithologic materials are sufficiently consolidated to preclude the possibility of hole collapse, the filter pack may be poured into the annular space of the well from the ground surface. This procedure applies to any drilling method.

During installation, measure the level of the top of the filter pack periodically to ensure that no bridging has occurred, and to determine the depth to the top of the filter pack. Be sure that the filter pack encloses the entire length of the screened section. For wells less than 100 feet in total depth, the filter pack shall generally extend to 2 feet above the top of the screened section of the well. For wells greater than 100 feet in total depth, an additional 1 foot of filter pack may be emplaced above the screen for each 100 feet of well depth.

An alternative to conventional monitoring well construction and installation is through the use of small diameter pre-fabricated monitoring wells, commonly referred to as “pre-pack” wells. Pre-pack wells typically consist of a well screen (slotted PVC) surrounded by sand (filter-pack) held in place by a stainless steel or polyethylene mesh. The pre-pack well assembly is commonly used in conjunction with direct-push drilling methodologies, which allows a relatively quick installation of these small diameter wells. Having the filter pack around the slotted PVC before the well screen is installed ensures that the filter pack is located directly around the well screen and minimizes the effort required for the filter pack installation.

The filter pack is normally an inert (e.g., siliceous) granular material that has a grain-size distribution chosen to retain formation materials. A sleeved screen consists of a slotted pipe base over which a sleeve of stainless steel mesh filled with selected filter media is installed. Pre-packed or sleeved screens may be used for any formation conditions, but they are most often used where heaving, running or blowing sands make placement of conventional well screens and filter packs difficult, or where predominantly fine-grained formation materials are encountered (ASTM 2010). During installation, the boring is advanced using hollow drive rods with an expendable drive point. Upon reaching the desired monitoring well installation depth, the entire well assembly (i.e., pre-pack well) is lowered to the desired depth within the hollow drive rods. At the desired depth, the hollow drive rods are retracted to a point above the screen. At this step a barrier is placed directly above the screen to prevent grout or material from entering the screened interval as the hollow drive rods are extracted from the boring. This barrier can be created either by natural formation collapse (occurring during the initial rod retraction), by gravity installation of fine-grade sand through the rod annulus, or as part of the pre-pack monitoring well components (e.g. expanding foam bridge). With the barrier in place, granular bentonite or bentonite slurry is then installed in the annulus to form a well seal. When installing pre-pack screens additional sand must be used to fill in the annular space between the pre-pack and the edge of the borehole. Furthermore, filter sand should be installed to at least 2 feet above the top of the pre-packed well screen.

Vendors offer pre-pack monitoring well components with varying outer diameters, which is typically based on the inner diameter of the hollow drill rods. These types of wells may be sampled by several methods including peristaltic pump, mini-bailer, or bladder pump to yield data of similar quality to that of conventional monitoring wells.

Following the installation of the filter pack, a surge block or large bailer shall be placed into and removed from the casing for approximately 10 minutes to set and compact the filter pack and to begin well development. Then, check the level of the filter pack again. Add more filter pack material according to the procedures described above if any settling of the filter pack has occurred. After emplacement, note the volume of filter pack material placed in the well, record it in the well completion record (Figure I-C-1-5), and compare it to the calculated volume of filter pack that was expected to have been used.

5.6.4 Annular Seal Installation

The sodium bentonite seal shall have a minimum thickness of 3 feet. Generally, to be effective the bentonite seal should extend above the filter pack approximately 3 to 5 feet. It may be constructed of powdered, granular, or pelletized bentonite, and may be emplaced as a dry solid, powder, or slurry. Use only sodium bentonite manufactured specifically for use in the drilling and construction of water wells. Typically, granular or pelletized bentonite is emplaced dry. Powdered bentonite is usually mixed with potable water to produce a slurry. Depending on the type of installation method, the bentonite may be emplaced through the HSAs, conductor casing, or tremie pipe.

In dry form, place the bentonite directly on the top of the filter pack. After emplacing each 1-foot-thick layer of dry bentonite in the well, add approximately 5 gallons of water of known chemical quality to hydrate the bentonite. Allow a minimum of 15 minutes for hydration of the bentonite seal once it is completely installed.

When emplacing the bentonite in slurry form, take care to ensure that the bentonite is thoroughly mixed, with no visible lumps to ensure the proper consistency. Then place a 1-foot layer of fine-grained silica sand over the top of the filter pack. This fine-grained sand layer will prevent infiltration of the filter pack by the bentonite slurry.

Emplace the remaining annular seal following the installation of the bentonite seal. The annular seal shall be a slurry consisting of 7 to 9 gallons of water per 94-pound bag of Portland cement Type I or II and a minimum of 3 to 5 percent bentonite (1/4 to 1/2 bags of bentonite powder per five bags of Portland cement). The slurry may be emplaced through a HSA, conductor casing, or tremie pipe, depending on the method of installation. Thoroughly mix the grout to ensure the proper consistency with no visible lumps of dehydrated powder. The rates at which the augers or pipe are withdrawn and the slurry added will be such that the level of the grout within the well annulus is just below the lowermost auger or pipe.

If a tremie pipe is used, emplace the annular grout seal by pumping through a pipe with a minimum 1-inch I.D., in one continuous pour, from the top of the transition seal to the ground surface. Place the bottom of the tremie pipe about 5 to 10 feet above the transition seal, depending on the stability of the hole and impact velocity of the grout.

A tremie pipe is not required for annular seals less than 10 feet from the ground surface to the top of the transition seal or for grouting within dual wall drill strings or HSAs. Measure the volume of grout seal material placed in the well, record it in the well construction log, and compare it with the calculated volume. The slurry shall extend from the top of the bentonite seal to a depth of approximately 2 feet below ground surface (bgs).

5.6.5 Annular Seal "Set Time" and Setting

Let the annular grout seal set at least 12 hours before disturbing the casing or well so that separations or breaks do not occur between the seal and the casing, or between the seal and the borehole. Development of the well is prohibited until the grout seal has set. Likewise, the concrete slab, traffic box, and/or casing riser of the surface completion shall not be poured and constructed until the grout seal has set. Top off any settlement of the grout seal as soon as possible after it sets. Record all pertinent data on the well construction log.

5.6.6 Surface Completion

The surface of a groundwater monitoring well shall be either an above-ground completion or as a flush-to-ground completion. Regardless of the method, each monitoring well shall have, at a minimum, a casing cap, concrete slab and annular seal, and a locking protective casing or locking vault. Although wellheads vary in size, effort should be made to use a consistent size wellhead or similar completion per site.

In an above-ground completion, the protective casing or monument is installed around the top of the well casing within a cement surface seal. A 2-foot-long by 2-foot-wide cement pad with a minimum thickness of 3 inches is constructed around the protective casing. Type 1 Portland cement, which meets the requirements of CLASS A standards, is used for the surface seal. Inspect the monument prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the monument in a plumb position with 2 to 3 inches of clearance between the top of the well casing and the lid of the monument. The monument shall extend at least 18 inches above grade and at least 12 inches below grade. Construct a minimum of three concrete-filled posts around the well to protect it from vehicular damage.

Inside the monument, cut or scribe two permanent survey marks, approximately 0.25 inches apart, into the top of the well casing, and also permanently mark the well with its identification number. Permanent marks may include painting, marking, or engraving on the protective casing or surface completion. An alternate option may be to attach a non-corroding, imprinted metal tag to part of the well. Cover the top of the well casing with a slip cap or locking cap to prevent debris from entering the well. Fit the monument with a casehardened lock to prevent unauthorized entry.

In a flush-to-ground completion, the protective casing or traffic box is installed around the top of the well casing, which has been cut off slightly below grade. The traffic box has a lid that is held firmly in place by bolts and has a flexible O-ring or rubber gasket to prevent water from entering the box. Whenever possible, wells with flush completions should not be placed in low spots where surface water can accumulate. If this is unavoidable, consider an aboveground completion. The traffic box is set within a cement surface seal slightly above grade to deflect surface water flow away from the well. The surface seal must form an apron at ground surface that is at least 2 feet wide and 4 inches thick. The concrete apron must slope away from the well (a minimum of 1 percent) to prevent surface water leakage into the well head (DOH 2009). An effort should be made to standardize the appearance of the well completions at a particular site. Type 1 Portland cement, which meets the requirements of CLASS A standard, is used for the surface seal. Where monitoring well protection must be installed flush with the ground, an internal cap should be fitted on top of the riser within the manhole or vault. This cap should be leak-proof so that if the vault or manhole fills with water, the water will not enter the well casing. The cap should also be able to lock to prevent unwanted access or tampering with the well. Ideally, the manhole cover cap should also be leak-proof (ASTM 2010). Inspect the traffic box prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the traffic box in a level position that leaves 2 to 3 inches of clearance between the top of the well casing and the lid of the traffic box. Regular maintenance may be necessary to maintain the integrity of the seals and pads protecting the wells.

Cut two permanent survey marks into the top of the well casing, approximately 0.25 inches apart, and also permanently mark the well with its identification number. Cover the top of the well casing with a lockable cap to prevent debris from entering the well. Also fit the lockable cap with a casehardened lock to prevent unauthorized entry.

In areas where there is a high probability of damaging the well (high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, or other means. The level of protection should meet the damage threat posed by the location of the well (ASTM 2010).

5.6.7 Installation of Surface Casing

The use of surface casing may be required to minimize the potential for cross-contamination of different hydrogeologic zones within the subsurface of a site. The depth of placement of the surface casing shall be based on site-specific geologic knowledge obtained from lithologic samples collected in situ during the drilling of the well boring.

If a surface casing is to be installed permanently along with the well, grout it in place. The borehole shall be of sufficient diameter that a tremie or grout pipe can be easily placed between the borehole wall and the outside of the surface casing. After the desired placement depth is reached and the drilling tools are removed from the borehole, lower the casing into the borehole and center it. The bottom of the surface casing may be plugged or driven into the sediment at the base of the borehole to keep grout from entering the casing, if necessary.

Install grout through the tremie pipe and pump it from the bottom of the casing to ground surface. As the grout is being placed, raise the tremie pipe slowly to avoid excessive backpressure and potential clogging of the tremie pipe. After the grout has been allowed to set for at least 24 hours, drilling and subsequent well installation can continue. The required time for grout to set before drilling can continue depends on the volume of grout emplaced; the more grout used, the longer the delay time.

JOB NO.: ______ WELL NO. ______ HYDROGEOLOGIST: ______

CLIENT: ______ DRILLER: ______

WELL LOCATION: ______ DATE/TIME: ______

DETAILS OF CONSTRUCTION

Date Completed ______

Borehole Diameter (in.) ______

Type and Size of Casing (in.) ______

Type and Size of Screen (in.) ______

Screen Perforation Diameter (in.) ______

Screen Length (ft.) ______

Centralizer Depths (ft.) ______

Completion Technique

1. Type of Filter Pack and Placement Method ______
2. Type of Bentonite and Placement Method ______
3. Type of Grout Mixture and Placement Method ______

Description of Potential Problems With Well:

______

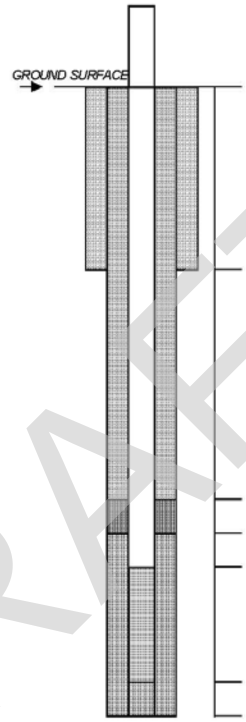
______

______

______

Development Technique

______



GROUT

BENTONITE

FILTER PACK

NOTE: ALL DEPTHS ARE REFERENCED TO GROUND SURFACE

Well Head Elevation ______

Ground Surface Elev. ______

Well Head Completion Method ______

Drilling Method/Rig Type ______

Surface Casing: Type ______

Diameter ______

Length ______

MATERIALS

Cement (sks.) ______

Filter Pack Material (ft.^{3}) ______

Casing Material (ft.) ______

Bentonite (ft.^{3}) ______

Top of Bentonite Seal ______ ft.

Top of Filter Pack ______ ft.

Top of Screen ______ ft.

Bottom of Screen ______ ft.

Bottom of Hole ______ ft.

Figure I-C-1-5: Well Completion Record

5.6.8 Shallow Well Completion

Due to the occurrence of shallow groundwater in some areas, there are instances when the top of the screened interval must be placed at a depth so shallow that it is impossible to install the well using the typical design for annular materials (i.e., 2 feet above the screen for filter pack followed by a 3-foot thickness of bentonite seal). In cases where the top of the screen must be placed between 4 and 6 feet bgs, use the following design alteration:

- Place the filter pack 1 foot above the top of the screened interval.
- Place a minimum of 3 feet of bentonite seal above the filter pack.
- Fill the remainder of annular space with a 3 percent to 5 percent bentonite-cement grout.

In no case shall the top of the screen be brought higher than 4 feet bgs because it is difficult to install a reliable annular seal at these shallow depths.

5.6.9 Method-specific Well Installation Techniques

The following sections describe well installation techniques for groundwater monitoring at hazardous waste sites. Sections on troubleshooting common problems encountered when using each technique and potential solutions to the problems are included.

5.6.9.1 HSA

General methods of well installation using the HSA technique are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Mark the well casing near the ground surface to signal to the drillers where the casing should be placed.
- Remember that wells are constructed within the augers as the augers are removed from the ground.
- The diameter of the well casing constructed within an HSA is limited to 4 inches. *Note:* The difference between the I.D. of the HSA and O.D. of the well casing must be at least 4 inches to permit effective placement of filter pack, bentonite seal, and grout.
- Remove the inner rod and hammer quickly, measure the depth of the borehole, and place the well screen and casing quickly into the auger to the desired depth. *Note:* the well screen and casing shall be suspended in hole by the use of a hoisting bail in order to ensure proper depth and plumb construction. This may not be necessary for wells less than 30 feet in depth.
- Prior to adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- The HSA acts as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour filter pack between the inside of the auger and the outside of the well casing.
- While the filter pack material is being poured, incrementally withdraw the auger. The rate of auger withdrawal and filter pack placement shall allow for the top of the filter pack level to be just below the lead auger. In general, the augers should be withdrawn in increments of

2 to 3 feet. *Note:* The level of the top of the filter pack shall be constantly tagged with a measuring tape during emplacement of the filter pack.

- Surge the well to consolidate the filter pack; add more if settlement occurs.
- Emplace bentonite pellets or chips through the HSA. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, pour 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the HSA.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the HSA from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be emplaced from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, the grout may be emplaced directly from the top of the borehole. If the top of the bentonite seal is greater than 10 feet bgs, a tremie tube shall be used to emplace the grout. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing within the HSA.

Avoidance of Locked Well Casing

- Carefully tag the filter pack level and keep it just below the lead auger while the auger is inched up and sand is slowly added.
- Use an auger with a larger I.D.
- Use filter pack materials with a larger grain size.
- Add water of known chemical quality while pouring the sand filter pack. Try this only in cases where the filter pack is very fine.

Solutions for Unlocking Well Casing from Augers

- Gently hold the casing in place while lifting and twisting the auger (do not force).
- Insert the surge block into the casing and gently surge the water column if bridge is below water table.
- Add water between the well and auger if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and then gently blow the bridge away.
- Completely remove the casing and screen, and reinstall the well.
- Never drive the casing out of the auger with a hammer because this will break the casing.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with HSA.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well installation begins. Begin placement of filter pack as soon possible. Add it quickly until over-drilled space is filled.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added shall be recorded on the well installation log and extracted during well development.
- Drill an initial pilot borehole and sample with a 6-inch-diameter auger. The 6-inch auger may be fitted with plastic or metal core catcher on the lead auger, which will allow for soil sampling and prevent sediments from entering augers. After the total sampling depth is reached, the 6-inch auger is removed and 10-inch-diameter augers are substituted to ream out the borehole. Fit the lead auger with a tapered stainless steel plug. At a depth below the desired total depth of the well, use the sampling hammer and center rod to knock out the stainless steel plug. Then complete well installation.

5.6.9.2 Direct Rotary with Foam or Mud

General well installation techniques using direct rotary with foam or mud are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Place mark on the portion of the well casing near ground surface to identify to the drillers where the casing should be placed. Place centralizers on the well casing and screen as discussed in Section 5.5.2.
- With DRD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. For mud rotary drilling, first thin the mud sufficiently prior to removing the bit and drill pipe from the hole. Thinning the mud allows faster and more accurate placement of the annular materials within the borehole, which balances the density of the borehole fluids so they more closely match the density of the fluids used to install the filter pack and bentonite seal. It also reduces the potential for annular materials to be washed out of the borehole through the tremie.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its stability.
- Suspend the well screen and casing in the hole by the use of hoisting bail in order to ensure proper depth and a plumb construction. This may be unnecessary for wells less than 30 feet in depth. Place the casing and screen in the hole as fast as is safely possible to minimize the time that the borehole stays open.
- Prior to the addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.

- Use a tremie pipe for placement of filter pack, bentonite, and grout. Also emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole.
- Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The level of the top of the filter pack shall be constantly tagged with measuring tape as the filter pack is being emplaced.
- Make the bentonite seal at least 3 feet thick. It should consist of bentonite pellets or chips emplaced through the tremie pipe. Tag the level of the bentonite periodically to ensure accurate placement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be placed directly from the top of the borehole rather than through the tremie pipe.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the tremie pipe from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be placed from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs, and the borehole is not subject to collapse and is not filled with drilling fluid, the grout may be placed directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solution

Controlled pouring of the annular materials is the best solution for bridging. In the case of mud rotary, however, it may be necessary to perform emplacement of the filter pack and bentonite chips or pellets through the borehole without the aid of a tremie pipe. For wells greater than 10 feet deep, obtain the approval of the QA Manager or Technical Director.

5.6.9.3 Air Rotary and Air Rotary With Casing Hammer

General well installation techniques using ARD or ARCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure the accurate placement of well casing and screen.
- Remember that with ARD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. With ARCH, the driven casing remains in the ground and is slowly withdrawn as well installation proceeds.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its borehole stability.
- To ensure proper depth and a plumb construction, suspend the well screen and casing in the hole using a hoisting bail. Place the casing and screen in the borehole as fast as is safely possible to minimize the time that the hole stays open, particularly for ARD.

- Before adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- For ARD, use a tremie pipe for placement of filter pack, bentonite, and grout. Emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole. For ARCH, the annular materials can in most cases be placed directly between the driven casing and the well casing. A tremie pipe is advisable if exacting placement is required.
- For ARD, place the tremie pipe within 2 feet of the interval where the filter pack is to be placed. Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The tremie pipe shall be slowly withdrawn during placement.
- Periodically tag the level of the top of the filter pack with measuring tape while the filter pack is being emplaced. Install bentonite in a similar manner.
- For ARCH, pour the filter pack slowly between the well casing and driven casing. The driven casing shall be withdrawn periodically while the filter pack is being emplaced. Withdraw the driven casing in increments no greater than 2 to 3 feet.
- For ARD, emplace bentonite pellets or chips through the tremie pipe to a minimum thickness of 3 feet. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, add 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe. For ARCH, emplace the bentonite between the well casing and the driven casing while the driven casing is being withdrawn.
- Emplace a grout seal through the tremie pipe for the ARD method or through the driven casing for the ARCH method. Emplace the grout from the top of the bentonite seal to within 2 feet of ground surface. The driven casing or tremie pipe shall be withdrawn as the grout is placed. Emplace the grout from bottom to top in one continuous pour following placement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, emplace the grout directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Drilling Problems

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solutions

Controlled pouring of the annular materials is the best solution against bridging.

Heaving Sediment

Fine-grained saturated materials that might cause heaving problems are common in coastal areas. Difficulties caused by heaving sediments might create problems when drilling with ARCH. Heaving sediments cannot be drilled using ARD techniques.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is begun.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Heaving sands may also be controlled by first removing the drill pipe from the hole, and then constructing an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin placement of filter pack as soon as possible and add it quickly until the over-drilled space is filled.

5.6.9.4 DTCH

General well installation techniques using DTCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate depth placement of well casing and screen. Place a mark near the top of the casing to identify to the drillers the proper position to place the casing and screen.
- Like HSA drilling techniques, wells are constructed within the dual tube pipe as the pipe is removed from the ground.
- Prior to setting the casing and screen in the hole, verify total depth of the hole by measuring it and check for surging materials. Suspend the well screen and casing in the hole using a hoisting bail in order to ensure proper depth and plumb construction.
- Prior to addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.
- The inner pipe of the dual tube assembly shall act as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour the filter pack between the inside of the augers and the outside of the well casing to avoid potential bridging of the annular materials. While the filter pack material is being poured, the dual tube pipe shall be incrementally withdrawn. The rate of pipe withdrawal and filter pack emplacement shall allow for the top of the filter pack level to be just below the shoe of the dual tube assembly. The level of the top of the filter pack shall be constantly tagged with measuring tape.
- Use bentonite pellets or chips to construct the well seal, which shall be a minimum of 3-feet thick, and shall also be emplaced through the dual tube assembly. For each foot of bentonite seal installed in an unsaturated completion, 5 gallons of water of known chemical quality shall be poured into the well to hydrate the bentonite. Tag the level of the bentonite periodically to ensure accurate emplacement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe.

- Emplace a grout seal through the dual tube assembly from the top of the bentonite seal to within 2 feet of ground surface. Emplace the grout from bottom to top in one continuous pour immediately following emplacement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs, the grout may be emplaced directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing and dual tube pipe together.

Avoidance of Locked Well Casing

- Tag carefully and always keep the filter pack just below the shoe while inching the dual tube assembly up and slowly adding sand.
- Use a smaller-diameter well casing.
- Use a filter pack with a larger grain size.
- Add water while pouring the sand filter pack. Avoid this unless absolutely necessary.

Solutions for Unlocking Well Casing from Dual Tube Pipe

- Insert a surge block into casing and gently surge the water column if the bridge is below water table.
- Add water between the well and piping if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and gently blow the bridge away.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with DTCH.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion begins.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Remove the drill pipe from the hole, and then construct an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin emplacement of the filter pack as soon as possible, and add it quickly until the over-drilled space is filled.

5.6.10 Well Construction Record Keeping Procedures

A written well completion record (Figure I-C-1-5) detailing the timing, amount of materials, and methods of installation/construction for each step of monitoring well construction shall be prepared during construction of each monitoring well by the FM or designate. Construction records shall be kept in a hard-bound field notebook dedicated to the CTO. An "as-built" drawing illustrating the placement location and amounts of all materials used in construction of each monitoring well shall be prepared in the field at the time of construction. The well construction record shall be filled out with indelible ink. Construction records shall include the date/time and quantities of materials used at each of the following stages of monitoring well construction, including:

- Drilling
  - Drill rig type
  - Drilling method/coring method
  - Drill bit/core barrel diameter (hole diameter)
  - Drill company, driller, helper(s)
  - Field geologist, supervising geologist
  - Dates/times start and finish drilling hole, interval drilling rates
  - Total depth of hole
  - Drilling location, surveyed ground elevation
  - Inclination of hole from horizontal
- Borehole abandonment – type, volume, and surface seal
- Casing material – type
- Casing decontamination – document process and equipment used
- Casing diameter – nominal I.D. of casing
- Screen material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Slot type, size, shape
  - Type of bottom plug and/or cap used
- Filter pack material
  - Composition and size gradation
  - Manufacturer
  - Actual volume and depth of top and bottom of filter pack
  - Calculated volume versus actual volume used and explanation of discrepancies
- Transition seal

- Composition and depth of top and bottom of seal
- Size (or gradation) or material used (e.g., pellets, granulated, or powdered)
- Time allowed for hydration prior to emplacement of annular grout slurry seal

- Annular slurry seal
  - Date and time of beginning and completion of annular seal
  - Type and actual volume of seal
  - Calculated volume versus actual volume and explanation of discrepancies
  - Set time allowed prior to commencement of additional work
- Surface completion
  - Type of construction
  - Nature of materials used for surface completion
  - Date/time of completion

5.6.11 Well Location

A registered land surveyor shall survey each monitoring well location for exact horizontal location to the nearest 0.5 foot, and exact vertical location to the nearest 0.01 foot, referenced to mean sea level or mean low low water. The vertical elevation shall be surveyed between the two notches cut in the top of the well casing, which is the point from which all water level measurements shall be made. The elevation of the ground or top of the concrete slab adjacent to the monitoring well shall also be surveyed, to the nearest 0.01 foot.

5.7 WELL ABANDONMENT/DESTRUCTION

Once a monitoring well is no longer needed as part of an investigation, or has been damaged to the extent that it cannot be repaired, it is essential that it be properly abandoned. The proper abandonment of a monitoring well ensures that the underlying groundwater supply is protected and preserved. In addition, proper well abandonment eliminates a potential physical hazard and liability. An additional permit and/or inspection may be required for abandonment, depending on state or local regulations.

The standard procedures for the abandonment of a groundwater monitoring well apply to the HSA drilling method. This type of installation was chosen because it is the primary method of abandoning groundwater monitoring wells. For wells abandoned on Guam, the current Guam Environmental Protection Agency Well Abandonment Procedures shall be followed (Attachment I-C-1-1).

The first step in abandoning a groundwater monitoring well is to remove the surface completion from around the top of the well casing. This is normally accomplished using a jackhammer to break the surface cement seal, and then removing the monument or traffic box. When the surface seal and the wellhead cover have been removed, over-drill the well to its total depth using HSAs. Once the total depth of the well has been reached, remove the casing and screen from the borehole. Then completely backfill the borehole with a grout seal. Typically, the grout seal is emplaced as slurry of Portland cement grout, which contains a minimum of 3 to 5 percent bentonite as described in

Section 5.4.5. When mixing the slurry, take care that the bentonite is mixed according to the manufacturer's specifications to ensure the proper consistency.

Emplace the slurry through the HSAs. The rates at which the augers are withdrawn and the slurry is added shall be such that the level of the slurry within the borehole is just below the lead auger. The borehole seal shall extend from the total depth of the borehole to a depth of approximately 1 foot bgs. Then repair the surface to prior conditions and grade.

If the monitoring well casing cannot be pulled or drilled out, perforate the well casing adjacent to the saturated zones so that the annular space and any nearby voids can be filled with sealing material. Fill the perforated well or borehole from the bottom up with an appropriate sealing material, such as neat cement. Inject the neat cement under pressure to force it into the annular space, nearby voids, and filter pack. Apply pressure for a sufficient time to allow the cementing mixture to set. After the cement has hardened, excavate a hole around the well (use a backhoe if necessary) to the depth specified in the Monitoring Well Abandonment Work Plan (WP) and ensure the excavation depth is in accordance with local regulatory agency guidelines (Attachment 1 for *Guam Monitoring Well Abandonment Procedure*) (GEPA 2006). Remove the uppermost portion of the casing, (if still in place), and pour a cement cap on top of the abandoned well, and backfill the remaining portion of the excavation with sealing material. Note, if personnel are required to enter the excavation to remove the upper portion of the casing, then proper sloping and shoring are required as per Section 25, *Excavations* of The Safety and Health Requirements Manual EM 385-1-1 (USACE 2008).

The State of Hawaii Department of Health Hazard Evaluation and Emergency Response must be notified at least 1 week prior to any well abandonment activities conducted in Hawaii (DOH 2009, Section 6.2.5.1). Additionally, an Abandonment of Monitoring Well Summary Report should be prepared using the form presented in Attachment 1-C-1-2. The record should include the following information:

- Well construction information:
  - Date of installation
  - Drilling company
  - Total depth
  - Casing material/length
  - Screen material/length
  - Annular material
- General abandonment information:
  - Drilling firm (contact, mailing address, and phone number).
  - Consulting firm (contact, mailing address, and phone number).
- Well abandonment information
  - Date of abandonment
  - Reason for abandonment

- Details of how the casing/screen was removed drilled out or perforated.
- Sealing material (weight/volume/bags/mix ratio)

5.8 VAPOR EXTRACTION/MONITORING WELLS

Vapor extraction/monitoring wells have most of the same design and installation considerations and procedures as groundwater-monitoring wells, with the exception that they are screened in the unsaturated zone. Vapor extraction/monitoring wells generally shall not be screened over an interval greater than 20 feet and shall not be screened over two or more lithologies that have air permeabilities that differ by more than one order of magnitude. Vapor extraction/monitoring wells shall be installed using drilling techniques that do not require drilling fluids other than filtered air. Vapor monitoring wells may have casing I.D.s of 2 inches or less while extraction wells shall generally have casing I.D.s of at least 4 inches. The design of vapor extraction/monitoring wells is dependent upon many site-specific factors, such as the depth of contamination, soil conditions, geology, and depth to groundwater. As a result, specifics related to the design of these wells shall be included in the CTO WP, field sampling plan, or plans and specifications.

5.9 DRIVE POINTS

An alternative to conventional monitoring well construction is, under limited conditions, the use of drive points. These consist of slotted steel pipe that is pushed, hammered, or hydraulically jetted into the ground. A filter pack is not constructed around the screen, so the width of the screen openings must be sufficiently small to prevent the passage of significant quantities of sediment into the well during the withdrawal of water for sampling. In some instances, the drive points are used only as piezometers.

Drive points are commonly used in hazardous waste investigations to sample ambient soil gases in the vadose zone. It is often possible to extend the drive point below the water table to collect water samples. In some instances, permits may be required because the drive points are considered in some jurisdictions to be equivalent to a temporary monitoring well.

5.10 DISCRETE DEPTH GROUNDWATER SAMPLING

Another alternative to conventional monitoring well construction is the use of a discrete groundwater sampling device such as a Hydropunch. The Hydropunch tool can be used in conjunction with a standard drill rig, a cone penetrometer rig, or possibly a vehicle capable of driving vapor probes to sample groundwater and non-aqueous phase liquid in unconsolidated formations. The Hydropunch tool is constructed of a stainless steel drive point, a perforated section of Teflon pipe for a sample intake, and a stainless steel sample chamber. The tool is 55.5 inches long, 2 inches in O.D., and weighs approximately 24 pounds.

Ideally, a standard HSA drilling rig is used to drill a pilot hole to a depth just above the desired sampling depth. The Hydropunch tool is then hydraulically pushed or driven 4 to 5 feet through the saturated zone at each sampling location. As the tool is advanced, the sample intake screen remains pristine within the watertight stainless steel chamber. When the desired sampling interval is reached, the steel sampling chamber is unscrewed and withdrawn 1 foot to several feet, depending on how long a sampling interval is needed. This exposes the intake screen to the groundwater. Under hydrostatic pressure, groundwater flows through the intake screen and fills the sample chamber, without aeration or agitation occurring. The drive cone, which is attached to the base of the screen, will remain in place by soil friction.

The pointed shape of the sampler and its smooth exterior surface prevent downward transport of surrounding soil and groundwater as the tool is advanced. Once in place, the intake screen will be sealed from groundwater above and below the interval being sampled, because the exterior of the Hydropunch tool is flush against the surrounding soil wall. Additionally, as the tool is advanced, the sample intake screen is retained within the steel watertight sample chamber.

A stainless steel or Teflon bailer with a bottom check valve is lowered into the sample chamber to collect the groundwater sample. Groundwater is then decanted at ground surface from the bailer into the appropriate sample containers.

6. Records

Monitoring well location, design, and construction shall be recorded in the field notebook for the CTO and on a well completion record form (Figure I-C-1-5). The field operations manager should provide a copy of this form to the CTO Manager for the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM) 2010. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. D5092-04^{e1}(Reapproved 2010). West Conshohocken, PA.

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of Health, State of Hawaii (DOH). 2009. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan.* Interim Final. Honolulu: Office of Hazard Evaluation and Emergency Response. 21 June.

Department of the Navy (DON). 2010. *Ammunition and Explosives Safety Ashore*. NAVSEA OP 5 Volume 1, 7th Revision, Change 11. 0640-LP-108-5790. Commander, Naval Sea Systems Command. July 1.

———.2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Guam Environmental Protection Agency (GEPA). 2006. *Well Abandonment Procedure*. Water Resources Management Program.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-5, Utility Clearance.

Procedure I-B-1, Soil Sampling.

Procedure I-B-5, Surface Water Sampling.

Procedure I-F, Equipment Decontamination.

9. Attachments

Attachment I-C-1-1, Guam Monitoring Well Abandonment Procedure

Attachment I-C-1-2, DOH Abandonment of Monitoring Well Summary Report Form

Attachment I-C-1-1

Guam Well Abandonment Procedure

Well Abandonment Procedure

Guam Environmental Protection Agency
Water Resources Management Program

I. Abandonment procedure for cased wells that ***will not*** have its casing removed

1. Remove the well pedestal and concrete pad if applicable.
2. Excavate down to six (6) feet and cut the casing.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the water table. If the well is completely within the vadose zone, proceed to item "I.4."
4. Provide a two-foot (2) a bentonite plug by placing 3/4 inch bentonite chip in six (6) inch lifts and hydrating with potable water.
5. Fill the casing with clean cement up to six (6) below the ground surface which will form a mushroom cap.
6. Fill the final six (6) feet with native soil.

Note: a. For wells with a depth to the water table greater than eleven (11) feet, the total depth of fill for item "I.5" will be equal to DWT less eleven feet.

b. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, item "I.5" will not be included.

c. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "I.4" and "I.5" will not be included.

II. Abandonment procedure for wells that ***will*** have its casing removed and open boreholes.

1. Remove the old pedestal and concrete pad if applicable.
2. Remove the casing if not an open borehole.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the measured water table. If the well is completely within the vadose zone, proceed to item "II.4."
4. Provide a two-foot (2) bentonite plug by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water.
5. Fill the remaining portion with bentonite/cement slurry (30% of bentonite by volume) in 10-foot lifts up to twenty-six (26) feet below the ground surface.
   a. After each 10-foot lift, the hole shall be sounded to determine if ten (10) feet of the hole is actually filled with the bentonite/cement slurry by at least eight (8) feet. If the depth of the fill is greater than eight (8) feet, continue with the next ten-foot (10) lift of bentonite/cement slurry. If the depth of the fill is less than eight (8) feet (an indication that there is a cavity), go to "II.5.b." Otherwise, continue with item "II.5.a." When the bentonite/cement fill reaches a height of twenty-six (26) feet below the ground surface, go to item "II.6."
   b. Fill the next ten (10) feet with 3/8 to 3/4 inch clean washed aggregate. Sound the hole to ensure that at least nine (9) feet has been filled with clean aggregate. If less than nine (9) feet is filled, repeat another ten-foot (10) lift of 3/8 to 3/4 inch clean washed aggregate until the sounding of the well/borehole reveals a rise of nine (9) feet or greater. Go to item "II.5.c."

c. Provide a two-foot (2) bentonite plug above the clean aggregate by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water. Continue with item "II.5.a."

6. Fill the next twenty (20) feet above the bentonite/cement fill with neat cement.
7. The remaining six (6) feet shall be filled with native soil.

Note:
a. For wells with a depth to the water table greater than thirty-one (31) feet, the total depth of fill for item "II.5" will be equal to DWT less thirty-one (31) feet.
b. For shallow wells with a depth to the water table greater than eleven (11) feet, but less than thirty-one (31) feet above the water table, item "II.5" will not be included.
c. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, items "II.5" and "II.6" will not be included.
d. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "II.4", "II.5" and "II.6" will not be included.

General Notes:

a. The driller shall submit a well abandonment plan following the above procedure to Guam EPA for review/approval.
b. The driller shall notify Guam EPA administrator 48 hours prior to starting date of the the approved abandonment plan.
c. All above-ground materials shall be removed from the well site and disposed in a manner that conforms to the Guam EPA's solid waste regulations.
d. If a well is in an area that is covered with asphalt or concrete that is not to be removed (such as a parking lot or a driveway/street), the native soil fill may be excluded and the well may be filled to the top with neat cement and then covered with new asphalt or concrete.

Attachment I-C-1-2
DOH Abandonment of Monitoring Well Summary Report Form

Abandonment of Monitoring Well Summary Report

___________________ (Monitoring Well ID)

Submit form within 30 days of well abandonment or within 90 days if included in a site closure, monitoring, or investigation report. In addition, submit copies of the original boring log and well construction diagram for the monitoring well, a site map showing the location of the abandoned monitoring well, and the disposal documentation for wastes generated during the abandonment process. Submit all documentation to: Hawaii Department of Health, Hazard Evaluation and Emergency Response Office, Attention: SDAR, 919 Ala Moana Blvd, Rm. 206, Honolulu Hawaii 96814.

Location Information	Owner Information
Facility Name:	Well Owner:
Facility Address:	Contact Person:
	Mailing Address:
Latitude:	
Longitude:	Phone Number: Fax Number:
TMK:	Land Owner:
Location Description:	Contact Person:
	Mailing Address:
Monitoring Well Location Map Attached: Y N	Phone Number: Fax Number:

Well Construction Information	
Date of Installation:	Casing Material: Casing Diameter:
Drilling Company:	Casing Length: Casing Depth:
Total Depth:	Screen Material: Slot Size:
Depth to Water:	Screen Length: Screen Depth:
Was the Well Set in an Aquifer that is a Current or Potential	Annular Material: Depth:
Drinking Water Source: Y N	Annular Material: Depth:
Boring Log/Well Construction Diagram Attached: Y N	Annular Material: Depth:

General Abandonment Information	
Drilling Firm:	Consulting Firm:
Contact Person:	Contact Person:
Mailing Address:	Mailing Address:
Phone Number: Fax Number:	Phone Number: Fax Number:

Well Abandonment Information	
Date of Abandonment:	Sealing Material: Depth:
Reason for Abandonment:	Volume/Weight/Bags Mixing Ratio:
Casing/Screen Removed: Y N	Sealing Material: Depth:
If Yes, was annular material removed?: Y N	Volume/Weight/Bags Mixing Ratio:
If No, was casing cut off below the surface?: Y N	Method of Sealing Material Placement:
Comments:	
Driller's Signature:	Date:
Consultant's Signature:	Date:

Monitoring Well Development

1. Purpose

This section describes the standard operating procedures for monitoring well development to be used by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these monitoring well development procedures are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well development shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedure

5.1 Introduction

Well development procedures are crucial in preparing a well for sampling. They enhance the flow of groundwater from the formation into the well and remove the clay, silt, and other fines from the formation so that produced water will not be turbid or contain suspended matter that can interfere with chemical analyses. A monitoring well should be a “transparent” window into the aquifer from which samples can be collected that are truly representative of the quality of water that is moving through the formation.

The goal of well development is to restore the area adjacent to a well to its natural condition by correcting damage to the formation during the drilling process. Well development shall accomplish the following tasks:

- Remove a filter cake or any drilling fluid within the borehole that invades the formation.
- Remove fine-grained material from the filter pack.
- Increase the porosity and permeability of the native formation immediately adjacent to the filter pack.

Well development shall not occur until 24 hours after the completion of well installation to allow the annular seal to fully set up.

5.2 FACTORS AFFECTING MONITORING WELL DEVELOPMENT

5.2.1 Type of Geologic Materials

Different types of geologic materials are developed more effectively by using certain development methods. Where permeability is greater, water moves more easily into and out of the formation and development is accomplished more quickly. Highly stratified deposits are effectively developed by methods that concentrate on distinct portions of the formation. If development is performed unevenly, a groundwater sample will likely be more representative of the permeable zones. In uniform deposits, development methods that apply powerful surging forces over the entire screened interval will produce satisfactory results.

5.2.2 Design and Completion of the Well

Because the filter pack reduces the amount of energy reaching the borehole wall, it must be as thin as possible if the development procedures are to be effective in removing fine particulate material from the interface between the filter pack and natural formation. Conversely, the filter pack must be thick enough to ensure a good distribution of the filter pack material during emplacement. The general rule is that filter pack material must be at least 2 inches thick.

The screen slot size must be appropriate for the geologic material and filter pack material in order for development to be effective. If slot size is too large, the removal of too much sediment may cause settlement of overlying materials and sediment accumulation in the casing. When screen openings are too small, full development may not be possible and well yield will be below the potential of the formation. Additionally, incomplete development coupled with a narrow slot size can lead to blockage of the screen openings.

5.2.3 Drilling Method

The drilling method influences development procedure. Typical problems associated with specific drilling methods include the following:

- If a mud rotary method is used, mud cake builds up on the borehole wall and must be removed during the development process.

- If drilling fluid additives have been used, the development process must include an attempt to remove all fluids that have infiltrated into the native formation.
- If driven casing or hollow-stem auger methods have been used, the interface between the casing or auger flights and the natural formation may have been smeared with fine particulate matter that must be removed during the development process.
- If an air rotary method has been used in rock formations, fine particulate matter is likely to build up on the borehole walls and may plug pore spaces, bedding planes, and other permeable zones. These openings must be restored during the development process.

5.3 PREPARATION

In preparing for monitoring well development, development logs for any other monitoring wells in the vicinity should be reviewed to determine the general permeability of the water-bearing formation and the appropriate development method.

Depth to groundwater and information from the well construction log should be used in calculating the required quantity of water to be removed. The distance between the equilibrated water level and the bottom of the screen is the saturated section. The saturated section (feet) multiplied by the unit well volume per foot (gallons/linear foot) equals the gallons required to remove one total well volume of water. The unit well volume is the sum of the casing volume and the filter pack pore volume, both of which depend upon casing and borehole diameter and the porosity of the filter pack material. Well volume can be calculated using Table I-C-2-1, Table I-C-2-2, or Table 1-C-2-3.

Table I-C-2-1: Casing Volume*

Casing Diameter (inches)	Volume (gallon/linear foot)
2	0.16
4	0.65
6	1.47

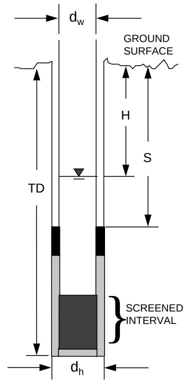
Table I-C-2-2: Filter Pack Pore Volume

Casing Diameter (inches)	Borehole Diameter (inches)	Volume [a] (gallon/linear foot)
2	6	0.52
2	8	0.98
4	10	1.37
4	12	2.09
6	12	1.76

* The above two volumes must be added together to obtain one unit well volume.
[a] Assumes a porosity of 40% for filter pack.

Table I-C-2-3: Well Volume Calculation

HOLE DIAMETER	d_h	=	
WELL CASING **INSIDE DIAMETER**	d_wID	=	
OUTSIDE DIAMETER	d_wOD	=	_____
DEPTH TO: **WATER LEVEL**	H	=	
BASE OF SEAL	S	=	_____
BASE OF WELL	TD	=	
EST. FILTER PACK POROSITY	P	=	_____



WELL VOLUME CALCULATION:

$$\text{CASING VOLUME} = V_c = \Pi\left(\frac{d_w ID}{2}\right)^2 (TD - H) = 3.14\left(\frac{\_\_}{2}\right)^2 (\_\_\_\_ - \_\_\_\_) = \_\_\_\_\_\_$$

$$\text{FILTER PACK PORE VOLUME} = V_f = \Pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_w OD}{2}\right)^2\right](TD - (S \text{ or } H^*)(P) = \_\_\_\_\_\_$$

$$(^* \text{if } S > H, \text{use } S; \text{ if } S < H, \text{use } H)$$

$$= 3.14\left[\left(\frac{\_\_\_\_}{2}\right)^2 - \left(\frac{\_\_\_\_}{2}\right)^2\right](\_\_\_ - \_\_\_)(\_\_\_\_) = \_\_\_\_\_\_$$

$$\text{TOTAL WELL VOLUME} = VT = Vc + Vf = \_\_\_\_ + \_\_\_\_ = \_\_\_\_\_\_ \text{ ft.}^3 \times 7.48 = \_\_\_\_\_\_ \text{ gal.}$$

5.4 DECONTAMINATION

The purpose of decontamination of development equipment is to prevent cross-contamination between monitoring wells. Use disposable equipment where appropriate. Use a steam-cleaner, if available, to decontaminate development equipment. Clean the equipment away from the monitoring well in such a fashion that decontamination effluent can be intercepted and drummed.

A triple rinse decontamination procedure is acceptable for equipment, such as bailers, or if access to a steam cleaner is not possible (Procedure I-F, *Equipment Decontamination*).

During well development, place visqueen around the well to prevent contamination at ground surface. Properly dispose of this sheeting after each use.

5.5 WELL DEVELOPMENT MONITORING

Throughout the well development process, maintain a development record using the form presented in Attachment I-C-2-1. The record should include the following information:

- General:
  - Project name and number
  - Well name/number and location
  - Date, time, and weather conditions
  - Names of personnel involved
- Development volume:
  - Initial and final water level
  - Casing total depth and diameter
  - Borehole diameter
  - Casing volume, filter pack pore volume, total well volume
  - Volume of water to be evacuated
  - Method and rate of removal
  - Appearance of water before and after development
- Monitoring data for each sample point:
  - Date, time, elapsed time
  - Cumulative gallons removed, removal method, removal rate
  - Temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, turbidity, dissolved oxygen, redox potential, and salinity

Part of the well development procedure shall consist of acquisition and analysis of water samples at appropriate intervals considering the total quantity of water to be removed. Measure conductivity, pH, temperature, dissolved oxygen, redox potential, turbidity, and salinity in each sample using a multi-parameter meter and flow-through cell. Collect readings on a periodic basis (approximately every 3 to 5 minutes) during development and obtain at least one reading after removal of each well volume. At the time each sample is analyzed, record the cumulative water removed, the time, the time elapsed during development, and calculated flow rate. Continue development until at least 3 borehole volumes have been removed, turbidity stabilizes at or below 5 nephelometric turbidity units, and three successive readings of the parameters have stabilized (values within 10 percent of each other). If stabilization has not been attained, if turbidity remains high, or if the well does not readily yield water, allow the water level in the well to recover, conduct an additional 15 minutes of mechanical surging and/or bailing, then continue development until stabilization can be achieved or for a reasonable time.

Section 5.7 describes well development in special situations, such as low yield formations and 2-inch wells.

5.6 METHODS OF MONITORING WELL DEVELOPMENT

The methods available for the development of monitoring wells have been inherited from production well practices. Methods include: (1) mechanical surging with a surge block or swab, and (2) surge pumping. Development methods using air or jetting of water into the well are generally inappropriate for development of monitoring wells due to the potential for affecting water quality.

Containerize and appropriately label all development water (unless it is permissible to discharge it on site). All development efforts must utilize mechanical surging or surge pumping, followed by bailing or groundwater removal with a pump. More detailed descriptions of appropriate development methods are presented below.

5.6.1 Mechanical Surging and Bailing

For mechanical surging and bailing, a surge block or swab is operated either manually or by a drill rig. The surge block or swab should be vented and be of sufficient weight to free-fall through the water in the well and create a vigorous outward surge. The equipment lifting the tool must be strong enough to extract it rapidly. A bailer is then used to remove fine-grained sediment and groundwater from the well.

Procedures:

1. Properly decontaminate all equipment entering the well.
2. Record the static water level and the total well depth.
3. Lower the surge block or swab to the top of the screened interval.
4. Operate in a pumping action with a typical stroke of approximately 3 feet.
5. Gradually work the surging downward through the screened interval during each cycle.
6. Surge for approximately 10 to 15 minutes per cycle.
7. Remove the surge block and attach the bailer in its place.
8. Bail to remove fines loosened by surging until the water appears clear.

9. Repeat the cycle of surging and bailing at least three times or until turbidity is reduced and stabilization of water quality parameters occurs.
10. The surging shall initially be gentle and the energy of the action should gradually increase during the development process.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.
+ It affects the entire screened interval.
+ It effectively removes fines from the formation and the filter pack.
– It might cause upward movement of water in the filter pack that could disrupt the seal.
– Potential exists for damaging a screen with a tight-fitting surge block or with long surge strokes.

5.6.2 Surge Pumping

Procedures:

1. Properly decontaminate all equipment entering the well.
2. Record the static water level and the total well depth.
3. Lower a submersible pump or airlift pump without a check valve to a depth within 1 to 2 feet of the bottom of the screened section.
4. Start pumping and increase discharge rate to maximum capacity (overpumping), causing rapid drawdown of water in the well.
5. Periodically stop and start the pump, allowing the water in the drop pipe to fall back into the well and surge the formation (backwashing), thus loosening particulates.
6. The pump intake shall be moved up the screened interval in increments appropriate to the total screen length.
7. At each pump position, the well shall be pumped, overpumped, and backwashed alternately until satisfactory development has been attained as demonstrated by reduction in turbidity and stabilization of water quality parameters.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.
+ It effectively removes fines from the formation and filter pack.
– The pump position or suction line must be changed to cover the entire screen length.

– Submersible pumps suitable to perform these operations may not be available for small diameter (1 inch or less) monitoring wells.

– It is not possible to remove sediment from the well unless particle size is small enough to move through the pump.

For additional information on well development, consult the references included in Section 8 of this procedure.

5.7 SPECIAL SITUATIONS

5.7.1 Development of Low Yield Wells

Development procedures for monitoring wells in low-yield (<0.25 gallons per minute), water-bearing zones are somewhat limited. Due to the low hydraulic conductivity of the materials, surging of water in and out of the well casing is difficult. Also, the entry rate of water is inadequate to remove fines from the well bore and the gravel pack when the well is pumped. Additionally, the process may be lengthy because the well can be easily pumped dry and the water level is very slow to recover.

Follow the procedures for mechanical surging and bailing for low yield wells. During surging and bailing, wells in low yield formations should be drawn down to total depth twice, if possible. Development can be terminated, however, if the well does not exhibit 80 percent recovery after 3 hours.

5.7.2 Development of 2-inch Wells

It is easier to develop monitoring wells that are large in diameter than small diameter wells. Mechanical surging or bailing techniques that are effective in large diameter wells are much less effective when used in wells 2 inches or less in diameter. Mechanical surge blocks and bailers have a high potential for damaging a small diameter well. As a result, the CTO Manager shall obtain approval from the QA Manager or Technical Director prior to installing groundwater monitoring wells with inside diameters of 2 inches or less.

Develop two-inch or smaller diameter wells by surging with a specially designed, hand-operated surge block or by pumping with a bladder or airlift pump. Information related to development of wells 2 inches or less in diameter shall be included in the CTO work plan.

6. Records

Well development information should be documented in indelible ink on well development monitoring forms (Attachment I-C-2-1). Copies of this information shall be sent to the CTO Manager and to the project files. The CTO Manager shall review all well development logs on a minimum monthly basis.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-F, *Equipment Decontamination.*

9. Attachments

Attachment I-C-2-1: Well Development Record

Attachment I-C-2-1
Well Development Record

WELL DEVELOPMENT LOG

PROJECT	WELL ID	SITE	PREPARED BY

METHOD
- OVERPUMPAGE ☐
- BAILER ☐
- SURGE BLOCK ☐
- AIR LIFT ☐
- OTHER __________

INITIAL WATER LEVEL:
INITIAL TOTAL DEPTH:

FINAL WATER LEVEL:
FINAL TOTAL DEPTH:

REMARKS:

*CAPACITY OF CASING (GALLONS/LINEAR FOOT)

1" - 0.012
2" - 0.16
4" - 0.65
6" - 0.1.47

*VOLUME BETWEEN CASING AND HOLE (GALLONS/LINEAR FOOT) (ASSUMING 40% POROSITY)

1" CASING AND 2" HOLE - 0.013
2" CASING AND 6" HOLE - 0.52
2" CASING AND 8" HOLE - 0.98
4" CASING AND 10" HOLE - 1.37
4" CASING AND 12" HOLE - 2.09

*The two volumes for the saturated portion of the well must be added together to obtain one unit well volume.

DEVELOPMENT LOG:					CUMULATIVE WATER REMOVED	WATER QUALITY							COMMENTS
DATE	TIME	METHOD	ELAPSED TIME	FLOW RATE (gpm)	GALLONS	pH	TEMP (°C)	SP. COND (mS/cm)	DO (mg/L)	ORP (mV)	TURBIDITY (ntu)	SALINITY (ppt)	

DO dissolved oxygen
ORP oxidation-reduction potential

Monitoring Well Sampling

1. Purpose

This standard operating procedure describes the monitoring well sampling procedures to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard groundwater sampling activities are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager or designee shall review all groundwater sampling forms on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

Minimum qualifications for sampling personnel require that one individual on the field team shall have a minimum of 1 year experience with sampling monitoring wells.

The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the QA Manager or Technical Director and then documented in the field logbook and associated report or equivalent document.

5. Procedures

5.1 PURPOSE

This procedure establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples of aquifer conditions with as little alteration of water chemistry as possible.

5.2 PREPARATION

5.2.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well history data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records (including depth of screened interval), well development methods, previous analytical results, presence of an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling, and water level measurement collection shall proceed from the least contaminated to the most contaminated as indicated in previous analytical results. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

5.2.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of QA/quality control (QC) samples to be collected (Procedure III-B, *Field QC Samples [Water, Soil]*), as well as the type and volume of sample preservatives, the number of sample containers (e.g., coolers), and the quantity of ice or other chilling materials. The sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. Document the analytical requirements for groundwater analysis in the project-specific work plan.

5.3 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling procedures at a site shall include: (1) measurement of well depth to groundwater; (2) assessment of the presence or absence of an immiscible phase; (3) assessment of purge parameter stabilization; (4) purging of static water within the well and well bore; and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events.

5.3.1 Measurement of Static Water Level Elevation

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Mark each well with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed.

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. Measure water levels twice in quick succession and record each measurement. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Measure the water level in each well immediately prior to purging the well.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

5.3.2 Decontamination of Equipment

Establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled and far enough from potential contaminant sources to avoid contamination of clean equipment. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in Procedure I-F, *Equipment Decontamination*.

Decontaminate each piece of equipment prior to entering the well. Also conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without onsite decontamination.

5.3.3 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL, as necessary, before the well is evacuated for conventional sampling:

1. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a photoionization detector or an organic vapor analyzer (flame ionization detector), and record the measurements.

2. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
3. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
4. In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error, and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water-table contour maps until they are corrected for depression by the product.

If the well contains an immiscible phase, it may be desirable to sample this phase separately. Sections 5.3.5.1 and 5.3.5.2 present immiscible phase sampling procedures. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the CTO Manager and QA Manager or Technical Director if this situation is encountered.

5.3.4 Purging Equipment and Use

The water present in a well prior to sampling may not be representative of *in situ* groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the investigation-derived waste (IDW) handling procedures in Procedure I-A-6, *Investigation-Derived Waste Management*.

Purging shall be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. Environmental Protection Agency (EPA) (EPA 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/min. The EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. The EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. The goal is minimal drawdown (less than 0.1 meter) during purging (EPA 1996). The amount of drawdown during purging should be recorded at the same time the other water parameters are measured. Also, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells shall not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable.

In high yield wells (wells that exhibit 80 percent recovery in less than 2 hours), purging shall be conducted at relatively low flow rates and shall remove water from the entire screened interval of the well to ensure that fresh water from the formation is present throughout the entire saturated interval. In general, place the intake of the purge pump 2 to 3 feet below the air-water interface within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified.

Low yield wells (those that exhibit less than 80 percent recovery in less than 2 hours) require one borehole volume of water to be removed. Allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis (approximately every 5 minutes) during well evacuation and analyze them in the field preferably using a multi-parameter meter and flow-through cell for temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), turbidity, salinity, and total dissolved solids (TDS). Take at least five readings during the purging process. These parameters are measured to demonstrate that the natural character of the formation water has been pumped into the well. Purging shall be considered complete when three consecutive sets of field parameter measurements stabilize within approximately 10 percent (EPA 2006). However, suggested ranges are ±0.2 degrees Celsius for temperature, ±0.1 standard units for pH, ±3 percent for specific conductance, ±10 percent for DO, and ±10 millivolts for redox potential (ASTM 2001). This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process including drawdown, into a groundwater sampling log (Figure I-C-3-1). Complete all blanks on this field log during sampling.

In cases where an LNAPL has been detected in the monitoring well, insert a stilling tube of a minimum diameter of 2 inches into the well prior to well purging. The stilling tube shall be composed of a material that meets the performance guidelines for sampling devices. Insert the stilling tube into the well to a depth that allows groundwater from the screened interval to be purged and sampled, but that is below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, insert the stilling tube into the well in a manner that prevents the LNAPL from entering the stilling tube. However, sampling groundwater beneath a NAPL layer is not generally recommended due to the fact that the interval with residual NAPL saturation is often unknown and the NAPL can be mobilized into the well from intervals below the water table.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. Slowly lower the stilling tube into the well to the appropriate depth and then attach it firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. Firmly fasten the membrane or material that is used to cover the end of the stilling tube so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off of the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required, based on the site-specific situation. Thoroughly decontaminate stilling tubes prior to each use. Collect groundwater removed during purging, and store it on site until its disposition is determined based upon laboratory analytical results. Storage shall be in secured containers, such as U.S. Department of Transportation-approved drums. Label containers of purge water with the standard NAVFAC Pacific ER Program IDW label.

The following paragraphs list available purging equipment and methods for their use.

5.3.4.1 BAILERS AND PUMPS

Submersible Pump: A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling groundwater for volatile, semivolatile, and non-volatile constituents. For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to over stressing of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to the placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to keep water from flowing back down the drop pipe into the well. Place the pump intake approximately 2 to 3 feet below the air-water interface within the well and maintain it in that position during purging. Additionally, when pulling the pump out of the well subsequent to purging, take care to avoid dumping water within the drop pipe and pump stages back into the well.

Bladder Pump: A stainless steel and/or Teflon bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Additionally, the bladder pump can be used for purging and obtaining groundwater samples overlain by a LNAPL layer as long as care is taken not to draw the product layer into the bladder pump. Use of the bladder pump is most effective in low to moderate yield wells.

Either a battery powered compressor, compressed dry nitrogen, or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use. Once purging is complete, collect the samples directly from the bladder pump.

Centrifugal or Diaphragm Pump: A centrifugal, or diaphragm, pump may be used to purge a well if the water level is within 20 feet of ground surface. A new, or properly decontaminated, hose is lowered into the well and water withdrawn at a rate that does not cause excessive well drawdown.

GROUNDWATER SAMPLING LOG

WELL NO. ______________ LOCATION: ______________ PROJECT NO. ______________

DATE: TIME: ______________ CLIMATIC CONDITIONS: ______________

TIDAL CONDITIONS: Rising ☐ Falling ☐ HIGH TIDE: LOW TIDE: CURRENT TIDE:

STATIC WATER LEVEL (FT.) and TIME: ______________ TOTAL DEPTH (FT.): ______________

WELL PURGING: LENGTH OF SATURATED ZONE: ______________ LINEAR FT.

a VOLUME OF WATER TO BE EVACUATED: _______ GALS. (Gals/Linear ft. X linear feet of saturation X 3-casing volumes)

METHOD OF REMOVAL: ______________ PUMPING RATE: mL/min

WELL PURGE DATA:

DATE/ TIME	DTW	GALLONS REMOVED	TDS (g/L)	pH	SP. COND. (mS/cm)	D.O. (mg/L)	TURB. (NTU)	TEMP. (°C)	ORP (mV)	SAL (ppt)

SAMPLE WITHDRAWAL METHOD: ______________

APPEARANCE OF SAMPLE: COLOR: ______________

SEDIMENT: ______________

OTHER: ______________

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES ______________

NUMBER AND TYPES OF SAMPLE CONTAINERS USED: ______________

SAMPLE IDENTIFICATION NUMBER(S) ______________

DECONTAMINATION PROCEDURES: ______________

NOTES: ______________

SAMPLED BY: ______________

SAMPLES DELIVERED TO: ______________ TRANSPORTER: ______________

DATE: ______________ TIME: ______________

CAPACITY OF CASING (GALLONS/LINEAR FOOT)
2"-0.16•4"-0.65•6"-1.47•8"-2.61•10"-4.08•12"-5.87

Figure I-C-3-1: Groundwater Sampling Log

Place the hose bottom approximately 2 to 3 feet below the air-water interface and maintain it in that position during purging.

Air Lift Pump: Airlift pumps are not appropriate for purging or sampling.

Bailer: Avoid using a bailer to purge a well because it can result in aeration of the water in the well and possibly cause excessive purge rates. If a bailer must be used, decontaminate the bailer, bailer wire, and reel as described in Section 5.3.2 prior to its use. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well. The QA Manager or Technical Director shall approve use of bailers for purging monitoring wells in advance.

5.3.5 Monitoring Well Sampling Methodologies

5.3.5.1 Sampling Light, Non-Aqueous Phase Liquids (LNAPL)

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with the LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well, and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. When using bailers to collect LNAPL samples for inorganic analyses, the bailer shall be composed of fluorocarbon resin. Bailers used to collect LNAPL samples for organic analyses shall be constructed of stainless steel. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

5.3.5.2 Sampling Dense, Non-Aqueous Phase Liquids (DNAPL)

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

5.3.5.3 Groundwater Sampling Methodology

The well shall be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton is not acceptable. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or single strand stainless steel wire) shall be used to raise and lower the bailer. Generally, bladder and submersible pumps are acceptable sampling devices for all analytical parameters. Dedicated equipment is highly recommended for all sampling programs. The following text describes sampling methods utilizing submersible pumps, bladder pumps, and bailers.

Submersible Pumps: When operated under low-flow rate conditions (100 to 300 milliliters [mL]/minute or less), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 300 mL/minute may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

Bladder Pumps: A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

Most models of bladder pumps can be operated with a battery powered compressor and control box. The compressor can be powered with either a rechargeable battery pack (provided with the compressor), by running directly off of a vehicle battery (via alligator clips), or by plugging into the vehicle's direct current connector (cigarette lighter receptacle). When using a vehicle to power a compressor, several precautions should be taken. First, position the vehicle downwind of the well. Second, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the compression hose from the well cap to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs so as to discharge water at a flow rate (purge rate) that minimizes drawdown in the well, usually around 100 to 300 mL/minute. The compressor should not be set as to discharge the water as hard as possible. The optimal setting is one that produces the required purge rate per minute (not per purge cycle) while maintaining a minimal drawdown.

Prior to sampling volatiles constituents, turn off the vehicle engine, and obtain a flow rate of 100 mL/minute so as not to cause fluctuation in pH, pH-sensitive analytes, the loss of volatile constituents, or draw down of the groundwater table. If necessary (when sampling wells that require a large sample volume) the vehicle engine may be turned back on after sampling volatile constituents. Higher flow rates (100 to 300 mL/minute) can be used once the samples for the analysis of volatile components have been collected, but should not allow for increased draw down in the well. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, DO, specific conductivity, and reduction/oxidation (redox).

For those samples requiring filtration, it is recommended to use in-line high capacity filters after all nonfiltered samples have been collected.

Bailers: A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The QA Manager or Technical Director must approve the use of bailers for groundwater sampling in advance.

Thoroughly decontaminate the bailer before being lowering it into the well if it is not a disposable bailer sealed in plastic. Collect two to three rinse samples and discharge them prior to acquisition of the actual sample. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

The preferred alternative when using bailers for sampling is to use disposable Teflon bailers equipped with bottom-discharging devices. Use of disposable bailers reduces decontamination time and limits the potential for cross-contamination.

Passive Sampling: Passive samplers include passive diffusion bags, HydraSleeve, Snap Sampler, Gore Sorbers, and rigid porous polyethylene samplers. Passive samplers generate minimal waste and purge water, if any. Passive samplers depend on ambient equilibrium with formation water. These are relatively inexpensive, simple to deploy and work well for low-yield wells. However, passive samplers have volume and or analyte limitations and may require consideration of contaminant stratification. Passive samplers should be handled in accordance with the manufacturer's instructions, Army guidance (USACE 2002), or ITRC guidance (ITRC 2007).

5.3.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, preserve samples. The EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846* (EPA 2007), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field team may add preservatives in the field. Sample containers should be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody*.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the CTO-specific work plan. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. An analytical laboratory shall provide these vials, preferably by the laboratory that will perform the analysis. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the investigator shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles form most of the time. Field logs and laboratory analysis reports shall note any headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

5.3.6.1 SPECIAL HANDLING CONSIDERATIONS

Samples requiring analysis for organics shall not be filtered. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples shall be handled and analyzed in the same manner as VOC samples.

Obtain groundwater samples to be analyzed for metals sequentially. One sample shall be obtained directly from the pump and be unfiltered. The second sample shall be filtered through a 0.45-micron membrane in-line filter. Both filtered and unfiltered samples shall be transferred to a container, preserved with nitric acid to a pH less than 2, and analyzed for dissolved metals. Remember to include a filter blank for each lot of filters used and always record the lot number of the filters. In addition, allow at least 500 mL of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

5.3.6.2 FIELD SAMPLING PRESERVATION

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples, and may require normalization of results. Guidance for the preservation of environmental samples can be found in the EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other EPA documents (EPA 1992, 1996).

5.3.6.3 FIELD SAMPLING LOG

A groundwater sampling log (Figure I-C-3-1) shall document the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis

- Field analysis data
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature

6. Records

Document information collected during groundwater sampling on the groundwater sampling log form in indelible ink (Figure I-C-3-1). Send copies of this information to the CTO Manager and to the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 2001. *Standard Guide for Sampling Ground-Water Monitoring Wells*. D4448). Reapproved in 2013). West Conshohocken, PA.

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United States Army Corps of Engineers (USACE). 2002. *Study of Five Discrete Interval-Type Groundwater Sampling Devices*. Cold Regions Research and Engineering Laboratory. Hanover, NH. August.

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Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody.*

9. Attachments

None.

Drum Sampling

1. Purpose

This standard operating procedure describes the methods by which United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel will sample drum(s) at hazardous waste and non-hazardous waste sites. Prior to disturbing and handling drums of unknown origin and/or with unknown contents, approval from the Navy will be required.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program. As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that drums of concern are handled and sampled according to this procedure. The CTO Manager is responsible for ensuring that all personnel involved in drum sampling have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that these procedures and the work plan (WP) are followed when drums are sampled.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 Method Summary

Prior to sampling, drums should be inventoried, staged, and opened. Inventorying entails recording the visible qualities of each drum and any characteristics pertinent to classification of the contents. Staging involves the organization, and sometimes consolidation, of drums containing similar wastes or that share characteristics. Closed drums may be opened manually or remotely. In the interest of worker safety, it is required to open drums remotely unless the drum contents are known not to present any potential physical or chemical threat to workers. Analytical results from associated field samples may be used to evaluate potential threats. The most widely used method of sampling a drum containing liquids involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and does not require decontamination. Additional information related to drum sampling is available in Section 8, References.

5.2 Interference and Potential Problems

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used. Any necessary air monitoring should be conducted when working near over-pressurized drums.

Do not move drums that are over-pressurized to the extent that the head is swollen several inches above the level of the chime (the protruding rings at the top and bottom of the drum). A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum, and the gas vents along the grooves. The venting should be done remotely (e.g., using a backhoe bucket) from behind a wall or barricade. Once the pressure has been relieved, the bung can be removed and the drum sampled. It is necessary that personnel experienced in sampling of over-pressurized or unknown drum contents, or known hazardous waste contents, perform this task. If project team personnel are not experienced in this type of sampling, it is recommended that a subcontractor experienced in this type of sampling implement this portion of the sampling.

5.3 Equipment/Apparatus

The following are standard materials and equipment required for sampling:

- An approved site-specific sampling plan and health and safety plan (HSP)
- Personal protection equipment
- Sample containers appropriate for the matrix being sampled
- Uniquely numbered sample identification labels
- One-gallon covered cans half-filled with absorbent packing material, to be used as necessary to hold waste
- Chain-of-custody sheets
- Decontamination equipment (Procedure I-F, *Equipment Decontamination*.)
- Glass thieving tubes, composite liquid waste sampler (COLIWASA), or equivalent
- Drum-opening devices
- Monitoring equipment for the detection of toxic and explosive environments, whenever the contents are not known

5.3.1 Drum-Opening Devices

5.3.1.1 Bung Wrench

A common method for opening drums manually is using a universal bung wrench. The fittings on a bung wrench are made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium, non-sparking alloy. The use of a non-sparking wrench does not eliminate the possibility of producing a spark.

5.3.1.2 Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to partially or completely cut off the lid of a drum by means of scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums. Drums with removable heads or over-pressurized drums should be opened by other means.

5.3.1.3 Backhoe Spike

The most common means of opening drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

5.3.1.4 Hydraulic Drum Opener

Hydraulic drum openers use hydraulic pressure to pierce the drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line attached to a metal point that pierces the side or head of the drum.

5.3.1.5 Pneumatic Devices

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system positions and aligns the pneumatic drill over the bung. The bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. The pneumatic bung opener does not permit the slow venting of the container, and therefore, appropriate precautions must be taken. The pneumatic bung opener also requires the container to be upright and relatively level. This device cannot remove bungs that are rusted shut.

5.4 Sampling Procedure

5.4.1 Drum Staging

Prior to sampling, stage the drums (if not already staged) for easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum with unknown contents or visibly over-pressurized should explode or catch fire when opened.

During staging, physically separate the drums into the following categories: those containing liquids; those containing solids; lab packs; gas cylinders; and those that are empty. The strategy for sampling and handling drum/containers in each of these categories will be different. Categories are determined by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open top drums. Closed head drums with a bung opening generally contain liquid.
- Visual inspection of the contents of the drum during sampling, followed by restaging, if needed.

For discovered drums that require excavation, eliminate immediate hazards by over packing or transferring the drum's contents to another suitable container, affixing with a numbered tag, and transferring to a staging area. Use color-coded tags, labels, or bands to mark similar waste types. Record a description of each drum, its condition, any unusual markings, and the location where it was buried or stored on a drum data sheet (see Attachment I-D-1-1.) This data sheet becomes the principal record-keeping tool for tracking the drum on site.

Where space allows, physically separate the unknown or suspected hazardous waste-containing or over-pressurized drum opening area from the drum removal and drum staging operations. Move drums from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

5.4.2 Drum Opening

There are three techniques for opening drums at suspected or known hazardous waste sites:

- Manual opening with non-sparking bung wrenches
- Drum deheading
- Remote drum puncturing and bung removal

The choice of drum opening technique and accessories depends on the number of drums to be opened, their waste contents, and their physical condition. Remote drum opening equipment should always be considered to protect worker safety. Under Occupational Safety and Health Administration 1910.120 (OSHA 1998), manual drum opening with bung wrenches or deheaders should be performed only on structurally sound drums whose waste contents are known not to be shock sensitive, reactive, explosive, or flammable.

5.4.2.1 Manual Drum Opening

Bung Wrench

Do not perform manual drum opening with bung wrenches unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. If opening the drum with bung wrenches is deemed reasonably cost-effective and safe, then certain procedures should be implemented to minimize the hazard:

- Field personnel should be fully outfitted with protective gear.
- Continually monitor atmospheres for toxicity, explosivity, and if applicable, radioactivity.

- Position drums upright with the bung up, or, for drums with bungs on the side, laid on their sides with the bung plugs up.
- The wrenching motion should be a slow, steady pull across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, attach a “cheater bar” to the handle to improve leverage.

5.4.2.2 DRUM DEHEADING

Do not perform drum deheading unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off, if desired. If the top chime of a drum has been damaged or badly dented, it may not be possible to cut the entire top off. Because there is always the possibility that a drum may be under pressure, make the initial cut very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote method prior to using the deheader.

Self-propelled drum openers, which are either electrically or pneumatically driven, are available and can be used for quicker and more efficient deheading.

5.4.2.3 REMOTE OPENING

Remotely operated drum opening tools are the safest available means of opening a drum. Remote drum opening is slow, but provides a high degree of safety compared to manual methods of opening.

Backhoe Spike

“Stage” or place drums in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, punching a hole in the drumhead or lid with the spike can quickly open the drums.

Decontaminate the spike after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is used, mounting a large shatter-resistant shield in front of the operator’s cage can protect the operator of the backhoe. When combined with the normal personal protection gear, this practice should protect the operator. Providing the operator with an on-board air line system affords additional respiratory protection.

Hydraulic Devices

Hydraulic devices consist of a piercing device with a metal point that is attached to the end of a hydraulic line and is pushed into the drum by hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head of the drum. Some of the metal piercing devices are hollow or tube-like so that they can be left in place, if desired, to serve as a permanent tap or sampling port. The piercing device is designed to establish a tight seal after penetrating the container.

Pneumatic Devices

Pneumatically operated devices using compressed air have been designed to remove drum bungs remotely.

5.4.3 Drum Sampling

Immediately after the drum has been opened, sample the headspace gases within the drum using an explosimeter, organic vapor analyzer, and/or a photoionization detector, and record the data on the Drum Data Sheet (see Attachment I-D-1-1) as necessary. The CTO WP shall reference procedures listed in the site HSP.

In most cases, it is impossible to observe the contents of these sealed or partially sealed drums. Because some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel. In addition, a sample of solid material collected from a drum should include the entire depth to be most representative of the drum contents.

When sampling a previously sealed drum, check for the presence of bottom sludge. This is easily accomplished by measuring the depth to apparent bottom, and then comparing it to the known interior depth.

5.4.3.1 Glass Thief Sampler

The most widely used implement for sampling liquids in a drum is a glass tube (glass thief, 6 millimeters inner diameter × 30.47 centimeters [cm] [48 inches] length). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate.

Specific Sampling Procedure Using a Glass Thief

1. Remove the cover from the sample container.
2. Slowly insert the glass tubing almost to the bottom of the drum or until a solid layer is encountered. About 1 foot of tubing should extend above the drum.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with the stopper.
5. Carefully remove the capped tube from the drum, and insert the uncapped end into the sample container. Do not spill liquid on the outside of the sample container.
6. Release the stopper, and allow the glass thief to drain completely into the sample container. Fill the container to about 2/3 of capacity.
7. Remove the tube from the sample container, carefully break it into pieces, and place the pieces in the drum.
8. Cap the sample container tightly, and place the pre-labeled sample container in a carrier.
9. Replace the bung or place plastic over the drum.
10. Transport the sample to the decontamination zone to be prepared for transport to the analytical laboratory.

In many instances, a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sampling tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

In some instances, disposal of the tube by breaking it into the drum might interfere with eventual plans for the removal of its contents. Clear this technique with NAVFAC Pacific personnel or evaluate other disposal techniques.

5.4.3.2 COLIWASA SAMPLER

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. It collects a sample from the full depth of a drum and maintains it in the transfer tube until delivery to the sample bottle. One configuration consists of a 152 cm by 4 cm-inner diameter section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The major drawbacks associated with using a COLIWASA include decontamination and cost. The sampler is difficult (if not impossible) to decontaminate in the field, and its high cost relative to alternative procedures (glass tubes) make it an impractical throwaway item. However, disposable, high-density, inert polyethylene COLIWASAs are available at a nominal cost. Although the applications of a disposable COLIWASA are limited, it is especially effective in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Open the sampler by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler’s locking block.
2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
4. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
6. Cap the sample container with a Teflon-lined cap, attach a label and seal, and record it on the sample data sheet.
7. Unscrew the T-handle of the sampler, and disengage the locking block.
8. Clean the sampler.

5.5 DRUM CLOSING

Upon completion of sampling activities, close the drums, and then store them in a secure area as described in Procedure I-A-6, *Investigation-Derived Waste Management*. If the bung opening and the bung are still intact, then close the drum by replacing the bung. In addition, open top drums that are still in good condition can be closed by replacing the top and securing the drum ring with the attached bolt.

If a drum cannot be closed in the manner discussed above, then secure it by placing it in an approved 85-gallon overpack drum (type UN 1A2/Y43/S). Fill the void spaces between the outer portion of the inner drum and the inside of the overpack drum with vermiculite to secure the drum contents to the extent possible.

5.6 Equipment Decontamination

Decontamination of sampling equipment should follow Procedure I-F, *Equipment Decontamination*.

5.7 Sample Preservation, Containers, Handling, and Storage

1. Do not add preservatives to the sample unless specifically required by the analytical method or WP.
2. Place the labeled sample container in two re-sealable plastic bags.
3. If the contents of the investigation-derived waste drum are unknown, or known to contain hazardous waste, place each bagged sample container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
4. Mark the sample identification number on the outside of the can.
5. Place the samples in a cooler, and fill the remaining space with absorbent packing material.
6. Fill out the chain-of-custody record for each cooler, place it in a re-sealable plastic bag, and affix it to the inside lid of the cooler.
7. Secure the lid of the cooler, and affix the custody seal.
9. Arrange for the appropriate transport mode consistent with the type of waste involved (hazardous or non-hazardous).

6. Records

Keep records of all sampling activities in the field notebook and on the Drum Data Sheets. Document sample custody on the chain-of-custody form. The CTO Manager shall review these documents at the completion of field activities, and, at least on a monthly basis for long-term projects.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Occupational Safety and Health Administration (OSHA). 1998. *Occupational Safety and Health Standards* (29 CFR 1910); with special attention to Section 1910.120, *Hazardous Waste Operations and Emergency Response (HAZWOPER)*. Washington, DC: United States Department of Labor.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

9. Attachments

Attachment I-D-1-1: Drum Data Sheet

Attachment I-D-1-1
Drum Data Sheet

DRUM DATA SHEET

CTO/DO #: ____________________ Date Sampled: ____________________

Drum I.D.#: ____________________ Time: ____________________

Estimated Liquid Quantity: ____________________

Original Drum Location: ____________________

Staging Location: ____________________

Sampler's Name: ____________________

Drum Condition: ____________________

Physical Appearance of the Drum/Bulk Contents: ____________________

Headspace Gas Concentration: ____________________

Odor: ____________________ Color: ____________________

pH: ____________________ % Liquid: ____________________

Laboratory Date of Analysis: ____________________

Analytical Data: ____________________

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____

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Compatibility: ____________________

Hazard: ____________________

Waste I.D.: ____________________

Treatment Disposal Recommendations: ____________________

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Soil and Rock Classification

1. Purpose

This section sets forth standard operating procedures for soil and rock classification for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil and rock classification procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual is defined as a person with a degree in geology, hydrogeology, soil science, or geotechnical/civil engineering with at least 1 year of experience classifying soil. Supervision is defined as onsite and continuous monitoring of the individual conducting soil classification. The CTO Manager is responsible for ensuring that all personnel involved in soil and rock classification have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The CTO Manager is responsible for reviewing copies of the field boring log forms on a monthly basis at a minimum. However, it is recommended that initially boring logs are reviewed daily to ensure accuracy.

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 SOIL CLASSIFICATION

The basic purpose of the classification of soil is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system for the NAVFAC Pacific ER Program. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serve as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but also a complete word description.

Describing soil on a common basis is essential so that soil described by different site qualified personnel is comparable. Site individuals describing soil as part of site activities *must* use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions, such as density/consistency, compaction, amount of induration/cementation or weathering, retention of the parent rock fabric, and structure
- USCS classification symbol

The USCS serves as “shorthand” for classifying soil into 15 basic groups:

GW[1] Well graded (poorly sorted) gravel (>50 percent gravel, <5percent fines)

GP[1] Poorly graded (well sorted) gravel (>50percent gravel, <5percent fines)

GM[1] Silty gravel (>50 percent gravel, >15 percent silt)

GC[1] Clayey gravel (>50 percent gravel, >15 percent clay)

SW[1] Well graded (poorly sorted) sand (>50 percent sand, <5 percent fines)

SP[1] Poorly graded (well sorted) sand (>50 percent sand, <5 percent fines)

SM[1] Silty sand (>50 percent sand, >15 percent silt)

SC[1] Clayey sand (>50 percent sand, >15 percent clay)

[1] If percentage of fine is 5 percent to 15 percent, a dual identification shall be given (e.g., a soil with more than 50 percent poorly sorted gravel and 10 percent clay is designated GW-GC.

ML[2] Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness, and plasticity)

CL[2] Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)

MH[2] Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)

CH[2] Inorganic, high plasticity (fat) clay (no dilatancy, high toughness, and plasticity)

OL Organic low plasticity silt or organic silty clay

OH Organic high plasticity clay or silt

PT Peat and other highly organic soil

Figure I-E-1 defines the terminology of the USCS. Flow charts presented in Figure I-E-2 and Figure I-E-3 indicate the process for describing soil. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification (e.g., SC/CL) if the soil has been identified as having properties that do not distinctly place the soil into one group.

5.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. Being proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below:

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5-inch diameter sample liner).
2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.
3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch).
4. Considering the rest of the sample, estimate, and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).
5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).
6. Estimate percentages to the nearest 5 percent. If one of the components is present in a quantity considered less than 5 percent, indicate its presence by the term “trace.”
7. The percentages of gravel, sand, and fines must add up to 100 percent. “Trace” is not included in the 100 percent total.

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[2] If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words “with sand” or “with gravel” (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30 percent or more sand or gravel, or both, the words “sandy” or “gravely” (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use “sandy.”

5.1.2 Soil Dilatancy, Toughness, and Plasticity

5.1.2.1 DILATANCY

To evaluate dilatancy, follow these procedures:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 millimeters [mm]) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
2. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table I-E-1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table I-E-1: Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

5.1.2.2 TOUGHNESS

Following the completion of the dilatancy test, shape the test specimen into an elongated pat and roll it by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, spread it into a thin layer and allow it to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, lump the pieces together and knead it until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table I-E-2.

Table I-E-2: Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread near the plastic limit. The thread and the lump have very high stiffness.

DEFINITION OF TERMS

MAJOR DIVISIONS			SYMBOLS	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	**GRAVELS** More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN GRAVELS** (Less than 6% Fines)	**GW**	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	**GM**	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN SANDS** (Less than 6% Fines)	**SW**	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	**SM**	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	**SILTS AND CLAYS** Liquid Limit is Less Than 50%		**ML**	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			CH	inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			**PT**	Peat and other highly organic soils

GRAIN SIZES

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

200 | 40 | 10 | 4 | 3/4" | 3" | 12"

U.S. STANDARD SERIES SIEVE | CLEAR SQUARE SIEVE OPENINGS

Figure I-E-1: Unclassified Soil Classification System (USCS)

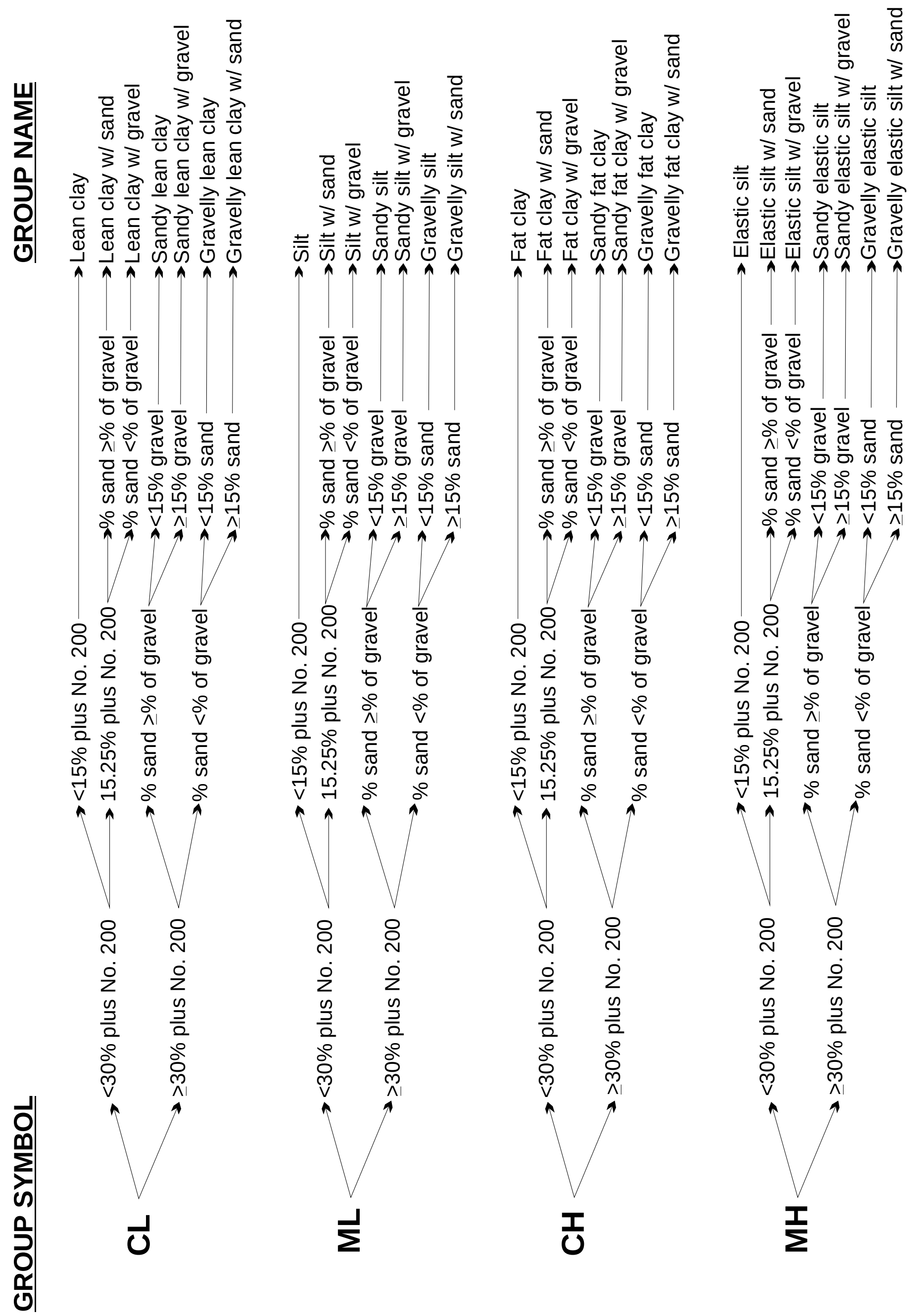

Figure I-E-2: Flow Chart for Fine Grain Soil Classification

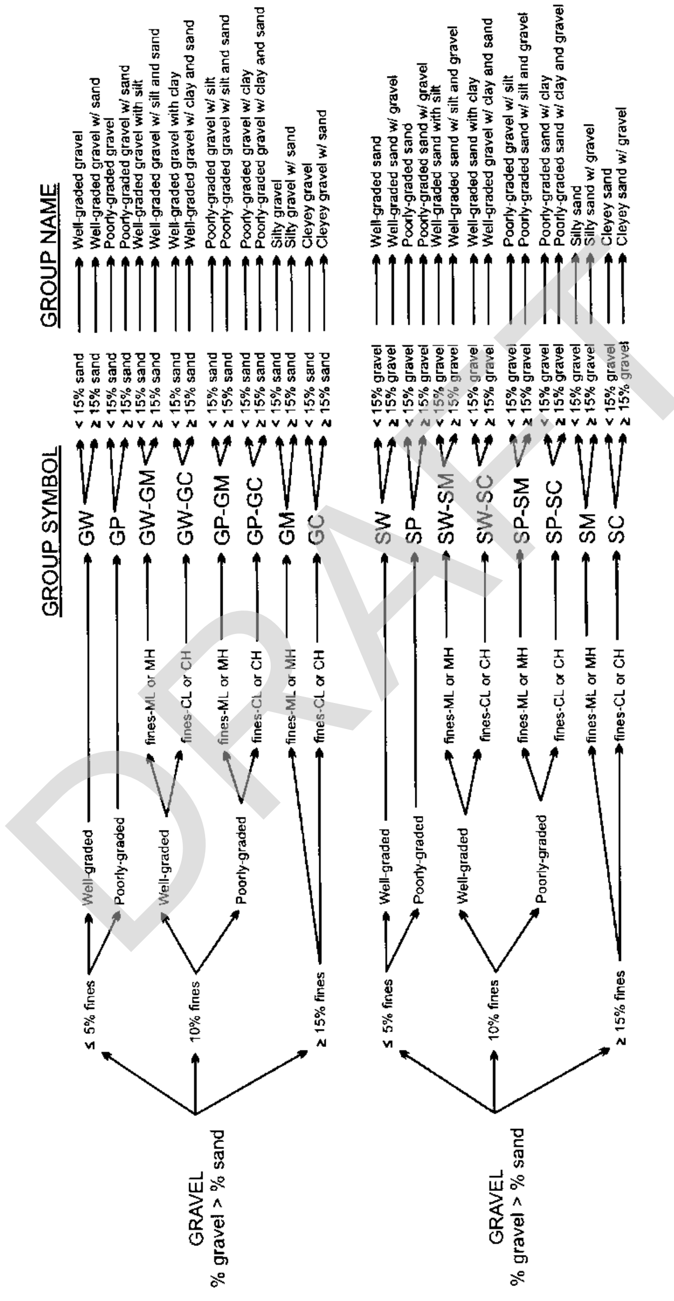

Figure I-E-3: Flow Chart for Soil with Gravel

5.1.2.3 PLASTICITY

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials is defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content, but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, add water prior to performing classification. If a soil sample is too sticky, spread the sample thin and allow it to lose some soil moisture.

Table I-E-3 presents the criteria for describing plasticity in the field using the rolled thread method.

Table I-E-3: Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low Plasticity	The thread can barely be rolled.
Medium Plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High Plasticity	It takes considerable time rolling the thread to reach the plastic limit.

5.1.3 Angularity

The following criteria describe the angularity of the coarse sand and gravel particles:

- *Rounded* particles have smoothly-curved sides and no edges.
- *Subrounded* particles have nearly plane sides, but have well-rounded corners and edges.
- *Subangular* particles are similar to angular, but have somewhat rounded or smooth edgesand.
- *Angular* particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

5.1.4 Color, Moisture, and Odor

The natural moisture content of soil is very important. Table I-E-4 shows the terms for describing the moisture condition and the criteria for each.

Table I-E-4: Soil Moisture Content Qualifiers

Qualifier	Criteria
Dry	Absence of moisture, dry to the touch
Moist	Damp but no visible water
Wet	Visible water, usually soil is below water table

Color is described by hue and chroma using the Munsell Soil Color Chart (Munsell 2000). For uniformity, all site geologists shall use this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists The Munsell Color Chart is a small booklet of numbered color chips with names like “5YR 5/6, yellowish-red.” Note mottling or banding of colors. It is particularly important to note and describe staining because it may indicate contamination.

In general, wear a respirator if strong organic odors are present. If odors are noted, describe them if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer may be used to detect the presence of volatile organic contaminants.

5.1.5 In-Place Conditions

Describe the conditions of undisturbed soil samples in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

5.1.5.1 Density/Consistency

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term “density” is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term “consistency” is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 pounds (63.5 kilograms) dropped over a distance of 30 inches (0.76 meters). Record the number of blows required to penetrate each 6 inches of soil in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded, but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the “standard penetration resistance,” or the “N-value.” The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch inner diameter Modified California Sampler equipped with brass or stainless steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

Drive the sampler and record blow counts for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed "refusal" and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, record the number of blows per partial increment on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Table I-E-5 and Table I-E-6 present representative descriptions of soil density/consistency vs. N-values.

Table I-E-5: Measuring Soil Density with a California Sample – Relative Density (Sands, Gravels)

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.43 factor
Very Loose	0–4	0–6
Loose	4–10	6–14
Medium Dense	10–30	14–43
Dense	30–50	43–71
Very Dense	>50	>71

Table I-E-6: Measuring Soil Density with a California Sampler – Fine Grained Cohesive Soil

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.13 factor
Very Soft	0–2	0–2
Soft	2–4	2–4
Medium Stiff	4–8	4–9
Stiff	8–16	9–18
Very Stiff	16–32	18–36
Hard	>32	>36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot. The values are as follows (Table I-E-7):

Table I-E-7: Measuring Soil Consistency with a Hand-Held Penetrometer

Description	Pocket Penetrometer Reading (psf)
Very Soft	0–250
Soft	250–500
Medium Stiff	500–1,000
Stiff	1,000–2,000
Very Stiff	2,000–4,000
Hard	>4,000

Consistency can also be estimated using thumb pressure using Table I-E-8.

Table I-E-8: Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

5.1.5.2 CEMENTATION

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

1. Quartz – siliceous
2. Chert – chert-cemented or chalcedonic
3. Opal – opaline
4. Carbonate – calcitic, dolomitic, sideritic (if in doubt, calcareous should be used)
5. Iron oxides – hematitic, limonitic (if in doubt, ferruginous should be used)
6. Clay minerals – if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as “kaolin-cemented,” “chlorite-cemented,” etc.
7. Miscellaneous minerals – pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

1. Weak – friable; crumbles or breaks with handling or slight finger pressure
2. Moderate – friable; crumbles or breaks with considerable finger pressure
3. Strong – not friable; will not crumble or break with finger pressure

5.1.5.3 STRUCTURE

This variable is used to qualitatively describe physical characteristics of soil that are important to incorporate into hydrogeological and/or geotechnical descriptions of soil at a site. Appropriate soil structure descriptors are as follows:

- *Granular:* Spherically shaped aggregates with faces that do not accommodate adjoining faces
- *Stratified:* Alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
- *Laminated:* Alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness
- Blocky: Cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown
- *Lensed:* Inclusion of a small pocket of different soil, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soil are present, the soil being described can be termed homogeneous if the description of the lenses is included
- *Prismatic or Columnar:* Particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top
- *Platy:* Particles are arranged about a horizontal plane

5.1.5.4 OTHER FEATURES

- *Mottled:* Soil that appears to consist of material of two or more colors in blotchy distribution
- *Fissured:* Breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)
- *Slickensided:* Fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

5.1.6 Development of Soil Description

Develop standard soil descriptions according to the following examples. There are three principal categories under which all soil can be classified. They are described below.

5.1.6.1 COARSE-GRAINED SOIL

Coarse-grained soil is divided into sands and gravels. A soil is classified as a sand if over 50 percent of the coarse fraction is "sand-sized." It is classified as a gravel if over 50 percent of the coarse fraction is composed of "gravel-sized" particles.

The written description of a coarse-grained soil shall contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); grain size of coarse fraction; Munsell color and color number; moisture content; relative density; sorting; angularity; other features, such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts) in parentheses.

Example: POORLY SORTED SAND WITH SILT, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20 percent coarse-grained sand-sized shell fragments, and 80 percent medium-grained quartz sand, and 5 percent to 15 percent ML).

5.1.6.2 Fine-grained Soil

Fine-grained soil is further subdivided into clays and silts according to its plasticity. Clays are rather plastic, while silts have little or no plasticity.

The written description of a fine-grained soil should contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); Munsell color; moisture content; consistency; plasticity; other features, such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: SANDY LEAN CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70 percent fines, 30 percent sand, with minor amounts of disarticulated bivalves [about 5 percent]).

5.1.6.3 Organic Soil

For highly organic soil, describe the types of organic materials present as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil usually has a dark brown to black color and may have an organic odor. Often, organic soils will change color, (e.g., from black to brown) when exposed to air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

Example: ORGANIC CLAY, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100 percent fines), weak reaction to HCl.

5.2 Rock Classification

The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed for the NAVFAC Pacific ER Program because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site work plan. Both the CTO Manager and the QA Manager or

Technical Director must approve any modifications to this classification system, or the use of another classification system.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens as a part of investigative activities must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

A rock classification template has been designated as shown in Figure I-E-4 to provide a more consistent rock classification between geologists. The template includes the classification of rocks by origin and mineralogical composition. When classifying rocks, all site geologists shall use this template.

The site geologist shall describe the rock specimen and record the description in a borehole log or logbook. The items essential for classification include:

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphanitic, glassy)
- Structure (i.e., foliated, fractured, lenticular)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage)
- Classification symbol (i.e., MF)

Example: Metamorphic foliated schist: Olive gray, 5Y, 3/2, Garnet 25 percent, Quartz 45 percent, Chlorite 15 percent, Tourmaline 15 percent, Fine-grained with Pegmatite garnet, highly foliated, slightly wavy, MF.

6. Records

Document soil classification information collected during soil sampling onto the field boring logs, field trench logs, and into the field notebook. Procedure I-B-1, *Soil Sampling* presents copies of the field boring log form. Copies of this information shall be placed in the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Munsell Color Company (Munsell). 2009. *Munsell Soil Color Chart*, (Revised). Baltimore.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-1, *Soil Sampling.*

9. Attachments

None.

DEFINITION OF TERMS

PRIMARY DIVISIONS			SYMBOLS	SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE	CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
		SANDSTONE	SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
		SHALE	SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
	Chemical Precipitates	CARBONATES	LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
		EVAPORITES	EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS		EXTRUSIVE (Volcanic)	IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
		INTRUSIVE (Plutonic)	II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS		FOLIATED	MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
		NON-FOLIATED	MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

Figure I-E-4: Rock Classification System

Direct-Push Sampling Techniques

1. Purpose

This standard operating procedure provides guidance on the use of direct-push techniques for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Direct-Push Techniques

Direct-push techniques are methods for subsurface sampling or monitoring that involve the application of downward pressure (usually supplied through hydraulic means) without the benefit of cutting tool rotation to enter soil or rock. A variety of systems are available under several trade names, such as Geoprobe and Strataprobe. Equipment may be skid-mounted, trailered, or mounted directly on the frame of a vehicle.

3.2 Membrane Interface Probe (MIP)

The membrane interface probe (MIP) is a continuous sampling tool advanced through the soil using a direct-push machine to log contaminant and lithologic data in real-time. A semipermeable membrane on the probe is heated to a temperature of 100 to 120 degrees Celsius. Clean carrier gas is circulated across the internal surface of the membrane carrying volatile organic contaminants, which have diffused through the membrane, to the surface for analysis by gas phase detectors. The MIP system is a timely and cost effective way to delineate volatile organic contaminants (e.g., benzene, toluene, solvents, trichloroethylene, tetrachloroethylene) with depth. The MIP provides real-time semi-quantitative measurements that can be used for optimizing the selection of sampling locations, particularly when using a dynamic work plan. By identifying the depth at which a contaminant is located, a more representative sample of soil or water can be collected. Correlation of a series of MIP logs across a site can provide 2-D and 3-D definition of the contaminant plume. When lithologic data are obtained (electrical conductivity, cone penetration test, hydraulic profiling tool, etc.) with the MIP data, contaminant migration pathways may be defined. The MIP logs provide a detailed record of contaminant distribution in the saturated and unsaturated formations. The MIP system does not provide specificity of analytes; however, it does use three different gas detectors. These detectors are a flame ionization detector, a photoionization detector, and a version of the electron capture detector. These three detectors allow the investigator to differentiate between certain classes of volatile contaminants such as petroleum fuels and chlorinated solvents. Soil and/or water samples must be collected and analyzed by a laboratory to identify specific analytes and quantitative concentrations. Only volatile organic compounds (VOCs) are detected by the MIP system. Detection limits are subject to the selectivity of the gas detector and the characteristics of the formation being penetrated (e.g., clay and organic carbon content) (ASTM 2012).

3.3 Laser-Induced Fluorescence (LIF) Tool

Laser-induced fluorescence (LIF) tools use the rapid emission of light from an atom or molecule after it has absorbed radiation from collimated and polarized monochromatic light source. LIF is a method for delineating the subsurface location of non-aqueous phase liquid (NAPL) petroleum hydrocarbons and other hydrocarbons using a fiber optic-based laser-induced fluorescence sensor system. The LIF tool uses a technique in which a laser emits pulsed ultraviolet light. The laser, mounted on the cone penetrometer platform, is linked via fiber optic cables to a window mounted on the side of a penetrometer probe. Laser energy emitted through the window causes fluorescence in adjacent contaminated media. The fluorescent radiation is transmitted to the surface via fiber optic cables for real-time spectral data acquisition and spectral analysis on the platform.

The LIF sensor responds to any material that fluoresces when excited by ultraviolet wavelengths produced by the laser, primarily the polynuclear aromatic, aromatic, and substituted hydrocarbons, along with a few heterocyclic hydrocarbons. The excitation energy causes all encountered fluorophores to fluoresce, including some minerals and some non-petroleum organic matter. However, because the sensor collects full spectral information, discrimination among the fluorophores may be accomplished by using the spectral features associated with the data. Soil samples should be taken to verify recurring spectral signatures to discriminate between fluorescing petroleum hydrocarbons and naturally occurring fluorophores.

3.4 Hydraulic Profiling Tool (HPT)

The hydraulic profiling tool (HPT) is a logging tool that can be used with LIF or MIP tools to better understand the details of soil permeability. The HPT measures the pressure required to inject a flow of water into the soil as the probe is advanced into the subsurface with a direct-push rig. The resulting injection pressure log is an indicator of formation permeability, which can be used to better understand contaminant mobility and migration.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard direct-push technique procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual for subsurface sampling or monitoring using direct-push techniques is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience supervising soil boring construction using conventional drilling or direct-push techniques. The CTO Manager is responsible for ensuring that all personnel involved in direct-push sampling techniques have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Direct-push techniques may be used as a cost-effective alternative to conventional drilling techniques for obtaining subsurface soil and groundwater samples and for monitoring subsurface conditions.

5.1 Method Selection

Base the decision to use direct-push techniques on: (1) their ability to achieve the required information at the required level of quality control and (2) their cost-effectiveness compared to conventional drilling methods. Major limitations of direct-push techniques are their inability to penetrate rock or cobbles and sometimes a shallow maximum depth of penetration. The capabilities of direct-push systems vary significantly among vendors. Consider these differences in capabilities when evaluating the method for a subsurface exploration program.

Use direct-push techniques to obtain groundwater samples for confirmatory analyses only if the screen placement method protects the screen from clogging during installation and allows the installation of a sand-pack around the exterior of the well screen. If semi-quantitative groundwater data is needed for screening purposes, direct-push tools are the best way to acquire that information.

The MIP can be effective in locating zones where dense nonaqueous phase liquids (DNAPL) may be present as well as dissolved phase concentrations of around 1 mg/L.

The LIF tool can provide accurate information on the location and characteristics of the contaminants encountered in the vadose zone and the saturated zone. Direct-push LIF is limited to soils that can be penetrated with the available equipment. The ability to penetrate strata is based on carrying vehicle weight, density of soil, and consistency of soil. Penetration may be limited by the delicacy of the window in the tool which can be damaged in certain ground conditions (ASTM 1997).

5.2 Inspection of Equipment

Inspect direct-push equipment prior to use for signs of fluid leakage, which could introduce contaminants to the soil. If at any time during equipment operation, fluid is observed leaking from the rig, cease operations and immediately repair or contain the leak. Collect, containerize, and label soil and other materials affected by the leak for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

5.3 Preparation of Work Site

Inspect the work site prior to commencing operations to ensure that no overhead hazards exist that could impact the direct-push equipment. In addition, clear locations planned for subsurface exploration using geophysical methods, and hand excavate them to a depth of 2 to 3 feet prior to soil penetration, unless it is certain (by virtue of subsurface clearing activities) that no utilities or other hazardous obstructions will be encountered in the first 2 to 3 feet (Procedure I-B-2, *Geophysical Testing*). Hand excavation may be waived when it is not practical.

Locate the direct-push rig so that it is downslope from the penetration point, if the work is to be performed on a grade. Locate the rig downwind or crosswind of the penetration point, if possible. Cover the area surrounding, and in the vicinity of, the penetration point with plastic. Establish required exclusion zones using plastic tape or cones to designate the various areas.

5.4 EQUIPMENT DECONTAMINATION

Thoroughly decontaminate equipment used for direct-push exploration and sampling in accordance with Procedure I-F, *Equipment Decontamination*, to avoid cross-contamination. Decontaminate sampling tools and downhole equipment between each sampling event and between penetration points. At a minimum, steam clean or wash and rinse the equipment. Collect, containerize, and label all wash and rinse water for proper disposal. Clean equipment (e.g., drive rods and samplers) shall not come into contact with contaminated soils or other contaminated materials. Keep equipment on plastic or protect it in another suitable fashion. Store push rods and other equipment removed from a hole on plastic sheeting until properly decontaminated.

5.5 SOIL SAMPLING

Vendors of direct-push equipment offer a variety of sampling systems designed specifically for their equipment. Both continuous and discreet soil samples may be obtained using sampling equipment similar to that described in Procedure I-B-1, *Soil Sampling*. The preferred methods for soil sampling using direct-push techniques use brass or stainless steel split-tube samplers that are driven through the horizon to be sampled. Disposable polytetrafluoroethylene or acetate sleeves may also be used. However, if the liner appears melted or otherwise damaged upon retrieval from the borehole, do not use for collecting samples that are to be analyzed for VOCs or SVOCs.

5.6 GROUNDWATER SAMPLING

Direct-push vendors offer numerous methods for obtaining groundwater samples. Key differences among methods involve: (1) the maximum well diameter achievable; (2) the ability to protect the well screen from exposure to contaminated overburden soils during installation; (3) the ability to install filter packing around the screen; (4) flexibility in the size, materials of construction, and design of well screens; and (5) the ability to convert sampling points into permanent monitoring wells. The limitations and abilities of a given system must be thoroughly understood and matched to the needs of the project before committing to the collection of groundwater samples using direct-push techniques.

Use direct-push techniques only to collect screening samples unless it is confirmed that the system:

1. Effectively protects the well screen from exposure to contaminated overburden soils during installation
2. Allows the installation of effective packing around the well screen
3. Allows the well screen to be effectively sealed against the downward infiltration of overlying groundwater or surface precipitation

4. Is constructed of materials compatible with the intended sampling and analysis goals of the project
5. Allows the use of a well screen properly sized and slotted for the needs of the project

Additional information on the collection of groundwater samples can be found in Procedures I-C-1, *Monitoring Well Installation and Abandonment*, I-C-2, *Monitoring Well Development*, and I-C-3, *Monitoring Well Sampling.*

It is the responsibility of the CTO Manager to evaluate and determine the appropriateness of direct-push systems prior to committing to their use on any project involving groundwater sampling. As part of this evaluation, it is recommended to obtain concurrence from regulatory authorities in advance for the method selection.

5.7 BOREHOLE ABANDONMENT

Methods for abandoning boreholes created with direct-push systems will vary among vendors. Coordinate the desired method for abandonment with the vendor in the planning stages of the project to ensure proper abandonment.

Some direct-push boreholes will close naturally as the drive rods and sampling tools are withdrawn. This may occur in loose, unconsolidated soils, such as sands. Close all boreholes using one of the procedures described in this procedure, unless natural caving precludes such closure.

The three methods for closing direct-push boreholes are:

1. Add granulated or pelletized bentonite and hydrate in layers, proceeding from the bottom of the hole to the surface.
2. Pour premixed cement/water (or cement/water/bentonite) mixture into the hole.
3. Fill the entire hole with granular or pelletized bentonite and hydrate by means of a previously emplaced water tube that is gradually withdrawn as water is supplied to the bentonite.

The second method is recommended. For shallow holes less than 10 feet in depth, pour a cement/water/bentonite mix directly into the opening using a funnel. For deeper holes, use a conductor (tremie) pipe to carry the grout mix to the far reaches of the borehole. Lower the conductor pipe to within 2 inches of the bottom and gradually withdraw it as grout is added, keeping the lower end of the pipe submerged in grout at all times.

The recommended grout mixture for well abandonment is 7 to 9 gallons of water per 94-pound bag of Portland cement, with 3 percent to 5 percent by weight of powdered bentonite added to the mixture. Commercial products, such as Volcay are acceptable with pre-approval of the CTO Manager and the QA Manager or Technical Director.

Seal boreholes to within 0.5 to 2.0 feet of the surface. Inspect the abandoned borehole after 24 hours to ensure that grout shrinkage does not occur. If significant shrinkage has occurred, re-grout the borehole. Fill the remaining portion of the hole with local topsoil or appropriate paving materials.

6. Records

Document soil classification information collected during soil sampling onto borehole log forms (see Procedure I-B-1, *Soil Sampling*). Fill out all logs with indelible ink. Record information about sampling activities on sample log forms or in the field logbook. Send copies of this information to the CTO Manager and to the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 1997. *Standard Practice for Cone Penetrometer Technology Characterization of Petroleum Contaminated Sites with Nitrogen Laser-Induced Fluorescence*. D6187-97 (Reapproved 2012). West Conshohocken, PA.

———. 2007. *Standard Practice for Direct Push Technology for Volatile Contaminant Logging with the Membrane Interface Probe (MIP)*. D7352-07 (Reapproved 2012). West Conshohocken, PA.

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United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-A-7, *Analytical Data Validation Planning and Coordination.*

Procedure I-B-1, *Soil Sampling.*

Procedure I-B-2, *Geophysical Testing.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-F, *Equipment Decontamination.*

9. Attachments

None.

Land Surveying

1. Purpose

This standard operating procedure sets forth protocols for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites for use by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the *Uniform Federal Policy-Quality Assurance Project Plan* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Boundary Survey

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

3.2 Global Positioning System (GPS)

A GPS is a system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

3.3 Waypoint

A waypoint is a reference point or set of coordinates that precisely identify a location.

4. Responsibilities

The prime contractor CTO Manager is responsible for determining the appropriate land surveying protocols for the project and ensuring this procedure is properly implemented. The CTO Manager is responsible for ensuring that all personnel involved in land surveying shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for ensuring that the appropriate protocols are conducted according to this procedure and the project-specific sampling plan. In virtually all cases, subcontractors will conduct these procedures. The FM is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 THEODOLITE/ELECTRONIC DISTANCE MEASUREMENT (EDM)

Follow the procedures listed below during theodolite/EDM land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer’s representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- Reference surveyed points to mean sea level (lower low water level).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the CTO Manager.
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.

- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.2 GLOBAL POSITIONING SYSTEM (GPS) TO CONDUCT LAND SURVEY

Follow the procedures listed below during GPS land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer’s representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet. Accuracy requirements shall be specified in the project work plan (WP).
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project WP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.3 GLOBAL POSITIONING SYSTEM (GPS) TO POSITION SAMPLE LOCATIONS OR LOCATE SITE FEATURES

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically when a level of precision greater than (±) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (±) 3 to 5 meters is sufficient to meet project requirements (i.e., when laying sampling grids, identifying significant site features, or locating features identified in geographic information system [GIS] figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available GPS unit with wide angle averaging system (WAAS), topographic map display, and waypoint storage capabilities should be used.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used. For Guam this is typically WGS84, Zone 55N. For Hawaii this will either be NAD83 Zone 3 and 4 or WGS84 Zone 5N.
- If a permanent reference point near the site is available, it is recommended that the reference point is surveyed each day the GPS unit is used.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e., building corner, roadway intersection, or USGS benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (±) 5 meters as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units “Go To” function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labeled.
- It is recommended that GPS coordinates be uploaded to a storage device such as a personal computer at the end of each day.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a WAAS system at the site, this should also be noted.

6. Records

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey
- General weather conditions
- The name of the surveying firm
- The names and job titles of personnel performing the survey work
- Equipment used, including serial numbers
- Field book designations, including page numbers

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

9. Attachments

None.

Logbooks

1. Purpose

This standard operating procedure describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data records for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan Appendix A. Section 1.4 *Field Documentation SOPs* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the Contract Task Order (CTO) Manager and the Quality Assurance Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 DATA FORM

A data form is a predetermined format used for recording field data that may become, by reference, a part of the logbook (e.g., soil boring logs, trenching logs, surface soil sampling logs, groundwater sample logs, and well construction logs are data forms).

4. Responsibilities

The prime contractor CTO Manager or delegate is responsible for determining which team members shall record information in field logbooks and for obtaining and maintaining control of the required logbooks. The CTO Manager shall review the field logbook on at least a monthly basis. The CTO Manager or designee is responsible for reviewing logbook entries to determine compliance with this procedure and to ensure that the entries meet the project requirements.

A knowledgeable individual such as the Field Manager, CTO Manager, or quality control (QC) Supervisor shall perform a technical review of each logbook at a frequency commensurate with the level of activity (weekly is suggested, or, at a minimum, monthly). Document these reviews by the dated signature of the reviewer on the last page or page immediately following the material reviewed.

The Field Manager is responsible for ensuring that all project field staff follow these procedures and that the logbook is completed properly and daily. The Field Manager is also responsible for submitting copies to the CTO Manager, who is responsible for filing them and submitting a copy to the Navy (if required by the CTO Statement of Work).

The logbook user is responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. The logbook user is also responsible for safeguarding the logbook while having custody of it.

Field personnel are responsible for the implementation of this procedure.

All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedure

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Store the logbook in a clean location and use it only when outer gloves used for personal protective equipment (PPE) have been removed.

Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, include names of all samples collected in the logbook even if they are recorded elsewhere.

Enter field descriptions and observations into the logbook, as described in Attachment III-D-1, using indelible black ink.

Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all onsite activities and entries made in logbooks/forms
- Site name, and description
- Site location by longitude and latitude, if known
- Weather conditions, including estimated temperature and relative humidity
- Fieldwork documentation, including site entry and exit times
- Descriptions of, and rationale for, approved deviations from the work plan or field sampling plan
- Field instrumentation readings
- Names, job functions, and organizational affiliations of personnel on-site

- Photograph references
- Site sketches and diagrams made on-site
- Identification and description of sample morphology, collection locations and sample numbers as described in Procedure I-A-8, *Sample Naming*
- Sample collection information, including dates (month/day/year) and times (military) of sample collections, sample collection methods and devices, station location numbers, sample collection depths/heights, sample preservation information, sample pH (if applicable), analysis requested (analytical groups), etc., as well as chain-of-custody (COC) information such as sample identification numbers cross-referenced to COC sample numbers
- Sample naming convention
- Field QC sample information
- Site observations, field descriptions, equipment used, and field activities accomplished to reconstruct field operations
- Meeting information
- Important times and dates of telephone conversations, correspondence, or deliverables
- Field calculations
- PPE level
- Calibration records
- Contractor and subcontractor information (address, names of personnel, job functions, organizational affiliations, contract number, contract name, and work assignment number)
- Equipment decontamination procedures and effectiveness
- Laboratories receiving samples and shipping information, such as carrier, shipment time, number of sample containers shipped, and analyses requested
- User signatures

The logbook shall reference data maintained in other logs, forms, etc. Correct entry errors by drawing a single line through the incorrect entry, then initialing and dating this change. Enter an explanation for the correction if the correction is more than for a mistake.

At least at the end of each day, the person making the entry shall sign or initial each entry or group of entries.

Enter logbook page numbers on each page to facilitate identification of photocopies.

If a person’s initials are used for identification, or if uncommon acronyms are used, identify these on a page at the beginning of the logbook.

At least weekly and preferably daily, the preparer shall photocopy (or scan) and retain the pages completed during that session for backup. This will prevent loss of a large amount of information if the logbook is lost.

6. Records

Retain the field logbook as a permanent project record. If a particular CTO requires submittal of photocopies of logbooks, perform this as required.

7. Health and Safety

Store the logbook in a clean location to keep it clean and use it only when outer gloves used for PPE have been removed.

8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Procedure I-A-8, *Sample Naming.*

9. Attachments

Attachment III-D-1: Description of Logbook Entries

Attachment III-D-1
Description of Logbook Entries

Logbook entries shall be consistent with Section A.1.4 *Field Documentation SOPs* of the UFP-QAPP Manual (DoD 2005) and contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously.

Name of Activity	For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing.
Task Team Members and Equipment	Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information.
Activity Location	Indicate location of sampling area as indicated in the field sampling plan.
Weather	Indicate general weather and precipitation conditions.
Level of PPE	Record the level of PPE (e.g., Level D).
Methods	Indicate method or procedure number employed for the activity.
Sample Numbers	Indicate the unique numbers associated with the physical samples. Identify QC samples.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Time and Date	Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year.
Analyses	Indicate the appropriate code for analyses to be performed on each sample, as specified in the WP.
Field Measurements	Indicate measurements and field instrument readings taken during the activity.
Chain of Custody and Distribution	Indicate chain-of-custody for each sample collected and indicate to whom the samples are transferred and the destination.
References	If appropriate, indicate references to other logs or forms, drawings, or photographs employed in the activity.
Narrative (including time and location)	Create a factual, chronological record of the team’s activities throughout the day including the time and location of each activity. Include descriptions of general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact the work schedule, request information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself. It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate.
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.
Checked by	Include the signature of the individual who performs the review of the completed entries.

Record Keeping, Sample Labeling, and Chain-Of-Custody

1. Purpose

The purpose of this standard operating procedure is to establish standard protocols for all United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific field personnel for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are used, and completing chain-of-custody/analytical request forms.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person responsible for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 CHAIN-OF-CUSTODY

Chain-of-custody (COC) is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

4. Responsibilities

The prime contractor CTO Manager is responsible for determining which team members shall record information in the field logbook and for checking sample logbooks and COC forms to ensure compliance with these procedures. The CTO Manager shall review COC forms on a monthly basis at a minimum.

The prime contractor CTO Manager and QA Manager or Technical Director are responsible for evaluating project compliance with the Project Procedures Manual. The QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Laboratory Project Manager or Sample Control Department Manager is responsible for reporting any sample documentation or COC problems to the CTO Manager or CTO Laboratory Coordinator within 24 hours of sample receipt.

The Field Manager is responsible for ensuring that all field personnel follow these procedures. The CTO Laboratory Coordinator is responsible for verifying that the COC/analytical request forms have been completed properly and match the sampling and analytical plan. The CTO Manager or CTO Laboratory Coordinator is responsible for notifying the laboratory, data managers, and data validators in writing if analytical request changes are required as a corrective action. These small changes are different from change orders, which involve changes to the scope of the subcontract with the laboratory and must be made in accordance with a respective contract (e.g., Comprehensive Long-Term Environmental Action Navy, remedial action contract).

NAVFAC Pacific ER Program field personnel are responsible for following these procedures while conducting sampling activities. Field personnel are responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedures

This procedure provides standards for documenting field activities, labeling the samples, documenting sample custody, and completing COC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

5.1 RECORD KEEPING

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct each day’s events. Field logs such as soil boring logs and groundwater sampling logs will also be used. These procedures are described in Procedure III-D, *Logbooks*.

5.2 SAMPLE LABELING

Affix a sample label with adhesive backing to each individual sample container with the exception of pre-tared containers. Record the following information with a waterproof marker (ballpoint pen for containers for volatile analyses) on each label:

- Project name or number (optional)
- COC sample number
- Date and time of collection
- Sampler's initials
- Matrix (optional)
- Sample preservatives (if applicable)

- Analysis to be performed on sample (This shall be identified by the method number or name identified in the subcontract with the laboratory)
- Indicate if sample is to be used as the matrix spike (MS)/matrix spike duplicate (MSD) or laboratory triplicate sample

With the exception of sample containers with pre-tared labels, place clear tape over each label (preferably prior to sampling) to prevent the labels from tearing off, falling off, or being smeared, and to prevent loss of information on the label.

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

For volatile soil organic analyses (VOA), labels are not to be affixed to vials that are pre-tared by the laboratory. Instead, on each of the VOA vials in the sample set (typically three per sample), mark the sample COC Sample identification (ID) on the vial in ballpoint pen. Then wrap the vials together in bubble wrap and place one sample label on the bubble wrap and cover with tape. It is imperative that the COC Sample ID be clearly marked on each vial as this will help prevent laboratory error if the vials are inadvertently separated after removal from the bubble wrap.

5.3 CUSTODY PROCEDURES

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. Maintain custody of samples in accordance with the U.S. Environmental Protection Agency (EPA) COC guidelines prescribed in U.S. Environmental Protection Agency (EPA) *NEIC Policies and Procedures*, National Enforcement Investigations Center, Denver, Colorado, revised August 1991 (EPA 1978); EPA *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (TEGD), *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA OSWER Directive 9355 3-01) (EPA 1988, Appendix 2 of the *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports* (Cal/EPA 1988), and *Test Methods for Evaluating Solid Waste* (EPA 2007). A description of sample custody procedures is provided below.

5.3.1 Sample Collection Custody Procedures

According to the EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one’s actual physical possession or view
- It is in one’s physical possession and has not been tampered with (i.e., it is under lock or official seal)
- It is retained in a secured area with restricted access
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal

Place custody seals on sample containers (on bubble wrap for pre-tared containers) immediately after sample collection and on shipping coolers if the cooler is to be removed from the sampler's custody.

Place custody seals in such a manner that they must be broken to open the containers or coolers. Label the custody seals with the following information:

- Sampler's name or initials
- Date and time that the sample/cooler was sealed

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment III-E-1.

Field personnel shall also log individual samples onto COC forms (carbon copy or computer generated) when a sample is collected or just prior to shipping. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 5.4, indicating sample identification number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The samplers will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the person delivering the samples for transport will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the sampler and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, both parties shall sign and date the accompanying carbon copy COC forms, and the individual relinquishing the samples shall retain a copy of each form. One exception is when the samples are shipped; the delivery service personnel will not sign or receive a copy because they do not open the coolers. The laboratory shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment III-E-2.

5.3.2 Laboratory Custody Procedures

The following custody procedures are to be followed by an independent laboratory receiving samples for chemical analysis; the procedures in their Naval Facilities Engineering and Expeditionary Warfare Center-evaluated Laboratory Quality Assurance Plan must follow these same procedures. A designated sample custodian shall take custody of all samples upon their arrival at the analytical laboratory. The custodian shall inspect all sample labels and COC forms to ensure that the information is consistent, and that each is properly completed. The custodian will also measure the temperature of the temperature blank in the coolers upon arrival using either a National Institute for Standards and Technology calibrated thermometer or an infra-red temperature gun. The custodian shall note the condition of the samples including:

- If the samples show signs of damage or tampering
- If the containers are broken or leaking
- If headspace is present in sample vials
- Proper preservation of samples (made by pH measurement, except volatile organic compounds (VOCs) and purgeable total petroleum hydrocarbons (TPH) and temperature). The pH of VOC and purgeable TPH samples will be checked by the laboratory analyst after the sample aliquot has been removed from the vial for analysis.

- If any sample holding times have been exceeded

All of the above information shall be documented on a sample receipt sheet by the custodian.

Discrepancies or improper preservation shall be noted by the laboratory as an out-of-control event and shall be documented on an out-of-control form with corrective action taken. The out-of-control form shall be signed and dated by the sample control custodian and any other persons responsible for corrective action. An example of an out-of-control form is included as Attachment III-E-4.

The custodian shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4 degrees Celsius (soil samples for VOC analysis are to be stored in a frozen state until analysis). The unique laboratory number for each sample, the COC sample number, the client name, date and time received, analysis due date, and storage shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The custodian shall sign the shipping bill and maintain a copy.

Laboratory personnel shall be responsible for the care and custody of samples from the time of their receipt at the laboratory through their exhaustion or disposal. Samples should be logged in and out on internal laboratory COC forms each time they are removed from storage for extraction or analysis.

5.4 COMPLETING COC/ANALYTICAL REQUEST FORMS

COC form/analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment III-E-2 is an example of a generic COC/analytical request form that may be used by field personnel. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Attachment III-E-3 is an example of a completed site-specific COC/analytical request form, with box numbers identified and discussed in text below.

Box 1 *Project Manager:* This name shall be the name that will appear on the report. Do not write the name of the Project Coordinator or point of contact for the project instead of the CTO manager.

Project Name: Write the project name as it is to appear on the report.

Project Number: Write the project number as it is to appear on the report. It shall include the project number and task number. Also include the laboratory subcontract number.

Box 2 *Bill to:* List the name and address of the person/company to bill only if it is not in the subcontract with the laboratory.

Box 3 *Sample Disposal Instructions:* These instructions will be stated in the Master Service Agreement or each CTO statement of work with each laboratory.

Shipment Method: State the method of shipment (e.g., hand carry; air courier via FED EX, AIR BORNE, or DHL).

Comment: This area shall be used by the field team to communicate observations, potential hazards, or limitations that may have occurred in the field or additional information regarding analysis (e.g., a specific metals list, samples expected to contain high analyte concentrations).

Box 4 *Cooler Number:* This will be written on the inside or outside of the cooler and shall be included on the COC. Some laboratories attach this number to the trip blank identification, which helps track volatile organic analysis samples. If a number is not on the cooler, field personnel shall assign a number, write it on the cooler, and write it on the COC.

QC Level: Enter the reporting/QC requirements (e.g., Full Data Package, Summary Data Package).

Turn around time (TAT): TAT will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Once the SDG has been completed, standard TAT is 21 calendar days from receipt of the last sample in the SDG. Entering NORMAL or STANDARD in this field will be acceptable. If quicker TAT is required, it shall be in the subcontract with the laboratory and reiterated on each COC to remind the laboratory.

Box 5 *Type of containers:* Write the type of container used (e.g., 1 liter glass amber, for a given parameter in that column).

Preservatives: Field personnel must indicate on the COC the correct preservative used for the analysis requested. Indicate the pH of the sample (if tested) in case there are buffering conditions found in the sample matrix.

Box 6 *COC sample number:* This is typically a five-character alpha-numeric identifier used by the contractor to identify samples. The use of this identifier is important since the labs are restricted to the number of characters they are able to use. See Procedure I-A-8, *Sample Naming*.

Description (sample identification): This name will be determined by the location and description of the sample, as described in Procedure I-A-8, *Sample Naming*. This sample identification should not be submitted to the laboratory, but should be left blank. If a computer COC version is used, the sample identification can be input, but printed with this block black. A cross-referenced list of COC Sample Number and sample identification must be maintained separately.

Identify if sample requires laboratory subsampling.

Date Collected: Record the collection date to track the holding time of the sample. Note: For trip blanks, record the date it was placed in company with samples.

Time Collected: When collecting samples, record the time the sample is first collected. Use of the 24-hour military clock will avoid a.m. or p.m. designations (e.g., 1815 instead of 6:15 p.m.). Record local time; the laboratory is responsible for calculating holding times to local time.

Lab Identification: This is for laboratory use only.

Box 7 *Matrix and QC:* Identify the matrix (e.g., water, soil, air, tissue, fresh water sediment, marine sediment, or product). If a sample is expected to contain high analyte concentrations (e.g., a tank bottom sludge or distinct product layer), notify the laboratory in the comment section. Mark an "X" for the sample(s) that have extra volume for laboratory QC matrix spike/matrix spike duplicate (MS/MSD) or laboratory triplicate purposes. The sample provided for MS/MSD purposes is usually a field duplicate.

Box 8 *Analytical Parameters:* Enter the parameter by descriptor and the method number desired (e.g. benzene, toluene, ethylbenzene, and xylenes 8260B, polynuclear aromatic hydrocarbons 8270C, etc.). Whenever practicable, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

If the COC does not have a specific box for number of sample containers, use the boxes below the analytical parameter, to indicate the number of containers collected for each parameter.

Box 9 *Sampler's Signature:* The person who collected samples must sign here.

Relinquished By: The person who turned over the custody of the samples to a second party other than an express mail carrier, such as FEDEX, must sign here.

Received By: Typically, a representative of the receiving laboratory signs here. Or, a field crew member who delivered the samples in person from the field to the laboratory might sign here. A courier, such as Federal Express, does not sign here because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are to be sent to a subcontractor.

Relinquished By: In the case of subcontracting, the primary laboratory will sign the Relinquished By space and fill out an additional COC to accompany the samples being subcontracted.

Received By (Laboratory): This space is for the final destination (e.g., at a subcontracted laboratory).

Box 10 *Lab Number and Questions:* This box is to be filled in by the laboratory only.

Box 11 *Control Number:* This number is the “COC” followed by the first contractor identification number in that cooler, or contained on that COC. This control number must be unique (i.e., never used twice). Record the date the COC is completed. It should be the same date the samples are collected.

Box 12 *Total No. of Containers/row:* Sum the number of containers in that row.

Box 13 *Total No. of Containers/column:* Sum the number of containers in that column. Because COC forms contain different formats depending on who produced the form, not all of the information listed in items 1 to 13 may be recorded; however, as much of this information as possible shall be included.

COC forms tailored to each CTO can be drafted and printed onto multi-ply forms. This eliminates the need to rewrite the analytical methods column headers each time. It also eliminates the need to write the project manager, name, and number; QC Level; TAT; and the same general comments each time.

Complete one COC form per cooler. Whenever possible, place all volatile organic analyte vials into one cooler in order to reduce the number of trip blanks. Complete all sections and be sure to sign and date the COC form. One copy of the COC form must remain with the field personnel.

6. Records

The COC/analytical request form shall be faxed or e-mailed to the CTO Laboratory Coordinator for verification of accuracy. Following the completion of sampling activities, the sample logbook and COC forms will be transmitted to the CTO Manager for storage in project files. The data validators shall receive a copy also. The original COC/analytical request form shall be submitted by the laboratory along with the data delivered. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

7. Health and Safety

Not applicable.

8. References

California Environmental Protection Agency (Cal/EPA). 1988. *Technical Guidance Manual, Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports.* Solid Waste Disposal Program, Hydrogeology Section, Land Disposal Branch, Division of Water Quality, State Water Resources Control Board. August.

Department of Defense, United States (DoD). 2005a. Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 1978. *NEIC Policies and Procedures.* EPA-330/9-78-001-R. Revised August 1991. National Enforcement Investigation Center. Denver. May.

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———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure I-A-8, *Sample Naming.*

Procedure III-D, *Logbooks.*

9. Attachments

Attachment III-E-1, Chain-of-Custody Seal

Attachment III-E-2, Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3, Sample Completed Chain-of-Custody

Attachment III-E-4, Sample Out-of-Control Form

Attachment III-E-1
Chain-of-Custody Seal

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	
Company Name (808) XXX-XXXX	
Sampler's Name/Initials:____________________	Date: _____________ Time: _____________

Attachment III-E-2
Generic Chain-of-Custody/Analytical Request Form

Chain-of-Custody

Control Number: *94H0*

Date ______ Page ______ of ______

CTO/DO Manager:
CTO/DO Name:
CTO/DO Number:
Deliver results to the address above or as stated in contract
Cooler No:
QC Level: TAT:

Bill To:
Company:
Address:

Sample Disposal
Shipment
Comments:

# of containers:
Preservatives:

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010					Extra Volume MS/MSD	HOLD	Total # of Containers
								TOTALS:																

Sample Data; Matrix/QC

	Date	Time
Samplers Signature		
Relinquished By:		
Received By:		
Relinquished By:		
Received By (LAB):		

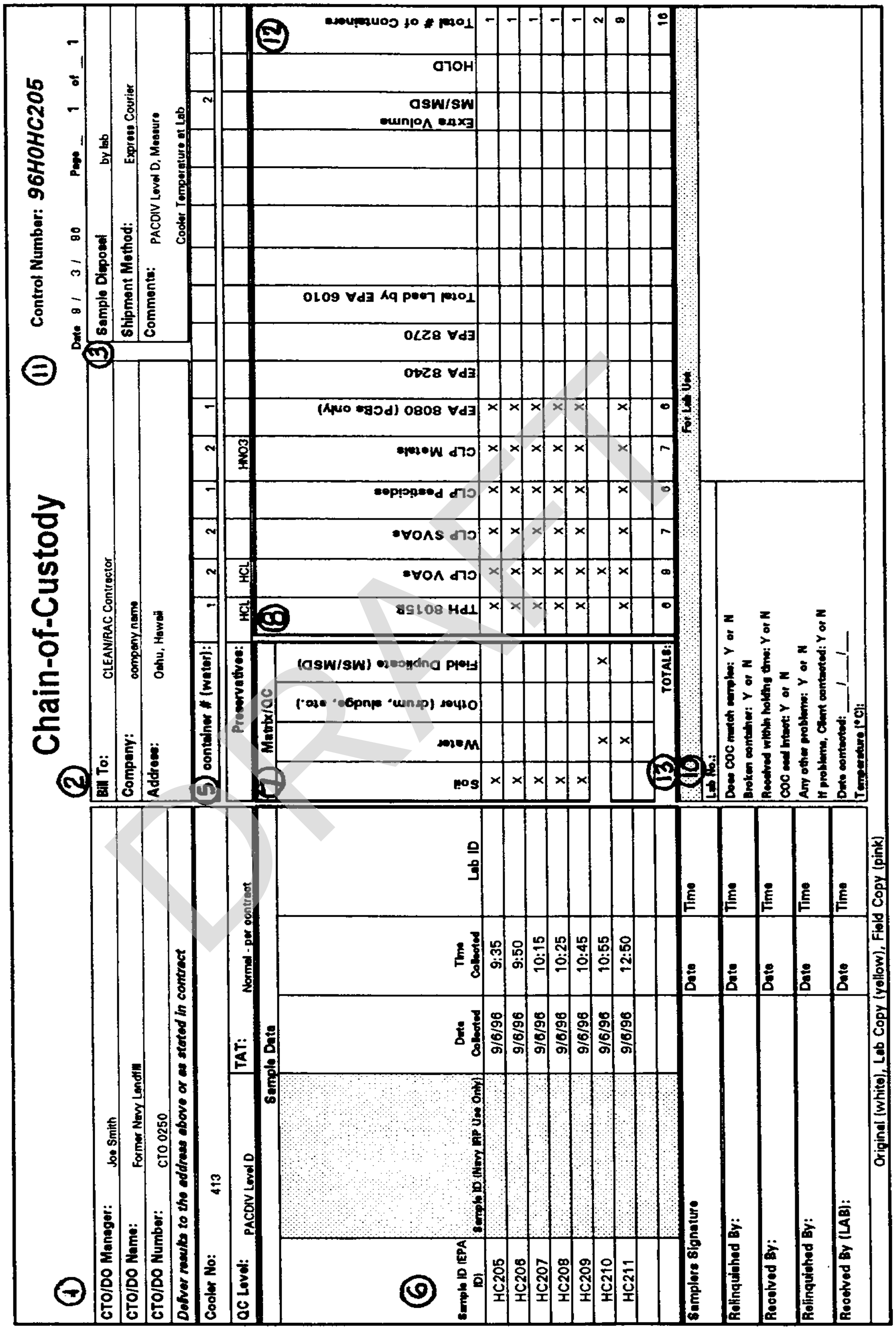
For Lab Use

Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3
Sample Completed Chain-of-Custody



Chain-of-Custody

(11) Control Number: **96H0HC205**

Date 9 / 3 / 96 Page 1 of 1

(1)
CTO/DO Manager: Joe Smith
CTO/DO Name: Former Navy Landfill
CTO/DO Number: CTO 0250
Deliver results to the address above or as stated in contract

(2)
Bill To: CLEAN/RAC Contractor
Company: company name
Address: Oahu, Hawaii

(3)
Sample Disposal: by lab
Shipment Method: Express Courier
Comments: PACDIV Level D, Measure Cooler Temperature at Lab

(4)
Cooler No: 413
QC Level: PACDIV Level D
TAT: Normal - per contract

(5) container # (water): 1, 2, 2, 1, 2, 1 (Extra Volume MS/MSD: 2)
Preservatives: HCL, HCL, HNO3

Sample Data (6) | (7) Matrix/QC | (8) | (12)

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015R	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010	Extra Volume MS/MSD	HOLD	Total # of Containers
HC205		9/6/96	9:35		X				X	X	X	X	X	X						1
HC206		9/6/96	9:50		X				X	X	X	X	X	X						1
HC207		9/6/96	10:15		X				X	X	X	X	X	X						1
HC208		9/6/96	10:25		X				X	X	X	X	X	X						1
HC209		9/6/96	10:45		X				X	X	X	X	X	X						1
HC210		9/6/96	10:55			X		X		X										2
HC211		9/6/96	12:50			X			X	X	X	X	X	X						8
								(13) TOTALS:	6	8	7	6	7	6						16

(9)
Samplers Signature | Date | Time
Relinquished By: | Date | Time
Received By: | Date | Time
Relinquished By: | Date | Time
Received By (LAB): | Date | Time

(10) For Lab Use
Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

DRAFT

Sample Completed Chain-of-Custody

Attachment III-E-4
Sample Out-of-Control Form

OUT OF CONTROL FORM	Status	Date	Initial
	Noted OOC		
	Submit for CA*		
	Resubmit for CA*		
	Completed		

Date Recognized:		By:	
Dated Occurred:		Matrix	
Parameter (Test Code):		Method:	
Analyst:		Supervisor:	
1. Type of Event (Check all that apply)		2. Corrective Action (CA)* (Check all that apply)	
	Calibration Corr. Coefficient <0.995		Repeat calibration
	%RSD>20%		Made new standards
	Blank >MDL		Reran analysis
	Does not meet criteria:		Sample(s) redigested and rerun
	Spike		Sample(s) reextracted and rerun
	Duplicate		Recalculated
	LCS		Cleaned system
	Calibration Verification		Ran standard additions
	Standard Additions		Notified
	MS/MSD		Other (please explain)
	BS/BSD		
	Surrogate Recovery		
	Calculations Error		

Samples Affected (List by Accession AND Sample No.)

☐	Holding Times Missed	
☐	Other (Please explain	Comments:

3. Results of Corrective Action	
☐	Return to Control (indicated with)
☐	Corrective Actions Not Successful - DATA IS TO BE FLAGGED with _____________.

Analyst:	Date:
Supervisor:	Date:
QA Department:	Date:

Sample Handling, Storage, and Shipping

1. Purpose

This standard operating procedure sets forth the methods for use by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel engaged in handling, storing, and transporting samples.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager and the Laboratory Project Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities are in compliance with this procedure.

The Field Manager is responsible for ensuring that all samples are shipped according to this procedure.

Field personnel are responsible for the implementation of this procedure.

The QA Manager or Technical Director is responsible for ensuring that sample handling, storage, and transport activities conducted during all CTOs are in compliance with this procedure.

All field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedures

5.1 HANDLING AND STORAGE

Immediately following collection, label all samples according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. In addition, when more than one volatile organic analyte

(VOA) vial is used to collect one sample, the chain-of-custody (COC) identification (ID) will be written on the VOA vials (even pre-tared vials) with a ball point pen for that sample. The lids of the containers shall not be sealed with duct tape, but should be covered with custody seals (except pre-tared containers which should have the custody seal placed on the outside of the protective bubble wrap). Wrap glass sample containers on the sides, tops, and bottoms with bubble wrap or other appropriate padding to prevent breakage during transport. When collecting three VOA vials per sample, it is acceptable to wrap all three vials together and store in one plastic bag. Store all glass containers for water samples in an upright position, never stacked or placed on their sides. Samples will be maintained as close to 4 degrees Celsius (°C) as possible from the time of collection through transport to the analytical laboratory, using refrigerators and/or freezers when appropriate. Place all containers into self-sealing bags and into an insulated cooler with wet ice while still in the field. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. Place an absorbent material (e.g., proper absorbent cloth material) on the bottom of the cooler to contain liquids in case of spillage. Ship samples as soon after collection as possible to allow the laboratory to meet holding times for analyses. Check with the laboratory for operating/sample receipt hours prior to all traditional and non-traditional holidays to ensure sample shipment will be received. When not shipping samples directly upon field collection, store samples in a refrigerator or freezer (never freeze water samples) until shipped to the laboratory.

5.2 PACKING

Each cooler must contain a temperature blank (small plastic bottle with sterile water) to confirm cooler temperature upon receipt at the laboratory. Water samples can be used as such, but it is best to include a designated temperature blank bottle, typically supplied by the laboratory with the coolers.

One trip blank must be included in each cooler containing samples for volatile analysis (e.g., volatile organic compounds, total petroleum hydrocarbons-gasoline range organics.

Cooler must be lined completely in ice at the bottom and all four sides. After confirming all project samples are accounted for and labeled correctly, place samples in cooler. Record sample IDs on cooler-specific COC(s). Pack glass containers for water samples in an upright position, never stacked or placed on their sides. Fill all empty space between sample containers with bubble wrap or other appropriate material (not Styrofoam). Place a layer of ice on top of samples and fill all empty space between ice and cooler lid with bubble wrap or other appropriate material.

Place laboratory copies of completed COC(s), and soil permit if applicable, into resealable bag and tape to underside of cooler lid.

5.3 SHIPPING

Follow all appropriate U.S. Department of Transportation regulations (e.g., 49 Code of Federal Regulations [CFR], Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized below.

5.3.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed to be hazardous unless enough evidence exists to indicate it is non-hazardous. If not suspected to be hazardous, shipments may be made as described in the Section 5.3.3 for non-hazardous materials. If hazardous, follow the procedures summarized below.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Perform hazardous materials identification by checking the list of dangerous goods for that particular mode of transportation. If not on that list, materials can be classified by checking the Hazardous Materials Table (49 CFR 172.102 including Appendix A) or by determining if the material meets the definition of any hazard class or division (49 CFR Part 173), as listed in Attachment III-F-2.

All persons shipping hazardous materials must be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials (49 CFR HM-126F Subpart H). The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. Carriers, such as commercial couriers, must also be trained. Modes of shipment include air, highway, rail, and water.

When shipping hazardous materials, including bulk chemicals or samples suspected of being hazardous, the proper shipping papers (49 CFR 172 Subpart C), package marking (49 CFR 172 Subpart D), labeling (49 CFR 172 Subpart E), placarding (49 CFR 172 Subpart F, generally for carriers), and packaging must be used. Attachment III-F-1 shows an example of proper package markings. Refer to a copy of 49 CFR each time hazardous materials/potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association Dangerous Goods Regulations publication, very small quantities of certain dangerous goods may be transported without certain marking and documentation requirements as described in 49 CFR Part 172. However, other labeling and packing requirements must still be followed. Attachment III-F-2 shows the volume or weight for different classes of substances. A “Dangerous Goods in Excepted Quantities” label must be completed and attached to the associated shipping cooler (Attachment III-F-3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment III-F-4, the Hazardous Materials Regulations do not apply to hydrochloric acid (HCl), nitric acid (HNO_3), sulfuric acid (H_2SO_4), and sodium hydroxide (NaOH) added to water samples if their pH or percentage by weight criteria are met. Hazardous Materials Regulations also do not apply to methanol (MeOH) for soil samples if the percentage by weight criterion is met. These samples may be shipped as non-hazardous materials as discussed below.

5.3.2 Non-hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

If preservatives (HCl, HNO_3, H_2SO_4, NaOH, or MeOH) are used, ensure their individual pH or percentage by weight criteria, as shown in item 4 of Attachment III-F-4, are met to continue shipping as non-hazardous samples.

When a cooler is ready for shipment to the laboratory, place the receiving laboratory address on the top of the cooler, place chain-of-custody seals on the coolers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, place soil permit labels on top if applicable, and seal the cooler with waterproof tape.

5.3.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the continental U.S. from locations outside the continental U.S. is controlled by the U.S. Department of Agriculture (USDA) and is subject to their inspection and regulation. A "USDA Soil Import Permit" is required to prove that the receiving analytical laboratory is certified by the USDA to receive and properly dispose of soil. In addition, all sample coolers must be inspected by a USDA representative, affixed with a label indicating that the coolers contain environmental samples, and accompanied by shipping forms stamped by the USDA inspector prior to shipment. In addition, the U.S. Customs Service must clear samples shipped from U.S. territorial possessions or foreign countries upon entry into the U.S. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs Service without the need to open coolers for inspection.

In Hawaii, soil sample shipments are typically brought to the courier at the airport where the courier contacts a USDA representative to make an inspection. Alternatively, the contractor may enter into an agreement with the USDA to ship soil samples. In this way, the USDA does not need to inspect each soil sample shipment. If the contractor maintains a Domestic Soil Permit, place the permit label and the soil origination label (Attachment III-F-9) on the top of the cooler. Place a copy of the receiving laboratory's soil permit with the COC inside the cooler. Confirm custody seals were placed on each container (Section 5.1) to ensure proper chain-of-custody control in the event coolers are opened for inspection.

In Guam, shipments can be dropped off directly to the Federal Express branch or to the courier at the airport. Alternatively, the courier can pick up shipments at each site provided that arrangements have been made regarding pickup time and location. USDA inspections occur outside of Guam. The laboratory's soil permit shall be placed with the COC inside the cooler, and the soil origination label (see Attachment III-F-9) should be placed on top of the cooler.

The USDA does not need to inspect water sample shipments.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need for the USDA and U.S. Customs Service to inspect the contents. Attachment III-F-5 shows an example of how paperwork may be placed on the outside of coolers for non-hazardous materials. For hazardous materials, refer to Section 5.3.1.

In summary, tape the paperwork listed below to the outside of the coolers to assist sample shipments. If a shipment is made up of multiple pieces (e.g., more than one cooler), the paperwork need only be attached to one cooler, provided that the courier agrees. All other coolers in the shipment need only be taped and have address and COC seals affixed.

1. **Courier Shipping Form & Commercial Invoice**. See Attachment III-F-6, and Attachment III-F-7 for examples of the information to be included on the commercial invoice for soil and water. Place the courier shipping form and commercial invoice inside a clear, plastic, adhesive-backed pouch that adheres to the package (typically supplied by the courier) and place it on the cooler lid as shown in Attachment III-F-5.
2. **Soil Import Permit (soil only)**. See Attachment III-F-8 and Attachment III-F-9 for examples of the soil import permit and soil samples restricted entry labels. The laboratory shall supply these documents prior to mobilization. The USDA in Hawaii often does stop

shipments of soil without these documents. Staple together the 2 inch × 2 inch USDA label (described below), and soil import permit, and place them inside a clear plastic pouch. The courier typically supplies the clear, plastic, adhesive-backed pouches that adhere to the package.

Placing one restricted entry label as shown in Attachment III-F-5 (covered with clear packing tape) and one stapled to the actual permit is suggested.

The USDA does not control water samples, so the requirements for soil listed above do not apply.

3. **Chain-of-Custody Seals**. The laboratory should supply the seals. CTO personnel must sign and date these. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. Placing the seals over the tape (as shown in Attachment III-F-5), then covering it with clear packing tape is suggested. This prevents the seal from coming loose and enables detection of tampering.
4. **Address Label**. Affix a label stating the destination (laboratory address) of each cooler.
5. **Special Requirements for Hazardous Materials**. See Section 5.3.1.

Upon receipt of sample coolers at the laboratory, the sample custodian shall inspect the sample containers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. The samples shall then be either immediately extracted and/or analyzed, or stored in a refrigerated storage area until they are removed for extraction and/or analysis. Whenever the samples are not being extracted or analyzed, they shall be returned to refrigerated storage.

6. Records

Maintain records as required by implementing these procedures.

7. Health and Safety

Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2012) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

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Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

Attachment III-F-1: Example Hazardous Materials Package Marking

Attachment III-F-2: Packing Groups

Attachment III-F-3: Label for Dangerous Goods in Excepted Quantities

Attachment III-F-4: SW-846 Preservative Exception

Attachment III-F-5: Non-Hazardous Material Cooler Marking Figure for Shipment From Outside The Continental United States

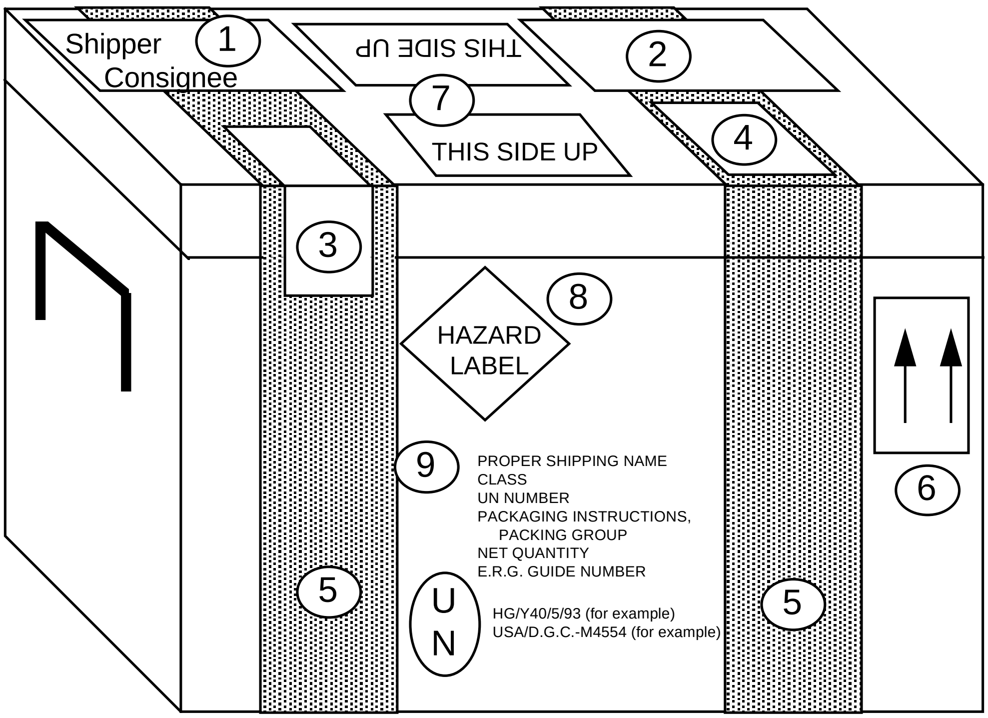
Attachment III-F-6: Commercial Invoice – Soil

Attachment III-F-7: Commercial Invoice – Water

Attachment III-F-8: Soil Import Permit

Attachment III-F-9: Soil Samples Restricted Entry Labels

Attachment III-F-1
Example Hazardous Material Package Marking



1. **AIR BILL/COMMERCIAL INVOICE**
2. **USDA PERMIT (Letter to Laboratory from USDA)**
3. **CUSTODY SEAL**
4. **USDA 2" X 2" SOIL IMPORT PERMIT**
5. **WATERPROOF STRAPPING TAPE**
6. **DIRECTION ARROWS STICKER - TWO REQUIRED**
7. **THIS SIDE UP STICKERS**
8. **HAZARD LABEL**
9. **HAZARDOUS MATERIAL INFORMATION**
10. **PACKAGE SPECIFICATIONS**

Attachment III-F-2
Packing Groups

PACKING GROUP OF THE SUBSTANCE	PACKING GROUP 1		PACKING GROUP II		PACKING GROUP III	
CLASS or DIVISION of PRIMARY or SUBSIDIARY RISK	Packagings		Packagings		Packagings	
	Inner	Outer	Inner	Outer	Inner	Outer
1: Explosives	---------------------------- Forbidden (Note A) ----------------------------------					
2.1: Flammable Gas	---------------------------- Forbidden (Note B) ----------------------------------					
2.2: Non-Flammable, non-toxic gas	---------------------------- See Notes A and B ----------------------------------					
2.3: Toxic gas	---------------------------- Forbidden (Note A) ----------------------------------					
3. Flammable liquid	30 mL	300 mL	30 mL	500 mL	30 mL	1 L
4.1 Self-reactive substances	Forbidden		Forbidden		Forbidden	
4.1: Other flammable solids	Forbidden		30 g	500 g	30 g	1 kg
4.2: Pyrophoric substances	Forbidden		Not Applicable		Not Applicable	
4.2 Spontaneously combustible substances	Not Applicable		30 g	500 g	30 g	1 kg
4.3: Water reactive substances	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.1: Oxidizers	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.2: Organic peroxides (Note C)	See Note A		30 g or 30 mL	500 g or 250 mL	Not Applicable	
6.1: Poisons - Inhalation toxicity	Forbidden		1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - oral toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - dermal toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.2: Infectious substances	---------------------------- Forbidden (Note A) ----------------------------------					
7: Radioactive material (Note D)	---------------------------- Forbidden (Note A) ----------------------------------					
8: Corrosive materials	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
9: Magnetized materials	---------------------------- Forbidden (Note A) ----------------------------------					
9: Other miscellaneous materials (Note E)	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L

Note A: *Packing groups are not used for this class or division.*
Note B: *For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.*
Note C: *Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.*
Note D: *See 6.1.4.1, 6.1.4.2 and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.*
Note E: *For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.*

Attachment III-F-3
Label for Dangerous Goods in Excepted Quantities

DANGEROUS GOODS IN EXCEPTED QUANTITIES

This package contains dangerous goods in excepted small quantities and is in all respects in compliance with the applicable international and national government regulations and the IATA Dangerous Goods Regulations.

____
Signature of Shipper

________________________ ______________________
Title Date

____

____
Name and address of Shipper

This package contains substance(s) in Class(es) (check applicable box(es))

Class:	2	3	4	5	6	8	9
	o	o	o	o	o	o	o

and the applicable UN Numbers are:

Attachment III-F-4
SW-846 Preservative Exception

Measurement	Vol. Req. (mL)	Container[2]	Preservative [3,4]	Holding Time[5]
MBAS	250	P,G	Cool, 4ºC	48 Hours
NTA	50	P,G	Cool, 4ºC	24 Hours

1. More specific instructions for preservation and sampling are found with each procedure as detailed in this manual. A general discussion on sampling water and industrial wastewater may be found in ASTM, Part 31, p. 72-82 (1976) Method D-3370.

2. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

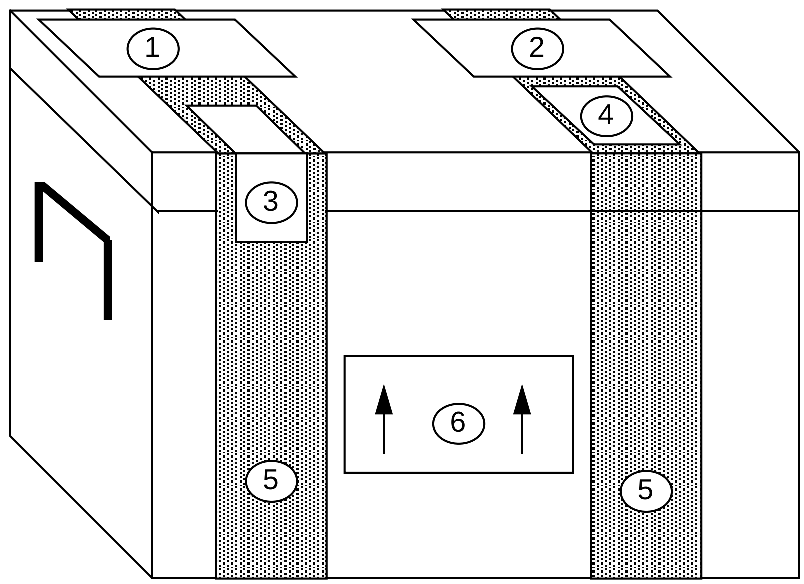
3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing and sample splitting is completed.

4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

Attachment III-F-5
Non-Hazardous Material Cooler Marking Figure for Shipment from outside the Continental United States



1 **AIR BILL/COMMERCIAL INVOICE**

2 **USDA PERMIT (Letter to Laboratory from USDA)**

3 **CUSTODY SEAL**

4 **USDA 2" X 2" SOIL IMPORT PERMIT**

5 **WATERPROOF STRAPPING TAPE**

6 **DIRECTION ARROWS STICKER - TWO REQUIRED**

Attachment III-F-6
Commercial Invoice – Soil

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Receipt <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Soil samples for labora analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00

Check one
- ☐ F.O.B.
- ☐ C&F
- ☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title	Signature	Date
Joe Smith, Ogden	Joe Smith	1/1/94

Attachment III-F-7
Commercial Invoice – Water

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Rece <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Water samples for labo analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title	Signature	Date
Joe Smith, Ogden	Joe Smith	1/1/94

Attachment III-F-8
Soil Import Permit

UNITED STATES DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Soil Permit

Permit Number: S-52299

Issued To: [redacted]
1317 S. 13th Avenue
Kelso, Washington 98626

TELEPHONE: (360) 577-7222

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed. Compliance Agreements and Soil permits are non-transferable. If you hold a Soil Permit and you leave your present employer or company, you must notify your local USDA office promptly.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Columbia Analytical Services, located in Kelso, Washington.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U [redacted]

JUNE 30, 2006
Expiration Date

WARNING: Any alteration, forgery, or unauthorized use of this Federal form is subject to civil penalties of up to $250,000 (7 U.S.C. s 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. s 1001).

PPQ FORM 525B (8/94)

Pt. 1 - PERMITTEE

Attachment III-F-9
Soil Samples Restricted Entry Label and Soil Origin Label

U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

PLANT PROTECTION AND QUARANTINE

HYATTSVILLE, MARYLAND 20782

SOIL SAMPLES

RESTRICTED ENTRY

The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550 *Edition of 12/77 may be used*

(JAN 83)

Soil Samples Restricted Entry Label

SOIL ENCLOSED

Origin of Soil ____________________________

Soil Origin Label

Appendix B:
Analytical Data Package Requirements for Chemical Analyses

GC-FID Stage 4 Deliverables

Item No.	Deliverable
1 [a]	Chain of Custody
2 [a]	Sample results with analysis and extraction/preparation dates
3 [a]	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4 [a]	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5 [a]	Method blanks (listing or link with associated samples)
6 [a]	Summary of surrogate recoveries
7 [a]	Summary of initial calibration data (RF and %RSD, or r if applicable)
8 [a]	Summary of continuing calibration (%D)
9 [a]	Injection logs
10 [a]	Extraction/preparation logs
11 [a]	Case narrative to discuss anomalies
12	Raw data associated with the summary forms listed above
13	Raw data for item #2 which includes chromatograms, logbooks, quantitation reports, and spectra

Note: The data deliverable package must have a table of contents and be paginated.
%D percent difference
%RSD percent relative standard deviation
GC-FID gas chromatography-flame ionization detector
MS matrix spike
MSD matrix spike duplicate
LCS laboratory control sample
LCSD laboratory control sample duplicate
RF response factor
[a] Included in Level 2 report.

GC-MS Stage 4 Deliverables

Item No.	Deliverable
1 [a]	Chain of Custody
2 [a]	Sample results with analysis and extraction/preparation dates
3 [a]	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4 [a]	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5 [a]	Method blanks (listing or link with associated samples)
6 [a]	Summary of surrogate recoveries
7 [a]	Summary of initial calibration data (RRF and %RSD, or r if applicable)
8 [a]	Summary of continuing calibration (%D and RRF)
9 [a]	Summary of internal standards (area response and retention time)
10 [a]	Summary of instrument tuning (listing or link with associated samples, must show 12-hour clock)
11 [a]	Injection logs
12 [a]	Extraction/preparation logs
13 [a]	Case narrative to discuss anomalies
14	Raw data associated with the summary forms listed above
15	Raw data for item #2 which includes chromatograms, logbooks, quantitation reports, and spectra

Note: The data deliverable package must have a table of contents and be paginated.
%D percent difference
%RSD percent relative standard deviation
GC-MS gas chromatography-mass spectrometry
MS matrix spike
MSD matrix spike duplicate
LCS laboratory control sample
LCSD laboratory control sample duplicate
RF response factor
RRF relative response factor
[a] Included in Level 2 report.

General Chemistry Stage 2 Deliverables

Item No.	Deliverable
1	Chain of custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of initial calibration data (correlation coefficient, r)
7	Summary of continuing calibration (%D or % recovery), if applicable
8	Injection logs, if applicable
9	Extraction/preparation logs, if applicable
10	Case narrative to discuss anomalies
11	Raw data associated with the summary forms listed above
12	Raw data for item #2, which includes logbooks, quantitation reports, and spectra

Note: The data deliverable package must contain a table of contents and be paginated.
%D percent difference
MS matrix spike
MSD matrix spike duplicate
LCS laboratory control sample
LCSD laboratory control sample duplicate

DATA DELIVERABLES REQUIREMENTS

The final report package shall include amended and additional pages requested during data review and validation. To support the data review and validation by AECOM Technical Services, Inc. or third-party, the laboratory shall be required to submit a final report electronically with the following directly into the EDMS online database:

- The images shall be clear and legible.
- The images shall be right side up.
- The images shall be straight.
- The report shall be submitted in Portable Document Format (PDF) and each file shall be bookmarked. The PDF shall be identified by the sample delivery group (SDG, also known as batch or work order) number.
- If the images are not clear, legible, right side up, straight or in order, then the laboratory shall resubmit the PDF.
- The report cover page or narrative shall contain the following information:
  - Navy contract number
  - Contract task order name and number
  - Sample delivery group number
  - Matrices and methods
  - Date of submittal
- The EDD for each report shall be submitted to the EDMS database in the format below:

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
AFIID	varchar	True	Yes	5	1	5	Facility identification is the unique code used to represent an installation, plant, or base.
LOCID	varchar	False	Conditional	15	7	21	Location Identification is the unique identifier assigned to a location within a project where measurements or samples are taken.
LOGDATE	varchar	False	Conditional	11	23	33	The date that the groundwater was collected.The format for this field is [DD-MMM-YYYY] where YYYY is the calendar year, MMM is the abbreviated month and DD is the numeric date.
LOGTIME	varchar	False	Conditional	4	35	38	The time of the day (24 hour clock) that a sample is collected, a field measurement is made, or a quality control sample is created. This value is expressed in the HHMM format of the Local Time.
MATRIX	varchar	True	Yes	2	40	41	Sampling Matrix is a coded value identifying the specific sample medium actually being analyzed. I.e., soil, water, drill cuttings, waste water, etc.
SBD	numeric	False	No	8	43	50	Sample Beginning Depth is the upper depth in feet from the ground surface or the water surface at which a sample is collected or recovered.
SED	numeric	False	No	8	52	59	Sample Ending Depth is the lower depth in feet from the ground surface or the water surface at which a
SACODE	varchar	True	Yes	2	61	62	Sample Code is a coded value identifying whether the sample is a QC or normal.
SAMPNO	int	False	Yes	2	64	65	Sample Number is the numerical identifier for the sample taken.
LOGCODE	varchar	True	No	4	67	70	Logging Company Code is the coded value identifying the company performing the field tests.
SMCODE	varchar	True	No	2	72	73	Sample Method Code is a coded value identifying the sampling method used to collect a sample.
FLDSAMPID	varchar	False	Yes	30	75	104	Field Sample Identification is a unique number assigned to the sample in the field. This number will be a reference to the specific sample regardless of the sample date or location.
COCID	varchar	False	No	12	106	117	Chain of Custody Identification is a unique identification reference to the chain of custody describing the transport of the sample to the laboratory.
COOLER	varchar	False	No	2	119	120	Cooler Number is the unique number assigned to the cooler transporting the sample.
ABLOT	varchar	False	No	8	122	129	Ambient Blank Field Lot Identifier is used to link the lot of normal samples (collected in the field) to the corresponding ambient blank. There will only be an entry for normal samples that are associated to an ambient blank. This field in the sample record for the ambient blank itself will be left blank. The format for the Ambient Blank Field Lot Identifier is [DDMMYYNN] where DD is the numeric date, MM is the number for the month, YY is the last two digits of the calendar year, and NN is the sequentially assigned number for the lot.

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
EBLOT	varchar	False	No	8	131	138	Equipment Blank Field Lot Identifier is used to link the lot of normal samples (collected in the field) to the corresponding equipment blank. There will only be an entry for normal samples that are associated to an equipment blank. This field in the sample record for the equipment blank itself will be left blank. The format for the Equipment Blank Field Lot Identifier is [DDMMYYNN] where DD is the numeric date, MM is the number for the month, YY is the last two digits of the calendar year, and NN is the sequentially assigned number for the lot.
TBLOT	varchar	False	No	8	140	147	Trip Blank Field Lot Identifier is used to link the lot of normal samples (collected in the field) to the corresponding trip blank. There will only be an entry for normal samples that are associated to a trip blank. This field in the sample record for the trip blank itself will be left blank. The format for the Trip Blank Field Lot Identifier is [DDMMYYNN] where DD is the numeric date, MM is the number for the month, YY is the last two digits of the calendar year, and NN is the sequentially assigned number for the lot.
REMARKS	varchar	False	No	240	149	388	Contains comments about the sample.
SDG	varchar	False	No	20	390	409	A lab created code used to identify a group or selection of samples. The SDG is used for processing and reporting accuracy by labs. This value is included in a prime project file for integrity references.
LABCODE	varchar	True	Yes	4	411	414	Analytical Laboratory Code is a coded value identifying the laboratory which performed the analysis of the samples.
ANMCODE	varchar	True	Yes	7	416	422	Analytical method code is a coded value representing the method of analyses of a given parameter.
EXMCODE	varchar	True	Yes	7	424	430	Extraction Method Code is a coded value representing the method used to extract or prepare a sample.
LCHMETH	varchar	True	Yes	7	432	438	Leachate Method is a coded value identifying the leachate method used in the test.
RUN_NUMBER	int	False	Yes	2	440	441	This information is stored in the test procedure class and is replaced by the use of test sequence.
LABSAMPID	varchar	False	Yes	20	443	462	Lab Sample Identification is a unique number assigned to a sample by a laboratory and included in the reporting of the results. This number is the prime number that the Lab will use to reference a specific sample for tests and results.
EXTDATE	varchar	False	Conditional	11	464	474	Extraction Date is the data that represents the start of an extraction test or other preparation methods. The format is [DD-MMM-YYYY] where YYYY is the calendar year, MM is the numeric month and DD is the numeric date.
EXTTIME	varchar	False	Conditional	4	476	479	Extraction Time is the time of day (24 hour clock) that represents the start of an extraction test or other preparation methods. This value is expressed in HHMM of the local time.
LCHDATE	varchar	False	Conditional	11	481	491	Leachate Date is the date on which a sample was leached. The format is [DD-MMMYYYY] where YYYY is the calendar year, MM is the numeric month and DD is the numeric date.

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
LCHTIME	varchar	False	Conditional	4	493	496	Leachate Time is the time of day (24 hour clock) that represents the time a sample was leached. This value is expressed in HHMM of the local time.
LCHLOT	varchar	False	Conditional	10	498	507	Leachate Lot is the batch designator of an autonomous group of environmental samples and associated quality control samples leached together.
ANADATE	varchar	False	Yes	11	509	519	Analysis Date is a date that represents the start of a test or procedure. The Date represents the date the sample or extraction is analyzed in the laboratory.The format is [DD-MMM-YYYY] where YYYY is the calendar year, MMM is the abbreviated month and DD is the numeric date.
ANATIME	varchar	False	Yes	4	521	524	Analysis Time is the time of day (24 hour clock) that represents the datart of a test or procedure. This value is expressed in HHMM of the local time.
ANALOT	varchar	False	Yes	10	526	535	Analysis Lot is the batch designator of an autonomous group of environmental samples and associated quality control samples analyzed together.
LABLOTCTL	varchar	False	Yes	10	537	546	Lab Lot Control is a more general identifier to indicate extractions or other preparation methods during the testing process.
CALREFID	varchar	False	No	10	548	557	Calibration Reference Identification is a coded value which establishes a reference link between environmental and quality control samples and their corresponding calibration records.
RTTYPE	varchar	True	No	5	559	563	Remediation Technology Type is a coded value describing the type of remediation technology being used. This value is the coded value for remediation technology like slurry wall, in situ vitrification, bio-reactor, etc.
BASIS	varchar	True	Yes	1	565	565	Basis is a coded value detailing whether tissue or solid sample results are reported on a wet (W) or dry (D) basis.
PARLABEL	varchar	True	Yes	12	567	578	Parameter Label Code is an abbreviated, common acronym representing a parameter/analyte.
PRCCODE	varchar	True	Yes	3	580	582	Parameter Class Code is a coded value identifying a class or group that a parameter is associated with. I. e., ORG, MET, STD, etc.
PARVQ	varchar	True	Yes	2	584	585	Parameter Value Qualifier is a coded value qualifying the analytical results field (Parameter Value). Note that in general, this field does not indicate QC failures or deficiencies such as accuracy, precision, blank contamination, or holding time violations.
PARVAL	numeric	False	Yes	17	587	603	Parameter value is the value of a calculated parameter reported in units consistent with the Units field.
PARUN	numeric	False	Conditional	13	605	617	Parameter Uncertainty is a value which measures the uncertainty of the measurement. This value is expressed as positive (+) or negative (-) some value.
PRECISION_	int	False	Yes	1	619	619	Precision is number indicating the number of digits after the decimal point of the results.
EXPECTED	float	False	Conditional	17	621	637	Expected Result is a number indicating the target result for a quality control sample or surrogate spike.

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
EVPREC	int	False	Conditional	1	639	639	Expected Value Precision is a number indicating the number of digits after the decimal point in the results of a test.
MDL	numeric	False	Yes	17	641	657	Method detection limit is the smallest quantity of an analyte that can be detected from a prepared sample.
RL	numeric	False	Yes	17	659	675	Reporting Limit is a number which is the smallest quantity of an analyte that should be reported in accordance with the QAPP.
UNITS	varchar	True	Yes	10	677	686	The Units field refers to the units of measure used for the parameter value.
VQ_1C	varchar	True	Conditional	2	688	689	1C Value Qualifier is a coded value qualifying the analytical results field.
VAL_1C	numeric	False	Conditional	17	691	707	First Column Parameter Value is a number field which represents the primary or initial value for a analyte generated from a Gas Chromatography or Gas Chromatography/Mass Spectroscopy results.
FCVALPREC	int	False	Conditional	1	709	709	First Column Value Precision is a number indicating the number of digits after the decimal point of the results of a test.
VQ_CONFIRM	varchar	True	Conditional	2	711	712	Value Qualifying Confirmation is a coded value qualifying the confirming analytical result.
VAL_CONFIRM	numeric	False	Conditional	17	714	730	Confirming Value is a number value of a chromatographic analytical result that requires second column confirmation.
CNFVALPREC	int	False	Conditional	1	732	732	Confirmation Value Precision is a number indicating the number of digits after the decimal point of the results of a test.
DILUTION	numeric	False	Yes	17	734	750	Dilution Required is a numeric expression of the amount of dilution required to bring the analyte concentration in the sample into analysis range.
PRIME_DQT	varchar	True	No	5	752	756	Prime Data Qualifier Type is a coded value identifying the type of data qualifier that the prime used
PRIME_FLAG	varchar	True	No	6	758	763	Prime Flags are codes that are assigned during chemistry data validation.
LAB_DQT	varchar	True	No	5	765	769	Laboratory Data Qualifier Type is a coded value indicating the specific QAPP or DQO document from which the entered performance criteria data originates.
LAB_QC_FLAG	varchar	True	Conditional	6	771	776	Laboratory Quality Control Flag is coded values entered by the laboratory to indicate the existence of a specific quality control exception or condition.
BEST_RESULT	varchar	False	Yes	1	778	778	Best Result is a single value that has been determined to be the best result. I.e., the value reported in the prime contractor's final report for the sampling event in focus. Appropriate Values are Y (Yes) or N (No)
REASON_CODE	varchar	False	No	30	780	809	Reason Code is a coded value that indicates why a laboratory or contractor flag was issued to a data point.
PERCENT_RECOVERY	numeric	False	Conditional	15	811	825	Percent Recovery is the calculated recovery value for the spiked or surrogate analyte. This value is expressed in percent plus 2 decimals.
RPD	numeric	False	Conditional	15	827	841	Relative Percent Difference is a measure of variability that adjust for the magnitude of observations. This value is used to assess total and analytical precision of duplicate measurements.

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
UPPER_RPD	numeric	False	Conditional	15	843	857	Upper Relative Percent Difference is a number representing the upper performance limit for relative percent difference.
UPPER_ACCURACY	numeric	False	Conditional	15	859	873	Accuracy Upper Limit is a number representing the upper control limit of percent recovery as measured for a known target analyte spiked into a quality control sample.
LOWER_ACCURACY	numeric	False	Conditional	15	875	889	Accuracy Lower Limit is a number representing the lower control limit of percent recovery as measured for a known target analyte spiked into a quality control sample.
SPIKE_ADDED	numeric	False	Conditional	17	891	907	Spike Amount Added is a number value of a final concentration of an analyte spiked into a sample.
SPIKE_ADDED_PREC	smallint	False	Optional	1	909	909	Spike Amount Added Precision is number indicating the number of digits after the decimal point of the spike added.
VALCODE	varchar	True	No	4	911	914	Coded value identifying the company validating analytical results.
TIC_NAME	varchar	False	No	54	916	969	Name of the Tentatively Identified Compound being reported.
RETENTION_TIME	varchar	False	No	6	971	976	Retention time of a Tentatively Identified Compound.
LOD	numeric	False	No	17	978	994	Limit of Detection

Valid values can be found on the project portal; navigate to Reports, ADR and Submission Reports, Valid Value Lists and select the field of interest from the dropdown menu.

Data Type Descriptions

float	A number in scientific notation containing a variable number of decimal places
int	An integer from -2,147,483,648 to 2,147,483,647
numeric	A number containing a fixed number of decimal places
smallint	An integer from -32,768 to 32,767
varchar	Text of variable length

FIELD SAMPLING, ANALYTICAL, AND QUALITY MANAGEMENT REFERENCE TABLES

- *Table B-1:* Location-Specific Sampling Methods/SOP Requirements
- *Table B-2:* Analyte List and Reference Limits
- *Table B-3:* Preparation and Analytical Requirements for Field and QC Samples
- *Table B-4:* Analytical Services
- *Table B-5:* Analytical SOP References
- *Table B-6:* Laboratory QC Samples for Chemistry Analyses
- *Table B-7:* Analytical Instrument and Equipment Maintenance, Testing, and Inspection
- *Table B-8:* Analytical Instrument Calibration
- *Table B-9:* Data Verification and Validation (Steps I and IIa/IIb) Process

REFERENCE TABLE ACRONYMS AND ABBREVIATIONS

%D	percent difference
BFB	4-bromofluorobenzene
CA	corrective action
CAS	Chemical Abstracts Service
CCB	continuing calibration blank
CCV	continued calibration verification
D	difference
DFTPP	decafluorotriphenylphosphine
DoD	Department of Defense
DQI	data quality indicator
EICP	extracted ion current profile
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency, United States
g	gram
GC	gas chromatography
GC-FID	gas chromatography-flame ionization detector
GC-MS	gas chromatography-mass spectrometry
ICAL	initial calibration
ICV	initial calibration verification
IS	internal standard
L	liter
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
mg/kg	milligram per kilogram
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NAPL	non-aqueous-phase liquid
NIST	National Institute of Standards and Technology
QA	quality assurance
QC	quality control
QSM	*Quality Systems Manual*
RPD	relative percent difference
RRT	relative retention time
RSD	relative standard deviation
RT	retention time
SOP	standard operating procedure
TBD	to be determined
TEL	tetraethyllead

Table B-1: Location-Specific Sampling Methods/SOP Requirements

Sampling Location/ID Number	Matrix	Depth (ft bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
HTLTBH01/HTLTBH01-SON01-##.# HTLTBH02/HTLTBH02-SON01-##.# HTLTBH03/HTLTBH03-SON01-##.# HTLTBH03/HTLTBH03-SOFD01-##.# HTLTBH04/HTLTBH04-SON01-##.# HTLTBH05/HTLTBH05-SON01-##.# HTLTBH06/HTLTBH06-SON01-##.# HTLTBH07/HTLTBH07-SON01-##.# HTLTBH08/HTLTBH08-SON01-##.# HTLTBH09/HTLTBH09-SON01-##.# HTLTBH10/HTLTBH10-SON01-##.# Step-Out Locations (TBD)	Soil	TBD	VOC – 8260C TPH-G – 8260C TPH-D/O – 8015C PAHs – 8270D SIM SVOCs – 8270 TEL-8270	1 composite sample from each 5' interval of each boring; 1 duplicate per 10 subsurface soil samples; 1 MS/MSD pair per 20 subsurface soil samples 1 trip blank per cooler containing VOCs.	Procedure I-B-1, *Soil Sampling*
HTLTUG/HTLTUG-WSN01-##### HTLTADJ/HTLTADJ-WSN01-##### HTLTADJ/HTLTADJ-WSFD01-#####	Surface Water	TBD	VOC – 8260C TPH-G – 8260C TPH-D/O – 8015C PAHs – 8270D SIM SVOCs – 8270 TEL-8270	1 sample collected from a bailer 1 duplicate per 10 1 trip blank per cooler containing VOCs. (Quarterly)	Procedure I-B-5, *Surface Water Sampling*
HTLTMW01/HTLTMW01-WGN01-##### HTLTMW02A/HTLTMW02A-WGN01-##### HTLTMW02B/HTLTMW02B-WGN01-##### HTLTMW03/HTLTMW03-WGN01-##### HTLTMW03/HTLTMW03-WGFD01-##### OWDFMW03B/OWDFMW03B-WGN01-##### OWDFMW05B/OWDFMW05B-WGN01-##### OWDFMW06B/OWDFMW06B-WGN01-##### OWDFMW07B/OWDFMW07B-WGN01-##### OWDFMW03A/OWDFMW03A-WGN01-##### OWDFMW05A/OWDFMW05A-WGN01-##### OWDFMW06A/OWDFMW06A-WGN01-##### OWDFMW07A/OWDFMW07A-WGN01-##### OWDFMW07C/OWDFMW07C-WGN01-#####	Ground Water	TBD	VOC – 8260C TPH-G – 8260C TPH-D/O – 8015C PAHs – 8270D SIM SVOCs – 8270 TEL-8270	1 sample collected from a peristaltic pump or bailer 1 duplicate per 10 1 trip blank per cooler containing VOCs. (Quarterly)	Procedure I-C-3, *Monitoring Well Sampling*
As needed	LNAPL	TBD	Saturated Hydrocarbons, Alkylated PAHs, PIANO Compounds	As needed	Procedure I-B-1*, Soil Sampling*
As needed	Investigation Derived Waste	N/A	TCLP RCRA 8 – 1311/6010/7470 BTEX+HVOC – 8260C TPH-G – 8260C TPH-D/O – 8015C PAHs – 8270D SIM SVOCs – 8270 MIS Preparation	1 MIS sample from each area from 30 subsamples	Procedure I-B-1, *Soil Sampling*

Notes:
Actual number of 5-ft interval composite samples will be dependent on total depth of borehole location.
Volumes for field duplicate, and MS/MSD samples will only be collected if sufficient soil is present at each sampling interval. If limited volume is present, collecting volume for VOCs, PAHs, and TPH will take priority.
One trip blank will be collected during each sampling event.
RCRA Resource Conservation and Recovery Act

Table B-2: Analyte List and Reference Limits

Matrix: Soil

Analyte	CAS Number	EPA RSL [a] (mg/kg)	DOH EAL [b] (mg/kg)	PSL (mg/kg)	PSL Reference	Laboratory-Specific Limits (mg/kg)		
						LOQ	LOD	DL
TPH								
TPH (gasolines)	STL00349	—	100	100	DOH EAL	TBD	TBD	TBD
TPH (middle distillates)	STL00096	—	180	180	DOH EAL	TBD	TBD	TBD
TPH (residual fuels)	STL00631	—	500	500	DOH EAL	TBD	TBD	TBD
TPH with SGC [c]								
TPH (middle distillates)	STL00096	—	180	180	DOH EAL	TBD	TBD	TBD
TPH (residual fuels)	STL00631	—	500	500	DOH EAL	TBD	TBD	TBD
VOCs								
Benzene	71-43-2	1.2	0.3	0.3	DOH EAL	TBD	TBD	TBD
Ethylbenzene	100-41-4	5.8	0.9	0.9	DOH EAL	TBD	TBD	TBD
m,p-Xylenes [d]	1330-20-7	58	1.4	1.4	DOH EAL	TBD	TBD	TBD
o-Xylenes [d]	95-47-6	58	1.4	1.4	DOH EAL	TBD	TBD	TBD
Toluene	108-88-3	490	0.78	0.78	DOH EAL	TBD	TBD	TBD
Trimethylbenzene, 1,2,4-	95-63-6	30	—	30	EPA RSL	TBD	TBD	TBD
Trimethylbenzene, 1,3,5-	108-67-8	27	—	27	EPA RSL	TBD	TBD	TBD
Fuel Additives								
1,2-dichloroethane	107-06-2	0.46	0.023	0.023	DOH EAL	TBD	TBD	TBD
1,2-dibromoethane (ethylene dibromide)	106-93-4	0.036	0.00042	0.00042	DOH EAL	TBD	TBD	TBD
Phenol	108-95-2	1900	1.8	1.8	DOH EAL	TBD	TBD	TBD
PAHs								
1-Methylnaphthalene	90-12-0	0.018	0.89	0.018	EPA RSL	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	24	1.9	1.9	DOH EAL	TBD	TBD	TBD
Acenaphthene	83-32-9	360	120	120	DOH EAL	TBD	TBD	TBD
Acenaphthylene	208-96-8	—	5.5	5.5	DOH EAL	TBD	TBD	TBD
Anthracene	120-12-7	1800	4.2	4.2	DOH EAL	TBD	TBD	TBD
Benzo(a)anthracene	56-55-3	1.1	10	1.1	EPA RSL	TBD	TBD	TBD
Benzo(a)pyrene	50-32-8	0.11	3.6	0.11	EPA RSL	TBD	TBD	TBD
Benzo(b)fluoranthene	205-99-2	1.1	5.8	1.1	EPA RSL	TBD	TBD	TBD
Benzo(g,h,i)perylene	191-24-2	—	35	35	DOH EAL	TBD	TBD	TBD
Benzo(k)fluoranthene	207-08-9	11	35	11	EPA RSL	TBD	TBD	TBD
Chrysene	218-01-9	110	7.3	7.3	DOH EAL	TBD	TBD	TBD

Matrix: Soil

Analyte	CAS Number	EPA RSL [a] (mg/kg)	DOH EAL [b] (mg/kg)	PSL (mg/kg)	PSL Reference	Laboratory-Specific Limits (mg/kg)		
						LOQ	LOD	DL
Dibenz(a,h)anthracene	53-70-3	0.11	1.1	0.11	EPA RSL	TBD	TBD	TBD
Fluoranthene	206-44-0	240	87	87	DOH EAL	TBD	TBD	TBD
Fluorene	86-73-7	240	93	93	DOH EAL	TBD	TBD	TBD
Indeno(1,2,3-c,d)pyrene	193-39-5	1.1	5.7	1.1	EPA RSL	TBD	TBD	TBD
Naphthalene	91-20-3	2	3.1	2	EPA RSL	TBD	TBD	TBD
Phenanthrene	85-01-8	—	69	69	DOH EAL	TBD	TBD	TBD
Pyrene	129-00-0	180	44	44	DOH EAL	TBD	TBD	TBD
TEL								
Tetraethyllead	78-00-2	7.8E-04	—	7.8E-04	EPA RSL	TBD	TBD	TBD

— not available
CAS Chemical Abstract Service
DL Detection Limit
DOH Department of Health
EAL Environmental Action Level
EPA Environmental Protection Agency
LOD Limit of Detection
LOQ Limit of Quantitation
PSL Project Screening Level
RSL Regional Screening Level
TBD To be determined
mg/kg milligram per kilogram

[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Residential Soil – November 2024 (EPA 2024).
[b] DOH Table A-2, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site) (DOH 2024b).
[c] TPH-d and TPH-o with SGC were analyzed only in samples with detections of TPH-d and TPH-o.
[d] References total Xylene values (-m,-p, -o).

Matrix: Groundwater

Analyte	CAS Number	EPA RSL [a] (µg/L)	DOH EAL [b] (µg/L)	PSL (µg/L)	PSL Reference	Laboratory-Specific Limits (µg/L)		
						LOQ	LOD	DL
TPH								
TPH (gasolines)	STL00349	—	74	74	DOH EAL	TBD	TBD	TBD
TPH (middle distillates)	STL00096	—	91	91	DOH EAL	TBD	TBD	TBD
TPH (residual fuels)	STL00631	—	91	91	DOH EAL	TBD	TBD	TBD
TPH with SGC [c]								
TPH (middle distillates)	STL00096	—	91	91	DOH EAL	TBD	TBD	TBD
TPH (residual fuels)	STL00631	—	91	91	DOH EAL	TBD	TBD	TBD
VOCs								
Benzene	71-43-2	0.46	5	0.46	EPA RSL	TBD	TBD	TBD
Ethylbenzene	100-41-4	1.5	30	1.5	EPA RSL	TBD	TBD	TBD
m,p-Xylenes [d]	1330-20-7	19	20	13	DOH EAL	TBD	TBD	TBD
o-Xylenes [d]	95-47-6	19	20	13	DOH EAL	TBD	TBD	TBD
Toluene	108-88-3	110	40	9.8	DOH EAL	TBD	TBD	TBD
Trimethylbenzene, 1,2,4-	95-63-6	5.6	—	5.6	EPA RSL	TBD	TBD	TBD
Trimethylbenzene, 1,3,5-	108-67-8	6	—	6	EPA RSL	TBD	TBD	TBD
Fuel Additives								
1,2-dichloroethane	107-06-2	0.17	5	0.17	EPA RSL	TBD	TBD	TBD
1,2-dibromoethane (ethylene dibromide)	106-93-4	0.0075	0.04	0.0075	EPA RSL	TBD	TBD	TBD
2-(2-Methoxylethoxy)ethanol	111-77-3	—	—	—	—	TBD	TBD	TBD
Phenol	108-95-2	580	300	300	DOH EAL	TBD	TBD	TBD
PAHs								
1-Methylnaphthalene	90-12-0	0.00063	10	0.00063	EPA RSL	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	3.6	10	3.6	EPA RSL	TBD	TBD	TBD
Acenaphthene	83-32-9	53	20	20	DOH EAL	TBD	TBD	TBD
Acenaphthylene	208-96-8	—	300	300	DOH EAL	TBD	TBD	TBD
Anthracene	120-12-7	180	0.18	0.18	DOH EAL	TBD	TBD	TBD
Benzo(a)anthracene	56-55-3	0.03	0.052	0.03	EPA RSL	TBD	TBD	TBD
Benzo(a)pyrene	50-32-8	0.025	0.2	0.025	EPA RSL	TBD	TBD	TBD
Benzo(b)fluoranthene	205-99-2	0.25	0.058	0.058	DOH EAL	TBD	TBD	TBD
Benzo(g,h,i)perylene	191-24-2	—	0.13	0.13	DOH EAL	TBD	TBD	TBD
Benzo(k)fluoranthene	207-08-9	2.5	0.36	0.36	DOH EAL	TBD	TBD	TBD
Chrysene	218-01-9	25	0.24	0.24	DOH EAL	TBD	TBD	TBD
Dibenz(a,h)anthracene	53-70-3	0.025	0.0048	0.0048	DOH EAL	TBD	TBD	TBD

Matrix: Groundwater

Analyte	CAS Number	EPA RSL [a] (µg/L)	DOH EAL [b] (µg/L)	PSL (µg/L)	PSL Reference	Laboratory-Specific Limits (µg/L)		
						LOQ	LOD	DL
Fluoranthene	206-44-0	80	13	13	DOH EAL	TBD	TBD	TBD
Fluorene	86-73-7	29	250	29	EPA RSL	TBD	TBD	TBD
Indeno(1,2,3-c,d)pyrene	193-39-5	0.25	0.018	0.018	DOH EAL	TBD	TBD	TBD
Naphthalene	91-20-3	0.12	17	0.12	EPA RSL	TBD	TBD	TBD
Phenanthrene	85-01-8	—	250	250	DOH EAL	TBD	TBD	TBD
Pyrene	129-00-0	12	68	12	EPA RSL	TBD	TBD	TBD
TEL								
Tetraethyllead	78-00-2	1.3E-04	—	1.3E-04	EPA RSL	TBD	TBD	TBD

— not available
CAS Chemical Abstract Service
DL Detection Limit
DOH Department of Health
EAL Environmental Action Level
EPA Environmental Protection Agency
LOD Limit of Detection
LOQ Limit of Quantitation
PSL Project Screening Level
RSL Regional Screening Level
TBD To be determined
µg/L micrograms per liter

[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024).
[b] DOH Table D-1b, GW Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is NOT located within 150 meters of release site) (DOH 2024b).
[c] TPH-d and TPH-o with SGC were analyzed only in samples with detections of TPH-d and TPH-o.
[d] References total Xylene values (-m,-p, -o).

Matrix: Surface Water

Analyte	CAS Number	EPA RSL [a] (µg/L)	DOH EAL [b] (µg/L)	PSL (µg/L)	PSL Reference	Laboratory-Specific Limits (µg/L)		
						LOQ	LOD	DL
TPH								
TPH (gasolines)	STL00349	—	74	74	DOH EAL	TBD	TBD	TBD
TPH (middle distillates)	STL00096	—	91	91	DOH EAL	TBD	TBD	TBD
TPH (residual fuels)	STL00631	—	91	91	DOH EAL	TBD	TBD	TBD
TPH with SGC [c]								
TPH (middle distillates)	STL00096	—	91	91	DOH EAL	TBD	TBD	TBD
TPH (residual fuels)	STL00631	—	91	91	DOH EAL	TBD	TBD	TBD
VOCs								
Benzene	71-43-2	0.46	5	0.46	EPA RSL	TBD	TBD	TBD
Ethylbenzene	100-41-4	1.5	30	1.5	EPA RSL	TBD	TBD	TBD
m,p-Xylenes [d]	1330-20-7	19	20	19	EPA RSL	TBD	TBD	TBD
o-Xylenes [d]	95-47-6	19	20	19	EPA RSL	TBD	TBD	TBD
Toluene	108-88-3	110	40	40	DOH EAL	TBD	TBD	TBD
Trimethylbenzene, 1,2,4-	95-63-6	5.6	—	5.6	EPA RSL	TBD	TBD	TBD
Trimethylbenzene, 1,3,5-	108-67-8	6	—	6	EPA RSL	TBD	TBD	TBD
Fuel Additives								
1,2-dichloroethane	107-06-2	0.17	5	0.17	EPA RSL	TBD	TBD	TBD
1,2-dibromoethane (ethylene dibromide)	106-93-4	0.0075	0.04	0.0075	EPA RSL	TBD	TBD	TBD
2-(2-Methoxylethoxy)ethanol	111-77-3	—	—	—	—	TBD	TBD	TBD
Phenol	108-95-2	580	160	160	DOH EAL	TBD	TBD	TBD
PAHs								
1-Methylnaphthalene	90-12-0	0.00063	2.1	0.00063	EPA RSL	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	3.6	4.7	3.6	EPA RSL	TBD	TBD	TBD
Acenaphthene	83-32-9	53	15	15	DOH EAL	TBD	TBD	TBD
Acenaphthylene	208-96-8	—	13	13	DOH EAL	TBD	TBD	TBD
Anthracene	120-12-7	180	0.02	0.02	DOH EAL	TBD	TBD	TBD
Benzo(a)anthracene	56-55-3	0.03	0.018	0.018	DOH EAL	TBD	TBD	TBD
Benzo(a)pyrene	50-32-8	0.025	0.018	0.018	DOH EAL	TBD	TBD	TBD
Benzo(b)fluoranthene	205-99-2	0.25	0.018	0.018	DOH EAL	TBD	TBD	TBD
Benzo(g,h,i)perylene	191-24-2	—	0.13	0.13	DOH EAL	TBD	TBD	TBD
Benzo(k)fluoranthene	207-08-9	2.5	0.018	0.018	DOH EAL	TBD	TBD	TBD
Chrysene	218-01-9	25	0.018	0.018	DOH EAL	TBD	TBD	TBD
Dibenz(a,h)anthracene	53-70-3	0.025	0.0048	0.0048	DOH EAL	TBD	TBD	TBD

Matrix: Surface Water

Analyte	CAS Number	EPA RSL [a] (µg/L)	DOH EAL [b] (µg/L)	PSL (µg/L)	PSL Reference	Laboratory-Specific Limits (µg/L)		
						LOQ	LOD	DL
Fluoranthene	206-44-0	80	0.8	0.8	DOH EAL	TBD	TBD	TBD
Fluorene	86-73-7	29	19	3.9	DOH EAL	TBD	TBD	TBD
Indeno(1,2,3-c,d)pyrene	193-39-5	0.25	0.018	0.018	DOH EAL	TBD	TBD	TBD
Naphthalene	91-20-3	0.12	17	0.12	EPA RSL	TBD	TBD	TBD
Phenanthrene	85-01-8	—	2.3	2.3	DOH EAL	TBD	TBD	TBD
Pyrene	129-00-0	12	4.6	4.6	DOH EAL	TBD	TBD	TBD
TEL								
Tetraethyllead	78-00-2	1.3E-04	—	1.3E-04	EPA RSL	TBD	TBD	TBD

— not available
CAS Chemical Abstract Service
DL Detection Limit
DOH Department of Health
EAL Environmental Action Level
EPA Environmental Protection Agency
LOD Limit of Detection
LOQ Limit of Quantitation
PSL Project Screening Level
RSL Regional Screening Level
TBD To be determined
µg/L micrograms per liter
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024).
[b] DOH Table D-2a, SW Action Levels (Fresh Water habitats) (DOH 2024b).
[c] TPH-d and TPH-o with SGC were analyzed only in samples with detections of TPH-d and TPH-o.
[d] References total Xylene values (-m,-p, -o).

Matrix: LNAPL

Analytical Group: Alkylated PAHs (8270-SIM)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
1-Methylnaphthalene	90-12-0	—	TBD	TBD	TBD
2,3,5-Trimethylnaphthalene	2245-38-7	—	TBD	TBD	TBD
2,6-Dimethylnaphthalene	581-42-0	—	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	—	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	—	TBD	TBD	TBD
Acenaphthene	83-32-9	—	TBD	TBD	TBD
Acenaphthylene	208-96-8	—	TBD	TBD	TBD
Anthracene	120-12-7	—	TBD	TBD	TBD
Benz(a)anthracene	56-55-3	—	TBD	TBD	TBD
Benzo(a)pyrene	50-32-8	—	TBD	TBD	TBD
Benzo(b)fluoranthene	205-99-2	—	TBD	TBD	TBD
Benzo(e)pyrene	192-97-2	—	TBD	TBD	TBD
Benzo(g,h,i)perylene	191-24-2	—	TBD	TBD	TBD
Benzo(j)+(k)fluoranthene	BJFBKF	—	TBD	TBD	TBD
Biphenyl	92-52-4	—	TBD	TBD	TBD
C1-Chrysenes	C1_218-01-9	—	TBD	TBD	TBD
C1-Dibenzothiophenes BS	132-65-0C1	—	TBD	TBD	TBD
C1-Fluoranthenes/Pyrenes	PFLCA1	—	TBD	TBD	TBD
C1-Fluorenes	FLRC1	—	TBD	TBD	TBD
C1-Naphthalenes	NPHC1	—	TBD	TBD	TBD
C1-Naphthalenes	NPHC1	—	TBD	TBD	TBD
C1-Phenanthrenes/Anthracenes	C1_PHENANTH	—	TBD	TBD	TBD
C2-Chrysenes BS	C2_218-01-9	—	TBD	TBD	TBD
C2-Dibenzothiophenes	132-65-0C2	—	TBD	TBD	TBD
C2-Fluoranthenes/Pyrenes	PFLCA2	—	TBD	TBD	TBD
C2-Fluorenes	FLRC2	—	TBD	TBD	TBD
C2-Naphthalenes	NPHC2	—	TBD	TBD	TBD
C2-Phenanthrenes/Anthr BS	C2_PHENANTH	—	TBD	TBD	TBD
C3-Chrysenes	C3_218-01-9	—	TBD	TBD	TBD
C3-Dibenzothiophenes	132-65-0C3	—	TBD	TBD	TBD
C3-Fluoranthenes/Pyrenes	PFLCA3	—	TBD	TBD	TBD
C3-Fluorenes	FLRC3	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: Alkylated PAHs (8270-SIM)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
C3-Naphthalenes	NPHC3	—	TBD	TBD	TBD
C3-Phenanthrenes/Anthracenes	C3_PHENANTH	—	TBD	TBD	TBD
C4-Chrysenes	C4_218-01-9	—	TBD	TBD	TBD
C4-Dibenzothiophenes	132-65-0C4	—	TBD	TBD	TBD
C4-Fluoranthenes/Pyrenes	PFLCA4	—	TBD	TBD	TBD
C4-Naphthalenes	NPHC4	—	TBD	TBD	TBD
C4-Phenanthrenes/Anthracenes	C4_PHENANTH	—	TBD	TBD	TBD
Chrysene/Triphenylene	CHRYTRIPHEN	—	TBD	TBD	TBD
Dibenz(a,h)+(a,c)anthracene	DAHDAC	—	TBD	TBD	TBD
Dibenzofuran	132-64-9	—	TBD	TBD	TBD
Dibenzothiophene	132-65-0	—	TBD	TBD	TBD
Fluoranthene	206-44-0	—	TBD	TBD	TBD
Fluorene	86-73-7	—	TBD	TBD	TBD
Indeno(1,2,3-cd)pyrene	193-39-5	—	TBD	TBD	TBD
Naphthalene	91-20-3	—	TBD	TBD	TBD
Perylene	198-55-0	—	TBD	TBD	TBD
Phenanthrene	85-01-8	—	TBD	TBD	TBD
Pyrene	129-00-0	—	TBD	TBD	TBD
Retene	483-65-8	—	TBD	TBD	TBD

Note: Units are in mg/kg.
— not available
CAS Chemical Abstracts Service
DL detection limit
LOD limit of detection
LOQ limit of quantification
PSL Project screening level
TBD to be determined
[a] No project limits; results are only for characterization only.

Matrix: LNAPL

Analytical Group: Saturated Hydrocarbons (8015D)

			Laboratory-Specific Limits		
Analyte	CAS No.	PSL [a]	LOQ	LOD	DL
2,6,10-Trimethyldodecane (1380)	3891-98-3	—	TBD	TBD	TBD
2,6,10-Trimethyltridecane (1470)	TMTD1470	—	TBD	TBD	TBD
n-Decane (C10)	124-18-5	—	TBD	TBD	TBD
n-Docosane (C22)	629-97-0	—	TBD	TBD	TBD
n-Dodecane (C12)	112-40-3	—	TBD	TBD	TBD
n-Dotriacontane (C32)	544-85-4	—	TBD	TBD	TBD
n-Eicosane (C20)	112-95-8	—	TBD	TBD	TBD
n-Heneicosane (C21)	629-94-7	—	TBD	TBD	TBD
n-Hentriacontane (C31)	630-04-6	—	TBD	TBD	TBD
n-Heptacosane (C27)	593-49-7	—	TBD	TBD	TBD
n-Heptadecane (C17)	629-78-7	—	TBD	TBD	TBD
n-Heptatriacontane (C37)	7194-84-5	—	TBD	TBD	TBD
n-Hexacosane (C26)	630-01-3	—	TBD	TBD	TBD
n-Hexadecane (C16)	544-76-3	—	TBD	TBD	TBD
n-Hexatriacontane (C36)	630-06-8	—	TBD	TBD	TBD
n-Nonacosane (C29)	630-03-5	—	TBD	TBD	TBD
n-Nonadecane (C19)	629-92-5	—	TBD	TBD	TBD
n-Nonane (C9)	111-84-2	—	TBD	TBD	TBD
n-Nonatriacontane (C39)	7194-86-7	—	TBD	TBD	TBD
n-Octacosane (C28)	630-02-4	—	TBD	TBD	TBD
n-Octadecane (C18)	593-45-3	—	TBD	TBD	TBD
n-Octatriacontane (C38)	7194-85-6	—	TBD	TBD	TBD
Norpristane (1650)	3892-00-0	—	TBD	TBD	TBD
n-Pentacosane (C25)	629-99-2	—	TBD	TBD	TBD
n-Pentadecane (C15)	629-62-9	—	TBD	TBD	TBD
n-Pentatriacontane (C35)	630-07-9	—	TBD	TBD	TBD
n-Tetracontane (C40)	4181-95-7	—	TBD	TBD	TBD
n-Tetracosane (C24)	646-31-1	—	TBD	TBD	TBD
n-Tetradecane (C14)	629-59-4	—	TBD	TBD	TBD
n-Tetratriacontane (C34)	14167-59-0	—	TBD	TBD	TBD
n-Triacontane (C30)	638-68-6	—	TBD	TBD	TBD
n-Tricosane (C23)	638-67-5	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: Saturated Hydrocarbons (8015D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
n-Tridecane (C13)	629-50-5	—	TBD	TBD	TBD
n-Tritriacontane (C33)	630-05-7	—	TBD	TBD	TBD
n-Undecane (C11)	1120-21-4	—	TBD	TBD	TBD
Phytane	638-36-8	—	TBD	TBD	TBD
Pristane	1921-70-6	—	TBD	TBD	TBD
Total Petroleum Hydrocarbons (C9-C44)	TPH	—	TBD	TBD	TBD
Total Saturated Hydrocarbons	TSATHC	—	TBD	TBD	TBD

Note: Units are in mg/kg.
— not available
CAS Chemical Abstracts Service
DL detection limit
LOD limit of detection
LOQ limit of quantification
PSL Project screening level
TBD to be determined
[a] No project limits; results are only for characterization only.

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
1,1,4-Trimethylcyclohexane	7094-27-1	—	TBD	TBD	TBD
1,1-Dimethylcyclopentane	1638-26-2	—	TBD	TBD	TBD
1,2,3,4-Tetramethylbenzene	488-23-3	—	TBD	TBD	TBD
1,2,3,5-Tetramethylbenzene	527-53-7	—	TBD	TBD	TBD
1,2,3-Trimethylbenzene	526-73-8	—	TBD	TBD	TBD
1,2,4,5-Tetramethylbenzene	95-93-2	—	TBD	TBD	TBD
1,2,4-Triethylbenzene	877-44-1	—	TBD	TBD	TBD
1,2,4-Trimethylbenzene	95-63-6	—	TBD	TBD	TBD
1,2-Dibromoethane	106-93-4	—	TBD	TBD	TBD
1,2-Dichloroethane	107-06-2	—	TBD	TBD	TBD
1,2-Diethylbenzene	135-01-3	—	TBD	TBD	TBD
1,2-Dimethyl-3-Ethylbenzene	933-98-2	—	TBD	TBD	TBD
1,2-Dimethyl-4-Ethylbenzene	934-80-5	—	TBD	TBD	TBD
1,2-Dimethylcyclohexane (cis)	112134	—	TBD	TBD	TBD
1,2-Dimethylcyclohexane (trans)	6876-23-9	—	TBD	TBD	TBD
1,3,5-Triethylbenzene	102-25-0	—	TBD	TBD	TBD
1,3,5-Trimethylbenzene	108-67-8	—	TBD	TBD	TBD
1,3-Diethylbenzene	141-93-5	—	TBD	TBD	TBD
1,3-Dimethyl-2-Ethylbenzene	354381	—	TBD	TBD	TBD
1,3-Dimethyl-4-Ethylbenzene	874-41-9	—	TBD	TBD	TBD
1,3-Dimethyl-5-Ethylbenzene	934-74-7	—	TBD	TBD	TBD
1,3-Dimethyl-5-tert-Butylbenzene	98-19-1	—	TBD	TBD	TBD
1,3-Dimethylcyclopentane (cis)	2532-58-3	—	TBD	TBD	TBD
1,4-Dimethyl-2-Ethylbenzene	1758-88-9	—	TBD	TBD	TBD
1,4-Dimethylcyclohexane (trans)	112227	—	TBD	TBD	TBD
1-Decene	872-05-9	—	TBD	TBD	TBD
1-Heptene/1,2-DMCP (trans)	592-76-7/822-50-4	—	TBD	TBD	TBD
1-Hexene	592-41-6	—	TBD	TBD	TBD
1-Methyl-2-Ethylbenzene	611-14-3	—	TBD	TBD	TBD
1-Methyl-2-Isopropylbenzene	527-84-4	—	TBD	TBD	TBD
1-Methyl-2-N-Propylbenzene	1074-17-5	—	TBD	TBD	TBD
1-Methyl-3-Ethylbenzene	620-14-4	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
1-Methyl-3-Isopropylbenzene	535-77-3	—	TBD	TBD	TBD
1-Methyl-3-N-Propylbenzene	1074-43-7	—	TBD	TBD	TBD
1-Methyl-4-Ethylbenzene	622-96-8	—	TBD	TBD	TBD
1-Methyl-4-Isopropylbenzene	99-87-6	—	TBD	TBD	TBD
1-Methyl-4-N-Propylbenzene	1074-55-1	—	TBD	TBD	TBD
1-Methylnaphthalene	90-12-0	—	TBD	TBD	TBD
1-Nonene	124-11-8	—	TBD	TBD	TBD
1-Octene	111-66-0	—	TBD	TBD	TBD
1-Pentene	109-67-1	—	TBD	TBD	TBD
2,2,3-Trimethylbutane	464-06-2	—	TBD	TBD	TBD
2,2,3-Trimethylpentane	564-02-3	—	TBD	TBD	TBD
2,2-Dimethylbutane	75-83-2	—	TBD	TBD	TBD
2,2-Dimethylhexane	590-73-8	—	TBD	TBD	TBD
2,2-Dimethylpentane	590-35-2	—	TBD	TBD	TBD
2,3,3-Trimethylpentane	560-21-4	—	TBD	TBD	TBD
2,3,4-Trimethylpentane	565-75-3	—	TBD	TBD	TBD
2,3-Dimethylbutane	79-29-8	—	TBD	TBD	TBD
2,3-Dimethylheptane	3074-71-3	—	TBD	TBD	TBD
2,3-Dimethylhexane	584-94-1	—	TBD	TBD	TBD
2,3-Dimethylpentane	565-59-3	—	TBD	TBD	TBD
2,4-Dimethylhexane	589-43-5	—	TBD	TBD	TBD
2,4-Dimethylpentane	108-08-7	—	TBD	TBD	TBD
2,5-Dimethylheptane	2216-30-0	—	TBD	TBD	TBD
2,5-Dimethylhexane	592-13-2	—	TBD	TBD	TBD
2-Ethylthiophene	872-55-9	—	TBD	TBD	TBD
2-Methyl-1-Butene	563-46-2	—	TBD	TBD	TBD
2-Methyl-2-pentene	625-27-4	—	TBD	TBD	TBD
2-Methylheptane	592-27-8	—	TBD	TBD	TBD
2-Methylhexane	591-76-4	—	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	—	TBD	TBD	TBD
2-Methylnonane	871-83-0	—	TBD	TBD	TBD
2-Methyloctane	3221-61-2	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
2-Methylpentane	107-83-5	—	TBD	TBD	TBD
2-Methylthiophene	554-14-3	—	TBD	TBD	TBD
2-Nonene	6434-77-1	—	TBD	TBD	TBD
3,3-Diethylpentane	1067-20-5	—	TBD	TBD	TBD
3,3-Dimethylheptane	4032-86-4	—	TBD	TBD	TBD
3,3-Dimethyloctane	4110-44-5	—	TBD	TBD	TBD
3,3-Dimethylpentane	562-49-2	—	TBD	TBD	TBD
3,4-Dimethylheptane	922-28-1	—	TBD	TBD	TBD
3,5-Dimethylheptane	926-82-9	—	TBD	TBD	TBD
3-Ethylhexane	619-99-8	—	TBD	TBD	TBD
3-Ethylpentane	617-78-7	—	TBD	TBD	TBD
3-Methyl-1-butene	563-45-1	—	TBD	TBD	TBD
3-Methylheptane	589-81-1	—	TBD	TBD	TBD
3-Methylhexane	589-34-4	—	TBD	TBD	TBD
3-Methylnonane	1465084	—	TBD	TBD	TBD
3-Methyloctane	2216-33-3	—	TBD	TBD	TBD
3-Methylpentane	96-14-0	—	TBD	TBD	TBD
3-Methylthiophene	616-44-4	—	TBD	TBD	TBD
4-Methyl-1-pentene	691-37-2	—	TBD	TBD	TBD
4-Methylheptane	589-53-7	—	TBD	TBD	TBD
4-Methyloctane	2216-34-4	—	TBD	TBD	TBD
Benzene	71-43-2	—	TBD	TBD	TBD
Benzothiophene	95-15-8	—	TBD	TBD	TBD
cis-2-Heptene	6443-92-1	—	TBD	TBD	TBD
cis-2-Hexene	7688-21-3	—	TBD	TBD	TBD
cis-2-Octene	2097322	—	TBD	TBD	TBD
cis-2-Pentene	627-20-3	—	TBD	TBD	TBD
cis-3-Nonene	20237-46-1	—	TBD	TBD	TBD
Cyclohexane	110-82-7	—	TBD	TBD	TBD
Cyclopentane	287-92-3	—	TBD	TBD	TBD
Decane (C10)	124-18-5	—	TBD	TBD	TBD
Dodecane (C12)	112-40-3	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
Ethylbenzene	100-41-4	—	TBD	TBD	TBD
Ethylcyclopentane	1640-89-7	—	TBD	TBD	TBD
Ethyl-Tert-Butyl-Ether	637-92-3	—	TBD	TBD	TBD
Heptane	142-82-5	—	TBD	TBD	TBD
Hexylbenzene	1077-16-3	—	TBD	TBD	TBD
Indane	496-11-7	—	TBD	TBD	TBD
Indene	95-13-6	—	TBD	TBD	TBD
Isobutylbenzene	538-93-2	—	TBD	TBD	TBD
Isobutylcyclohexane	1678-98-4	—	TBD	TBD	TBD
Isooctane	540-84-1	—	TBD	TBD	TBD
Isopentane	78-78-4	—	TBD	TBD	TBD
Isoprene	78-79-5	—	TBD	TBD	TBD
Isopropyl Ether	108-20-3	—	TBD	TBD	TBD
Isopropylbenzene	98-82-8	—	TBD	TBD	TBD
Isopropylcyclohexane	696-29-7	—	TBD	TBD	TBD
Isopropylcyclopentane	3875-51-2	—	TBD	TBD	TBD
Methyl tert butyl ether	1634-04-4	—	TBD	TBD	TBD
Methylcyclohexane	108-87-2	—	TBD	TBD	TBD
Methylcyclopentane	96-37-7	—	TBD	TBD	TBD
MMT	12108-13-3	—	TBD	TBD	TBD
Naphthalene	91-20-3	—	TBD	TBD	TBD
n-Butylbenzene	104-51-8	—	TBD	TBD	TBD
n-Hexane	110-54-3	—	TBD	TBD	TBD
Nonane (C9)	111-84-2	—	TBD	TBD	TBD
N-Pentylbenzene	538-68-1	—	TBD	TBD	TBD
n-Propylbenzene	103-65-1	—	TBD	TBD	TBD
Octane	111-65-9	—	TBD	TBD	TBD
o-Xylene	95-47-6	—	TBD	TBD	TBD
p/m-Xylene	M+P-XYLENE	—	TBD	TBD	TBD
Pentadecane	629-62-9	—	TBD	TBD	TBD
Pentane	109-66-0	—	TBD	TBD	TBD
sec-Butylbenzene	135-98-8	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
Styrene	100-42-5	—	TBD	TBD	TBD
tert-Butylbenzene	98-06-6	—	TBD	TBD	TBD
Tertiary Butanol	75-65-0	—	TBD	TBD	TBD
Tertiary-Amyl Methyl Ether	994-05-8	—	TBD	TBD	TBD
Tetradecane (C14)	629-59-4	—	TBD	TBD	TBD
Thiophene	110-02-1	—	TBD	TBD	TBD
Toluene	108-88-3	—	TBD	TBD	TBD
trans-2-Heptene	14686-13-6	—	TBD	TBD	TBD
trans-2-Hexene	4050-45-7	—	TBD	TBD	TBD
trans-2-Pentene	646-04-8	—	TBD	TBD	TBD
trans-3-Heptene	14686-14-7	—	TBD	TBD	TBD
trans-3-Nonene	20063-92-7	—	TBD	TBD	TBD
Tridecane	629-50-5	—	TBD	TBD	TBD
Undecane	1120-21-4	—	TBD	TBD	TBD
Xylene (Total)	1330-20-7	—	TBD	TBD	TBD

Note: Units are in mg/kg.

— not available
CAS Chemical Abstracts Service
DL detection limit
LOD limit of detection
LOQ limit of quantification
PSL Project screening level
TBD to be determined

[a] No project limits; results are only for characterization only.

Table B-3: Preparation and Analytical Requirements for Field and QC Samples

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Soil						
Soil	VOC	Preparation Method: EPA 5035A Preparation SOP: TBD Analysis Method: EPA 8260B or 8260C Analysis SOP: TBD	6 × 4 oz wide-mouth amber glass with 25 mL of methanol, Teflon-lined lid	25 g per amber glass	Methanol ratio of 1 g soil to 1 ml methanol.	Samples analyzed within 14 days of collection.
	TPH-GRO	Preparation Method: EPA 5035A Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD	6 × 4 oz wide-mouth amber glass with 25 mL of methanol, Teflon-lined lid	25 g per amber glass	Methanol ratio of 1 g soil to 1 ml methanol and frozen.	14 days when shipped to laboratory.
	TPH-DRO/ORO	Preparation Method: EPA 3550C Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD	1 × 1 gallon-size plastic bag, unpreserved	1 kg	Store in dark. Cool to ≤6°C.	Samples extracted within 14 days and analyzed within 40 days following extraction.
	PAH/SVOC	Preparation Method: EPA 3550C Preparation SOP: TBD Analysis Method: EPA 8270D SIM and 8270 Analysis SOP: TBD	1 × 1 gallon-size plastic bag, unpreserved	1 kg	Store in dark. Cool to ≤6°C. Frozen after extraction.	Samples extracted within 14 days and analyzed within 40 days following extraction.
	TEL	Preparation Method: EPA 3510C Preparation SOP: TBD Analysis Method: EPA 8270 Analysis SOP: TBD	1 × 1 gallon-size plastic bag, unpreserved	1 kg	Store in dark. Cool to ≤6°C. Frozen after extraction.	Samples extracted within 14 days and analyzed within 40 days following extraction.
Water						
Groundwater, Surface Water	VOC	Preparation Method: EPA 5030B Preparation SOP: TBD Analysis Method: EPA 8260C Analysis SOP: TBD	3 × 40-mL VOA vials, HCl-preserved, Teflon-lined septum caps	40 mL per VOA vial	Cool to ≤6°C and adjust to pH <2.	14 days when shipped to a laboratory within 48 hours at <6°C upon receipt. Headspace should not exceed 5–6 mm. If not preserved, samples are to be analyzed within 7 days of collection.
	TPH-GRO	Preparation Method: EPA 5030B Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD	3 × 40-mL VOA vials, HCl-preserved, Teflon-lined septum caps	40 mL per VOA vial	Cool to ≤6°C and adjust to pH <2 using HCl.	14 days when shipped to a laboratory within 48 hours at <6°C upon receipt. Headspace should not exceed 5–6 mm. If not preserved, samples are to be analyzed within 7 days of collection.
	TPH-DRO/ORO	Preparation Method: EPA 3510C Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD	2 × 1-L amber glass, unpreserved, Teflon-lined lid	1L	Store in dark. Cool to ≤6°C.	Samples extracted within 7 days and analyzed within 40 days following extraction.

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Groundwater, Surface Water (cont'd)	PAH/SVOC	Preparation Method: EPA 3510C Preparation SOP: TBD Analysis Method: EPA 8270D SIM and 8270 Analysis SOP: TBD	2 × 1-L amber glass, unpreserved, Teflon-lined lid	1L	Store in dark. Cool to ≤6°C. Frozen after extraction.	Samples extracted within 7 days and analyzed within 40 days following extraction.
	TEL	Preparation Method: EPA 3510C Preparation SOP: TBD Analysis Method: EPA 8270 Analysis SOP: TBD	2 × 1-L amber glass, unpreserved, Teflon-lined lid	1L	Store in dark. Cool to ≤6°C. Frozen after extraction.	Samples extracted within 7 days and analyzed within 40 days following extraction.
LNAPL	Saturated Hydrocarbons	Preparation Method: 3510C Preparation SOP: TBD Analysis Method: EPA 8015 Analysis SOP: TBD	4 × 40-mL vial, Teflon-lined lid	40 mL	None.	None.
	Alkylated PAHs	Preparation Method: 3510C Preparation SOP: TBD Analysis Method: EPA 8270 Analysis SOP: TBD				
	PIANO	Preparation Method: EPA 5035 Preparation SOP: TBD Analysis Method: EPA 8260D Analysis SOP: TBD				

°C degree Celsius
DRO diesel range organics
EPA Environmental Protection Agency, United States
g gram
GRO gasoline range organics
HCl hydrogen chloride
kg kilogram
L liter
mL milliliter
N/A not applicable
oz ounce
PAH polynuclear aromatic hydrocarbon
SIM selective ion monitoring
SOP standard operating procedure
SVOC semivolatile organic compound
TEL tetraethyllead
TPH total petroleum hydrocarbons
VOA volatile organic analyte
VOC volatile organic compound

Table B-4: Analytical Services

Matrix	Analytical Group	Sampling Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization [a] (name and address)
Soil	VOCs (BTEX,1,2-dichloroethane, 1,2-dibromoethane [ethylene dibromide]) TPH-g, TPH-d/o, PAHs (full suite) SVOCs (Phenol) TEL (Tetraethyllead)	See Table B-1.	TBD	14 days after samples are received at laboratory	TBD
Water	VOCs (BTEX, 1,2-dichloroethane, 1,2-dibromoethane [ethylene dibromide]) TPH-g, TPH-d/o, PAHs (full suite) SVOCs (2-[2-Methoxylethoxy]ethanol, Phenol) TEL (Tetraethyllead)	See Table B-1.	TBD	14 days after samples are received at laboratory	TBD
Product	PIANO, alkylated PAHs, SVOCs, saturated hydrocarbons	As needed.	TBD	14 days after samples are received at laboratory	TBD

AASHTO American Association of State Highway and Transportation Officials
[a] Laboratory meets DoD ELAP or AASHTO accreditation requirements, as applicable, to support project needs.

Table B-5: Analytical SOP References

Laboratory: TBD
Point of Contact: TBD
Point of Contact Phone Number: TBD

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
Preparatory Methods						
TBD	TBD	Definitive	VOCs and TPH-GRO (Soil, Water)	Preparation	No	No
TBD	TBD	Definitive	TPH-DRO/ORO (Soil, Water)	Preparation	No	No
TBD	TBD	Definitive	PAHs and SVOCs (Soil, Water)	Preparation	No	No
TBD	TBD	Definitive	TEL (Soil, Water)	Preparation	No	No
Analytical Methods						
TBD	TBD	Definitive	VOC (Soil, Water)	GC-MS	No	No
TBD	TBD	Definitive	TPH-GRO (Soil, Water)	GC-FID	No	No
TBD	TBD	Definitive	TPH-DRO/ORO (Soil, Water)	GC-FID	No	No
TBD	TBD	Definitive	PAHs and SVOCs (Soil, Water)	GC-MS-SIM	No	No
TBD	TBD	Definitive	TEL (Soil, Water)	GC-MS	No	No
TBD	TBD	Definitive	Percent Solids (Soil, Water)	N/A	No	No

Note: The laboratory SOPs listed in the table are the most current revisions at the time of publication of this *MWIWP Addendum 03*. The Navy consultant will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the DoD QSM annual review requirement.
GC-FID gas chromatography-flame ionization detector
GC-MS gas chromatography-mass spectrometry

Table B-6: Laboratory QC Samples for Chemistry Analyses

Matrix	**Soil, Water**
Analytical Group	**VOCs, TPH-g**
Analytical Method/SOP Reference	Analytical Method: EPA 8260, 8015 Preparation Method: EPA 5035A, EPA 5030B Laboratory SOPs: TBD
Analytical Organization	TBD

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial setup and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 6.0 (DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2021).
Tune check	Prior to the ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.
CCV	Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value. All reported analytes and surrogates within ±50% for the end of the analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. If the specific version of a method requires additional evaluation (e.g., average response factors) these additional requirements must also be met.

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time analytical batch.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. Results may not be reported without a valid LCS.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2021).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2021).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2021).
Trip blank	1 per cooler.	Target analytes ≤1/2 LOQ.	Reanalyze for confirmation through a second analysis of the trip blank. Examine the PQOs.	Analyst Lab QA Officer Project Chemist	Accuracy/Bias, Representativeness/ Contamination	Target analytes ≤1/2 LOQ.

Matrix **Soil, Water**

Analytical Group **TPH-d, TPH-o**

Analytical Method/SOP Reference Analytical Method: EPA Method 8015C
Preparation Method: EPA 3550C, EPA 3510C
Laboratory SOPs: TBD

Analytical Organization TBD

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial setup and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 6.0 (DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2021).
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 6.0.
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 6.0.
Surrogate spike for silica gel cleanup procedure	All field and QC samples.	Acceptable recovery range of 0% to 1% of spiked amount of polar hydrocarbon surrogate.	For QC and field samples, if sufficient sample extract is available, re-run extracts through silica gel cleanup procedure and reanalyze all failed samples for failed surrogates in the associated preparatory batch. Otherwise, re-extract samples and re-run silica gel cleanup on re-extract prior to re-analysis, if sufficient sample material is available.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Polar hydrocarbon surrogate recovered at ≤1% of spiked amount.
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD. MSD or Matrix Duplicate: RPD of all analytes ≤30%.	Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 6.0.

Matrix **Soil, Water**

Analytical Group **PAHs, TEL**

Analytical Method/SOP Reference Analytical Method: EPA Method 8270D SIM, PA Method 8270D
Preparation Method: EPA 3550C, EPA 3510C
Laboratory SOPs: TBD

Analytical Organization TBD

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial setup and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 6.0.	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 6.0.
Performance check	Before ICAL and sample analysis, and at the beginning of each 12-hour shift.	Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses and will not exceed a tailing factor of 2.	Correct problem, then repeat performance checks.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	Degradation of DDT must be ≤20%; and benzidine and pentachlorophenol must be present at normal responses and tailing factor is ≤2. No samples must be analyzed until performance check is within criteria.
Tune Check	Prior to the ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 6.0.
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 6.0.
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify Lab QA Officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 6.0.

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial setup and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 6.0.	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 6.0.

Note: No laboratory QC samples are generated for geotechnical and petrographic analyses.

Table B-7: Analytical Instrument and Equipment Maintenance, Testing, and Inspection

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-FID and GC-MS	Change gas purifier.	N/A.	Visually inspect if traps are changing color.	Every 6–12 months	No moisture	Replace indicating traps.	Analyst or certified instrument technician	TBD
	Change syringes/syringe needles.	N/A.	Visually inspect for wear or damage.	Every 3 months	N/A	Replace syringe if dirt is noticeable in the syringe.	Analyst or certified instrument technician	
	Change inlet liner, liner O-rings, and inlet septum.	N/A.	Visually inspect for dirt or deterioration.	Weekly for liner Monthly for O-rings Daily for septum	N/A	Replace and check often.	Analyst or certified instrument technician	
	Change front-end column.	N/A.	Check peak tailing, decreased sensitivity, retention time changes, etc.	Weekly, monthly, or when needed	N/A	Remove 1/2 to 1 meter from the front of the column when experiencing problems.	Analyst or certified instrument technician	
	Clean injector ports.	N/A.	N/A.	As needed	N/A	N/A.	Analyst	
	Replace trap on purge-and-trap systems.	N/A.	N/A.	Bi-monthly or as needed	N/A	N/A.	Analyst	
	Replace columns.	N/A.	N/A.	If chromatograms indicate possible contamination	N/A	N/A.	Analyst	
GC-FID	Replace detector jets.	N/A.	N/A.	As needed	N/A	N/A.	Analyst	TBD
	Replace hydrocarbon traps and oxygen traps on helium and hydrogen gas lines.	N/A.	N/A.	Every 4–6 months	N/A	N/A.	Analyst	
	Replace chemical trap.	N/A.	N/A.	Yearly or as needed	N/A	N/A.	Analyst	
	Replace converter tube in gas purifier system.	N/A.	N/A.	Yearly or as needed	N/A	N/A.	Analyst	

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-MS	Change tune MSD, check the calibration vial, and replace the foreline pump oil.	N/A.	Visually inspect and monitor the fluid becoming discolored.	As needed or every 6 months	In accordance with manufacturer's recommendation or lab SOP	Keep plenty of PFTBA; refill the vial and check the fluid; change when the fluid becomes discolored.	Analyst or certified instrument technician	TBD
	Run tuning program to determine if source is functioning properly.	N/A.	N/A.	Daily	N/A	Cool system, vent, disassemble, and clean.	Analyst	TBD
	N/A.	Tune instrument.	N/A.	Daily or every 12 hours	Per method	Liner and septa are replaced; tune file used is manually adjusted.	Analyst	
	Vacuum rough pump oil level is checked.	N/A.	N/A.	Every 4–6 weeks	N/A	Add oil if needed.	Analyst	
	Replace/refill carrier gas line oxygen and moisture traps.	N/A.	N/A.	Yearly or as needed	N/A	N/A.	Analyst	
Water Bath (Precision Microprocessor controlled)	Check instrument connections, water level, and thermometer.	Measure water temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	INS001
Drying Oven	Thermometer indicator.	Measure oven temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	INO003
Analytical Balance	Check digital LCD display and ensure a flat base for the Instrument.	Calibrate against verified (NIST) mass.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	INO011
pH Meter	Check LCD display and pH probe.	3-point calibration using known standards.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	±0.05 units	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified manufacture instrument technician	INO038

Note: No instrument and equipment maintenance, testing, and inspection criteria for geotechnical and petrographic analyses.
N/A not applicable
NIST National Institute of Standards and Technology
PFTBA perfluorotributylamine
[a] See Analytical SOP References table (Table B-5).

Table B-8: Analytical Instrument Calibration

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260C, 8720D SIM	Tuning	Prior to ICAL and at the beginning of each 12-hour period	Refer to method for specific ion criteria.	Retune instrument and verify. Rerun affected samples.	Lab Manager/Analyst or certified instrument technician	TBD
	Breakdown check (DDT-Method 8270 only)	At the beginning of each 12-hour period, prior to analysis of samples	Degradation ≤20% for DDT. Benzidine and pentachlorophenol should be present at their normal responses and should not exceed a tailing factor of 2.	Correct problem, then repeat breakdown checks.	Lab Manager/Analyst or certified instrument technician	
	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic calibration	Prior to sample analysis	RSD for each analyte ≤15% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995.	Correct problem then repeat ICAL.	Lab Manager/Analyst or certified instrument technician	
	Second source calibration verification	After ICAL	All analytes within ±20% of expected value.	Correct problem and verify second source standard; rerun second source verification. If fails, correct problem and repeat ICAL.	Lab Manager/Analyst or certified instrument technician	
	RT window position for each analyte and surrogate	Once per ICAL	Position will be set using the midpoint standard for the ICAL.	N/A.	Lab Manager/Analyst or certified instrument technician	
	RRT	With each sample	RRT of each target analyte in each calibration standard within ±0.06 RRT units of ICAL.	Correct problem, then reanalyze all samples analyzed since the last RT check. If fails, then rerun ICAL and samples.	Lab Manager/Analyst or certified instrument technician	
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence	All analytes within ±20% of expected value (%D). All reported analytes and surrogates within ±50% for end of analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst or certified instrument technician	
	IS	Each CCV and sample	RT ±10 seconds from RT of the ICAL mid-point standard. EICP area within -50% to +100% of area from IS in ICAL mid-point standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed during failure is mandatory.	Lab Manager/Analyst or certified instrument technician	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-FID EPA Method 8015C	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic calibration	Prior to sample analysis	RSD for each analyte ≤20% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995.	Correct problem then repeat ICAL.	Lab Manager/Analyst or certified instrument technician	TBD
	Second source calibration verification	Once after each ICAL	Analytes within ±20% of expected value (initial source), and within established RT windows.	Correct problem and verify second source standard. Rerun second source verification. If fails, correct problem and repeat ICAL.	Lab Manager/Analyst or certified instrument technician	
	RT window width	At method setup and after major maintenance	RT width is ±3 times standard deviation for each analyte RT from 72-hour study. For TPH-d: calculate RT based on C12 and C25 alkanes.	N/A.	Lab Manager/Analyst or certified instrument technician	
	Establishment and verification of the RT window for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift for establishment of RT; and with each CCV for verification of RT	Using the midpoint standard or the CCV at the beginning of the analytical shift for RT establishment; and analyte must fall within established window during RT verification.	N/A.	Lab Manager/Analyst or certified instrument technician	
	Run second source calibration verification (ICV)	ICV: Daily, before sample analysis, unless ICAL performed same day	All analytes within ±20% of expected value (%D).	Correct problem and rerun ICV. If fails, repeat ICAL.	Lab Manager/Analyst or certified instrument technician	
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence	All analytes within ±20% of expected value (%D).	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst or certified instrument technician	
Water Bath	Measure water temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	TBD
Drying Oven	Measure oven temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	TBD

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
Analytical Balance	Calibrate against verified (NIST) mass	Daily or prior to analyzing samples	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	TBD
pH Meter	Run a minimum 3-point calibration; run CCV	Daily or prior to analyzing samples; one CCV for every 10 samples	±0.05 unit.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	TBD

Note: No instrument calibration procedures for geotechnical and petrographic analyses.
%D percent difference
CA corrective action
CCV continued calibration verification
D difference
DDT dichlorodiphenyltrichloroethane
ICAL initial calibration
ICV initial calibration verification
IS internal standard
RRT relative retention time
RSD relative standard deviation
RT retention time
[a] See Analytical SOP References table (Table B-5).

Table B-9: Data Verification and Validation (Steps I and IIa/IIb) Process

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/External
Laboratory system audits	Determine whether the laboratory holds a current DoD ELAP certification for all analyses to be performed for the project.	Project Chemist (Navy consultant)	Step I	Internal
Field procedures	Determine whether field procedures are performed in accordance with this SAP and prescribed procedures.	QA Program Manager (Navy consultant)	Step I	Internal
Field logbook and notes	Review the field logbook and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the Navy consultant CTO manager and included in the Field Audit Report.	Field Manager (Navy consultant)	Step I	Internal
Instrument calibration sheets	Determine whether instruments are calibrated and used in accordance with manufacturer's' requirements.	Project Chemist (Navy consultant) and Data Validator (TBD)	Step I	Internal and External
CoC forms	Review CoC completed forms and verify them against the corresponding packed sample coolers. A copy of each CoC will be placed in the project file. The original CoC will be taped inside the cooler for shipment to the analytical laboratory.	Project Chemist (Navy consultant)	Step I	Internal
Sampling analytical data package	Verify all analytical data packages for completeness prior to submittal of the data to the data validator.	Laboratory Project Manager (TBD)	Step I	External
Analytes	Determine whether all analytes specified in Table B-2 were analyzed and reported on by the laboratory.	Project Chemist (Navy consultant)	Step IIa	Internal
CoC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist (Navy consultant)	Step IIa	Internal
Laboratory data and SAP requirements	Assess and document the performance of the analytical process. A summary of all QC samples and results will be verified for measurement performance criteria and completeness. Full Validation will be performed on 10% of the data and Standard Validation will be performed on 90% of the data. A report will be prepared within 21 days of receipt.	Data Validator (TBD) and Project Chemist (Navy consultant)	Steps IIa and IIb	Internal and External
VOCs	General Data Validation Guidelines (DoD 2019), Module 1 Data Validation Guidelines-GCMS (DoD 2020), Module 4 Data Validation Guidelines-GC (DoD 2021).	Data Validator (TBD)	Step IIa	External
PAHs, SVOCs and TEL	General Data Validation Guidelines (DoD 2019), Module 1 Data Validation Guidelines-GCMS (DoD 2020).	Data Validator (TBD)	Step IIa	External
TPH	General Data Validation Guidelines (DoD 2019), Module 4 Data Validation Guidelines-GC (DoD 2021).	Data Validator (TBD)	Step IIa	External
Sampling plan	Determine whether the number and type of samples specified in Table B-1 were collected and analyzed.	Project Chemist (Navy consultant) and Field Manager (Navy consultant)	Step IIb	Internal
Field QC samples	Establish that the number of QC samples specified in Table B-1 were collected and analyzed.	Project Chemist (Navy consultant)	Step IIb	Internal

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/External
Project quantitation limits and data qualifiers	Establish that sample results met the project quantitation limits and qualify the data in accordance with Procedure II-A, *Data Validation Procedure* (DON 2015).	Data Validator (TBD) and Project Chemist (Navy consultant)	Step IIb	Internal and External
Validation report	Summarize outcome of data comparison to MPC in the SAP. Include qualified data and an explanation of all data qualifiers.	Data Validator (TBD)	Step IIa	External

CTO contract task order
MPC measurement performance criteria
[a] IIa Compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP manual, V.1 (IDQTF 2005).
IIb Comparison with measurement performance criteria in the SAP. See Table 11, page 118, UFP-QAPP manual, V.1 (IDQTF 2005).

Appendix C:
Monitoring Well Installation Procedures

CONTENTS

ATTACHMENT

FIGURES

TABLE

ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
COPC	chemical of potential concern
COR	Contracting Officer's Representative
CWRM	Commission on Water Resource Management
DLNR	Department of Land and Natural Resources, State of Hawaii
DO	dissolved oxygen
ft	foot/feet
gpm	gallons per minute
IDW	investigation-derived waste
msl	mean sea level
ORP	oxidation-reduction potential
PFAS	per- or polyfluoroalkyl substances
PID	photoionization detector
ppmv	parts per million by volume
PVC	polyvinyl chloride
U.S.	United States
VOC	volatile organic compound

DEFINITIONS

Annulus	The opening between an inner and outer cylindrical body, often used to describe the space between the well screen or drill pipe and the borehole wall. Also called the annular space.
Aquifer	A geologic formation that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells.
Bailer	A cylindrical piece of equipment used to collect groundwater samples.
Basal Groundwater	An aquifer in which a body of groundwater floats on a body of saltwater in accordance with the buoyant density difference of the two bodies of water. Oahu's southern basal aquifer is a drinking water source.
Borehole	The void created by the advancement of a drilling bit through the formation. Boreholes are sometimes enlarged in multiple passes with a reamer bit, to facilitate coring or testing in smaller-diameter holes, or to improve the alignment or cutting efficiency of the drill bits for larger-diameter boreholes.
Drill Bit	Cutting tools used in a drill to remove material to create holes, almost always of circular cross-section. Drill bits come in many sizes and shapes.
Casing [Conductor]	A cylindrical device (steel or plastic) that is installed in a well to maintain the well opening and to provide a seal. Conductor casing provides a seal for upper intervals while a deeper borehole is advanced.
Casing [Production]	The final well casing installed with a screened interval that is in communication with and will "produce" water from the aquifer.
Confined Aquifer	An aquifer, separated from atmospheric pressure by an impermeable layer, in which the water is under pressure greater than that of the atmosphere.
Confining Layer	Geologic material with little or no permeability or hydraulic conductivity such as clay or dense rock. Water either does not pass through this layer or its rate of movement is extremely slow. In a confined groundwater system, the physical presence of water is constrained beneath a confining later, and the physical water occurs in the aquifer below the elevation that water would rise to in a well that penetrates the confining layer.
Consolidated Material	A tightly bound geologic formation composed of sandstone, limestone, granite, basalt, or other rock.
Core	A continuous cylinder of rock, usually from 5 to 10 centimeters in diameter, cut from the bottom of a borehole as a sample of an underground formation.
Corehole	Any borehole drilled for the purpose of obtaining rock core samples.
Cuttings	Small pieces of rock that break away due to the action of the bit. Cuttings are monitored for composition, size, shape, color, texture, hydrocarbon content, and other properties.
Diverter	A device attached to a wellhead to divert the air, fluids, and drill cuttings traveling up the borehole annulus into a discharge hose for transfer into a container.
Drawdown	A lowering of the groundwater level caused by pumping.

Drilling Mud	A special mixture of clay, water, and chemical additives pumped downhole through the drill pipe and drill bit. The mud cools and lubricates the rapidly rotating bit, carries rock cuttings to the surface, and serves to limit fluid loss into the formation. Drilling mud also provides the weight or hydrostatic pressure needed to prevent formation fluids from entering the hole and prevent borehole collapse in unconsolidated formations.
Elevated Head	A condition within a continuously saturated zone above a confined aquifer where the hydraulic head is hydraulically distinct from, and higher than, that within the confined aquifer.
Formation	A general term for the rock or unconsolidated materials around the borehole.
Grout	A fluid-sealing mixture usually comprising bentonite and/or cement that is used to seal well casing. Once emplaced, grout forms an impermeable seal.
Headspace Analysis	A technique for sampling and examining volatile compounds associated with a solid or liquid sample. The actual headspace itself is the volume of vapor or gas above the sample. The sample and its associated headspace are held within an enclosed container leaving one-third to one-half empty; the concentration of volatile compounds in the container's empty 'headspace' is measured, typically with a photoionization detector.
Hydraulic Gradient	The rate of change in total head per unit of distance of in the direction perpendicular to the lines of equipotential for hydraulic head. Water will flow from higher hydraulic head to lower hydraulic head.
Hydraulic Head	In an aquifer, the altitude to which water will rise in a properly constructed well: the altitude of the water table in an unconfined aquifer or of the potentiometric surface in a confined aquifer.
Monitoring Well	A well constructed or used for collecting water level data, water quality data, or other data.
Over Drill	Drilling a larger borehole in the same footprint of a previous open borehole without a reamer and pilot bit, or redrilling a backfilled hole with a larger diameter bit.
Perched Groundwater	Groundwater that occurs at a higher elevation than the regional unconfined aquifer and that is separated from the regional aquifer by an unsaturated zone.
Permeability	A measure of the resistance of rock or sediments to the movement of fluids.
Plug	A seal of cement (or other impervious material) deliberately placed in a wellbore to allow emplacement of materials above it that are separated from materials below it.
Potentiometric Surface	Under confined conditions, potentiometric surface is the distribution and elevation of confined pressure, even though the water is physically present only beneath the confining layer. Under unconfined or "water table" conditions, the potentiometric surface is the same as the elevation of the physical occurrence of the water.
PQ, HQ	Standard wire-line bit sizes for drilling rock cores. Outside hole/inside core diameters are 96/63.5 millimeters for an HQ bit and 122.6/85 millimeters for a PQ bit.
Reaming	Enlarging an existing open borehole by using a reamer and pilot bit assembly.

Rotary Drilling A well drilling method achieved by the rotary cutting action of a drill bit. Typically refers to methods that use rotating or rolling cutting heads. Circulation can be normal, which is down through the drill pipe and up the annulus, reverse of which is down the annulus returning up the drill pipe, or dual-wall reverse circulation that requires drill pipe with concentric pipe.

Screen A cylinder of steel or plastic material used to allow water to enter a well while preventing sediment or rock particles from entering the well. A screen operates similar to a sieve. Well screens can be wire-wrapped, louvered or perforated, saw-cut, or factory-slotted, and can be constructed from different materials and at different opening sizes. Selection of well screen design and opening size may depend on characteristics of the geologic formation, required yield, and thickness of the aquifer.

Surface Casing Near-surface conductor casing is cemented into place and serves to shut out shallow water formations and as a foundation for well control.

Test Hole [Test Boring] A temporary uncased hole typically used for one-time collection of samples or evaluations in applications of engineering geology, whereas test wells are completed with well casing and used in groundwater investigations to obtain ongoing information about geologic or hydrologic conditions. Test holes are usually drilled at a small diameter, and require proper abandonment when testing is complete. Temporary test holes do not require a drilling permit.

Total Depth The bottom of a particular hole section, hole, or wellbore.

Tremie Pipe A pipe used to carry materials (usually grout) to a specific depth in a drilled hole to ensure proper depth of emplacement and to avoid bridging of materials.

Unconfined Aquifer An aquifer in which the water table is at or near atmosphere pressure and is the upper boundary of the aquifer. Because the aquifer is not constrained by a confining unit, the water level in a well is the same as the water table outside the well.

Unconsolidated Material Loosely bound geologic formation typically composed of clays, sands, or gravel.

Well An excavation or opening into the ground, or an artificial enlargement of a natural opening, drilled, tunneled, dug, or otherwise constructed for the location, exploration, monitoring, development, injection, or recharge of groundwater and by which groundwater is drawn or is capable of being withdrawn or made to flow.

Well Development The application of techniques following well construction designed to mitigate the impacts of drilling on the formation, remove fine particles from the filter pack, and confirm that the well will meet the conditions for water clarity, stability, and minimum yield required to meet the goals of the well.

Wellbore A borehole intended for completion as a well by installing permanent casing.

Wellhead The surface completion of a well.

1. Introduction

This plan provides the procedures for installing the proposed groundwater monitoring wells under the Holding Tank-Leach Tank site Characterization Work Plan. The proposed approach is based on a Monitoring Well Installation Work Plan for the Red Hill Bulk Fuel Storage Facility prepared under a separate contract task order and was updated to be specific to the Holding Tank-Leach Tank investigation. The effort will expand the current groundwater monitoring network at the holding tank and leach tank Site and increase understanding of groundwater heads and gradients (horizontal and vertical), stratigraphic formation hydraulic conductivities, subsurface geology, extent of chemicals of potential concern (COPCs), geochemical parameters, and potential lateral and vertical migration of COPCs in the project study area. The data gathered from these monitoring wells will be used to estimate risks to public water supply infrastructure and refine the conceptual site model, the groundwater flow model, and contaminant fate and transport model associated with the study area. This plan describes the procedures and methodologies for drilling, well installation, and well development.

2. Field Project Implementation

2.1 Well Installation Procedures

Drilling, sampling (during drilling), monitoring well installation, and other field activities will be conducted as applicable in accordance with the State of Hawaii Department of Health *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (DOH 2021), the Hawaii *Well Construction and Pump Installation Standards* (DLNR 2004), the relevant standard operating procedures from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, Naval Facilities Engineering Command (NAVFAC) Pacific* (DON 2015), which are identified in Table C-1.

Table C-1: Field SOPs Reference Table

Reference Number	Title [a]	Originating Organization of Sampling SOP	Equipment Type
I-A-5	*Utility Clearance*	NAVFAC Pacific	Geophysical equipment (electromagnetic, magnetic, and ground-penetrating radar)
I-A-6	*Investigation Derived Waste Management*	NAVFAC Pacific	N/A
I-A-8	*Sample Naming*	NAVFAC Pacific	N/A
I-B-1	*Soil Sampling*	NAVFAC Pacific	Split-spoon sampler and liners with hollow-stem or solid-stem auger
I-B-2	*Geophysical Testing*	NAVFAC Pacific	Low frequency electromagnetic induction, magnetometers, and ground-penetrating radar
I-B-5	*Surface Water Sampling*	NAVFAC Pacific	N/A
I-C-1	*Monitoring Well Installation and Abandonment*	NAVFAC Pacific	Continuous coring drill rig
I-C-2	*Monitoring Well Development*	NAVFAC Pacific	Surge block or submersible pump
I-D-1	*Drum Sampling*	NAVFAC Pacific	COLIWASA or glass thieving tubes
I-E	*Soil and Rock Classification*	NAVFAC Pacific	N/A
I-F	*Equipment Decontamination*	NAVFAC Pacific	N/A
I-I	*Land Surveying*	NAVFAC Pacific	Theodolite - horizontal and vertical control; GPS
III-A	*Laboratory QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-B	*Field QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-D	*Logbooks*	NAVFAC Pacific	N/A

Reference Number	Title [a]	Originating Organization of Sampling SOP	Equipment Type
III-E	*Record Keeping, Sample Labeling, and Chain of Custody*	NAVFAC Pacific	N/A
III-F	*Sample Handling, Storage and Shipping*	NAVFAC Pacific	N/A

COLIWASA composite liquid waste sampler
GPS Global Positioning System
N/A not applicable
NAVFAC Naval Facilities Engineering Systems Command
QC quality control
SOP standard operating procedure
[a] Applicable procedures from the *Project Procedures Manual* (DON 2015).

Prior to drilling, all onsite activities will be coordinated with the Navy Contract Task Order Contracting Officer's Representative (COR) and landowner's representative to ensure that all requirements such as obtaining site access, working hours, using or accessing potable water supply sources, or other requirements are understood and followed.

The Regulatory Agencies may conduct site visits for monitoring and split sampling. Advanced notice is appreciated for coordination. The Navy will provide weekly drilling and well installation notifications to the Hawaii Department of Land and Natural Resources (DLNR) Commission on Water Resource Management (CWRM) as the well construction permitting authority, and to the Regulatory Agencies. These updates may include, as applicable.

- Well information
- Completed operations
- Upcoming, planned operations
- Water level data
- Field parameter data
- Photoionization detector (PID) readings
- Water lost during drilling
- Generalized geology
- Relative permeability
- Fractures zones
- No-recovery zones
- Well construction
- Borehole water levels
- Geophysical logs

If mud rotary drilling (not including rock coring) is proposed/employed, it will be noted in the weekly updates.

2.2 Well Construction Permits and Reporting

A permit will be obtained from DLNR CWRM to construct each well. Well construction permit applications will be submitted by a drilling company licensed in the State of Hawaii. Well construction permits are not required for test borings. Boreholes are considered test borings and do not require well permits.

Following installation of each well, a Well Completion Report will be submitted by the drilling company to DLNR within 30 days following well installation. A Well Completion Report is a standard DLNR CWRM form signed by the driller that includes the State well number, well completion details, and a general driller's lithologic log.

Within 90 days of well installation, the following documentation associated with that well will be uploaded to the Navy's Joint Base Pearl Harbor-Hickam Red Hill Bulk Fuel Storage Facility Environmental Data Management System: lithologic log, well construction diagram, geophysical logs, and data collected during drilling (monitored water levels, PID readings, and drilling water usage).

2.3 Site Surveys

Prior to ground disturbance, available utility drawings will be reviewed, and utility clearance surveys will be performed by a qualified subcontractor to locate and delineate subsurface utilities in all areas where the ground will be disturbed in the vicinity of the drilling locations, discussed in the main body text of the Work Plan in Section 6. The survey will employ geophysical techniques that may include magnetic, electromagnetic, or ground-penetrating radar. All utility clearance activities will be conducted in accordance with Procedure I-A-5, *Utility Clearance* (DON 2015).

An application for site clearance will be submitted to 811 One-Call to obtain information from local utilities on potential underground conflicts at least 5 working days before intrusive activities begin. Prior to coring or drilling, each drilling location will be cleared using air knife, hand auger, or other manual method to a minimum depth of 5 feet (ft) below ground surface (bgs) or refusal on bedrock. The proposed well locations may be adjusted, if necessary, based on information gathered during the shallow subsurface clearance.

Surveying will be conducted in two phases. Prior to drilling, a licensed surveyor will establish the land surface elevation of the drilling location. After the well has been installed, the well will be surveyed to establish the horizontal and vertical coordinates and measurement point elevation for the final well completion using Second Order, Class I procedures consistent with those described in the *Technical Memorandum, Topographic Survey* (DON 2017). Land survey activities will be conducted as applicable in accordance with Procedure I-I, *Land Surveying* (DON 2015).

2.4 Site Preparation

To facilitate drilling and well completion, site preparation may include vegetation clearance, tree trimming, access pathway construction, drill site grading, cutting, or concrete coring. Each borehole location will be marked once the area is cleared of utilities and the staging area is established. The construction site will be maintained in accordance with National Pollutant Discharge Elimination System permit requirements, including implementation of site-specific BMPs to control run-on and run-off. Noise and dust monitoring will be implemented at all proposed well installation locations and will be maintained throughout drilling activities. A drilling pad will be established at unpaved locations by grading and filling to level the area, as much as practicable, to provide an even working surface for the drill rig and support equipment. The drill pad will be finished with coarse gravel. Any unstable surface conditions encountered (e.g., ponding, soft ground after heavy rainfall, presence of voids) may require the use of gravel or rock (e.g., base course or surge rock) to stabilize the ground surface during pad construction, drilling, and well installation.

Secondary containment will be installed around roll-off bins and off-rig storage tanks. Rainwater within secondary containment will be inspected for evidence of contamination (sheen, olfactory, PID). If no evidence of contamination is found, the water can be discharged to the ground surface. If evidence of contamination is observed, the water will be containerized and disposed of appropriately.

Drip pans and absorbents will be used under or around items with the potential to leak fluids. Recycled oil and oily wastes will be recycled/disposed of in accordance with Federal, State, and local requirements. Impacted surfaces or areas will be cleaned up immediately, using dry cleanup measures where practicable, to eliminate the source of the spill and prevent a discharge or furtherance of an ongoing discharge. Adequate supplies will be kept available at all times to handle spills, leaks, and disposal of used liquids, such as absorbent pads or similar. Surfaces are not to be cleaned by hosing down the affected area.

Refueling or vehicle maintenance conducted on site will be limited to vehicles or equipment engaged in active drilling activities. Vehicles that leave the project site daily should not be refueled on location. Best management practices to protect the environment during refueling activities will include inspection of equipment and vehicles for leaks daily, performed in a contained area with impervious surface and berms around the refueling areas, and the use of drip pans and absorbents. Additionally, supervision is required of any and all refueling or fuel transfer operations, and these activities will implement the use of nozzles with automatic shutoff devices. All onsite fuels will be stored in approved, flammable-rated containers within appropriately sized secondary containment.

After well completion, drilling locations will be restored to their roughly original pre-construction condition.

3. Protection of the Site

3.1 DRILLING ADDITIVES

No additives other than potable water and approved well materials will be added to the borehole without prior notification to and approval by the Navy's COR. All chemicals, lubricants, and drilling fluid additives used during any part of the drilling or well construction process that have the potential to impact water quality will be reviewed prior to use. Drillers will use products selected from the list of acceptable materials (the current list of acceptable materials as of the date of this report is included in Attachment 1, but items are subject to change based on drillers' requests and Navy COR review). Additional materials can be considered with sufficient advance notice. Drillers propose materials for use and submit relevant product information (e.g., Safety Data Sheets) to the Navy. The Navy then reviews and concurs when materials are appropriate. The drilling subcontractor will provide a food-grade, non-petroleum-containing oil or grease for use on all downhole tools and water pump lubricants. No products documented to contain Teflon or other compounds containing per- or polyfluoroalkyl substances (PFAS) will be used. Coated bentonite pellets (which may contain PFAS) will not be used. Uncoated bentonite pellets, bentonite chips, powdered bentonite, or bentonite granules may be used where appropriate.

Compressed air systems will be equipped with an oil-coalescing air filter(s) to capture oil that could otherwise be discharged downhole in the compressed air stream. Oil used for air compressors and downhole lubrication of drill bits will be selected from the list of approved materials and described on the inventory of well materials. The quantities and rate of application of oil for downhole bit lubrication and other drilling additives will be listed on the drilling log forms for drilling. All drilling equipment will also be placed within or on secondary containment.

3.2 DRILLING WATER

Drilling water will be required for circulation fluid during drilling to remove drill cuttings and to cool and lubricate the bit. Water used for drilling activities will be obtained from a potable water source.

3.3 EQUIPMENT MATERIALS AND DECONTAMINATION

Downhole equipment and tools will not contain or be treated with any materials that have the potential to impact groundwater quality in the well. No substances, materials, or equipment will be introduced to the borehole or well without prior approval from the Navy. All downhole drilling tools and equipment will be decontaminated prior to use in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015). Drilling equipment rinse water will be collected and treated as investigation-derived waste (IDW) (Section 5).

3.4 SPILL CONTAINMENT

A spill kit will be located on the drill rig. All drilling fluids will be contained within the borehole, drill rig pump and hoses (recirculation), the mud pan, or appropriate waste containers. A hydrated bentonite seal will be used to seal the mud pan to the ground. Additionally, sorbent socks will be placed beneath the mud pan, and biosocks will be placed around the base of the mud pan. Drums and totes should be placed on spill containment pallets within secondary containment and, when feasible, water alert systems should be used for early spill detection.

4. Monitoring Well Drilling and Installation Procedures

Basalt bedrock is anticipated to be encountered at shallow depths underneath and in the vicinity of ridges, and at deeper depths in valleys or lower topographic areas. Lithology will be characterized at each site by core drilling. Water table, perched, depressed, or elevated head conditions may also be evaluated during coring by pumping, bailing, or air lifting, or monitoring water levels and water quality. Observations of perched, depressed, or elevated head will be confirmed during drilling of the corehole or well borehole with air methods. Evaluation of perched groundwater, depressed heads, elevated heads, and contamination during corehole drilling and well borehole drilling is described in Section 4.4.3 and Section 6. Bailer jar headspace PID tests will be conducted during coring at the beginning of each day. Jar headspace PID tests will be collected off the cyclone at the start of air drilling and tricone / mud rotary each day. The corehole and well borehole will be spaced approximately 15 ft apart at the land surface. The corehole will be drilled first, if practicable. The well borehole may be reamed or overdrilled on top of the corehole or drilled in a separate borehole. Procedures for monitoring well drilling and installation are described below, including:

1. Drilling for Lithological Investigation
2. Drilling for Well Installation
3. Geophysical and Video Logging
4. Evaluation of Groundwater Conditions
5. Conductor Casing, if required
6. Well Design and Completion
7. Well Development
8. Initial Sampling
9. Borehole, Corehole, and Well Abandonment

4.1 DRILLING FOR LITHOLOGICAL INVESTIGATION

At each location, initial drilling at the site may be advanced through unconsolidated materials using hollow-stem auger, bucket auger, or other method that allows for soil sampling and inspection. Soil will be collected for logging using split-spoons or from drill cuttings. Logged soil cuttings will be screened for volatile organic compounds (VOCs) using a PID in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Logging and screening will take place at intervals of no greater than 5 ft. Unconsolidated material that has observable signs of contamination (visual or olfactory) will be submitted for laboratory analysis (Section 6). The auger may be left in place during coring as a temporary surface casing to stabilize the unconsolidated interval. These procedures apply to the first drilled borehole at each site.

Below the top of bedrock, lithologic characterization will be accomplished by diamond core drilling methods to total depth in general accordance with ASTM D2113 (ASTM 2014). Subsurface material will be continuously collected using rotary wireline coring to record the lithologic characteristics and description of the subsurface material, and screening for contaminants by PID, visual, and olfactory inspection to the extent practicable in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Coreholes may intersect intensely fractured or faulted zones, where poor rock strength or difficult drilling conditions may be encountered. Reasonable measures will be taken to maximize core recovery, including timely replacement of worn equipment such as drill bits or core sleeves, changes in type of drill bit, rate of feed, down-pressure on the drill bit, volume of water added, length of coring interval, or type of coring equipment.

The cores will be inspected and logged to characterize the lithology and evaluate potential pathways for migration of light nonaqueous-phase liquid and associated constituents. The entire corehole will be logged by the field geologist (according to the procedures described below). A summary rock core chart will be used in the field to log the information. In general, each log will note rock-quality designation; rock color; texture; strength; degree and angle of fracturing; shape, size, and volume of voids; weathering; and secondary staining and mineralization. Additionally, details of basalt flow and intraflow structures (e.g., aa clinker flow-top breccias [clinker sub-types], inflated pahoehoe lobes, massive aa dense core interiors) will be included in logging of the core.

Fracture types (cooling joints versus drilling-induced fractures) and any mineralization within the fractures will also be noted. High-resolution photographs will be taken to document the cores, and detailed photo logs will be prepared. The Geological Society of America rock color chart (Munsell 2009) with Munsell color chips will be used for color characterization. Lithologic descriptions, PID screening results and other observations will be recorded on the geologic logs in conformance with Procedure I-E, *Soil and Rock Classification* (DON 2015). Cores will be stored in a secure on-island location and available for inspection if approved by the Navy.

Evaluation of perched groundwater, elevated head, and contamination during corehole drilling is described in Sections 4.4.3 and 6. If the corehole is drilled before the well borehole, for the basal groundwater monitoring well, coring will pause at a depth elevation of 30 ft mean sea level (msl), and the presence of inflow to the borehole will be evaluated by bailing or pumping down the water level and measuring water level recovery and conducting bailed water jar headspace PID tests to evaluate contamination. If groundwater inflow is detected from intervals above the basal aquifer, a video borehole inspection may be conducted (Section 4.3). Procedures for evaluating the bailer jar headspace test results and required actions and notifications are described in Section 6. If the well bore was drilled first and did not encounter significant amounts of groundwater inflow greater than 5 gallons per minute, or perch water contamination above 30 ft msl, core drilling will proceed without interruption to the target depth elevation. Deep wells (i.e., to be screened deeper than the basal head elevation in water table conditions or below the confining unit in confined conditions) will be investigated to identify zones of higher flow or good hydraulic connection to the basal aquifer by means of periodically pausing drilling to perform water level and water quality testing (e.g., associated with or following bailing, slug testing, or pumping; with or without use of packer(s) to isolate testing zones), video logging, or geophysical logging. Packers may not be appropriate in certain conditions, such as in unstable boreholes or coreholes.

Geophysical logging and video surveys may be conducted in the corehole (Section 4.3) if conditions are acceptable. If conditions are unfavorable geophysical logging may be conducted in the well borehole.

Coreholes will be advanced to approximately 20 ft greater depth than the target depth of the well borehole. For water-table wells, the coreholes will be advanced to -25 ft msl. After the corehole is drilled to total depth, and geophysical logging, if conducted, is complete, the corehole will be backfilled to above the proposed screened interval in the adjacent monitoring well with sand and/or uncoated bentonite pellets using a tremie pipe. The purpose of this sand backfill is to minimize impacts to water quality or hydraulic conductivity of the adjacent monitoring well. Above approximately 30 ft msl, the corehole will be backfilled with neat cement, cement-bentonite grout, uncoated bentonite granules, chips, or uncoated pellets, or sand-cement slurry in accordance with DLNR (2004) standards for hole abandonment. If the required grout volume is more than 150% of the calculated borehole volume due to voids in the formation, then gravel, bentonite chips, sand, or uncoated bentonite pellets can be used to fill intervals of the corehole. In some cases, the corehole may be reamed to a larger diameter to install a well in the same borehole.

4.2 DRILLING FOR WELL INSTALLATION

Drilling of the well borehole will follow core drilling and will incorporate information from the lithologic characterization data obtained in the corehole to direct drilling and well design. Logged soil cuttings will be screened for VOCs using a PID in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Evaluation of perched groundwater, elevated head, and contamination during well borehole drilling is described in Sections 4.4.3 and 6.

4.2.1 Well Boreholes

The well borehole will be advanced through unconsolidated materials (which could include soil such as valley fill, saprolite, tuff, or other materials) using hollow-stem auger, bucket auger, or other methods that allow inspection and sampling until competent bedrock is encountered. A surface casing may be required to install a diverter for the discharge during air drilling and may be temporary or permanent. A conductor casing may be installed to mitigate groundwater conditions in accordance with Section 4.5 or to maintain the integrity of the borehole through unconsolidated material.

Below the top of bedrock, well boreholes will typically be advanced using air-rotary or percussion air-hammer drilling methods. Drill cuttings and fluids will be collected periodically from the discharge for lithologic description and screening for contamination. Note that the cores from the nearby corehole will be screened with a PID.

In cases where air drilling methods are not effective, alternative methods such as mud rotary may be used. Notice will be provided to the Regulatory Agencies, via weekly drilling update emails, when mud rotary (not including coring) is planned.

For intervals where the borehole is unstable or, if the basal groundwater well is being drilled and the borehole shows evidence of perched or elevated head groundwater conditions, the affected interval may be grouted and redrilled, and conductor casing may be installed, in accordance with Section 6.

After rock coring is complete, the corehole will be reamed, over drilled, or a new borehole may be advanced to install a monitoring well. For intervals where the borehole is unstable or shows evidence of perched or elevated head groundwater conditions, the affected interval may be grouted and redrilled, and conductor casing may be installed, in accordance with Section 6.

Packers may not be appropriate in certain conditions, such as in unstable boreholes or coreholes. Boreholes for wells with submerged screens will be extended at least 60 ft below the base of the confining unit until hydraulic communication with the basal aquifer is established to provide sufficient borehole length for this testing.

4.3 GEOPHYSICAL AND VIDEO LOGGING

In addition to lithologic logging completed by the field geologists, portions of the open borehole (before well installation) or corehole may be logged using downhole geophysical techniques. If conducted, logging will be completed in accordance with Procedure I-B-2 *Geophysical Testing* (DON 2015). Borehole geophysical or video logging may be conducted in the vadose zone if hole stability and impacts to drilling logistics are judged acceptable. Geophysical or video logging may not be performed if there are concerns with hole stability. Logging tools may include optical televiewer, caliper, natural gamma ray, induction resistivity, colloidal borescope, downhole camera, or others. At or below the basal aquifer water level, logging may include acoustic televiewer, optical televiewer, caliper, natural gamma ray, induction resistivity, fluid temperature and conductivity, electromagnetic flowmeter, colloidal borescope, downhole camera, or others. The data will be used to inform well construction and obtain additional information on the hydrogeology and geochemistry.

After the monitoring well is installed, a well alignment survey will be conducted and the results will be used to conduct a quantitative true vertical depth analysis to apply to depth-to-water measurements for the purpose of more accurately determining hydraulic gradient.

4.4 EVALUATION OF BASAL GROUNDWATER CONDITIONS

4.4.1 Unconfined Groundwater

For the basal groundwater monitoring well, after drilling to target depth approximately 25 ft below msl, the static water level will be evaluated by removing groundwater from the well borehole by air injection (blowing), pumping, or bailing the corehole and measuring recovery of the water level using a pressure transducer, water level meter, or oil/water interface probe. If the estimated water level stabilizes within the range expected in the basaltic basal aquifer (roughly 16–20 ft msl), then the borehole has been drilled in unconfined conditions and the well can be installed with well screen from 10 ft above to 20 ft below the water level (Section 4.6.2). If groundwater elevations do not fall within this range, indicating non-water table conditions, then the borehole will be extended and tested until good communication with the basal basalt aquifer is observed (Section 4.4.2).

4.4.2 Confined Groundwater

If confined conditions are suspected in the basal aquifer, drilling will advance to approximately -25 ft msl. The water level (i.e., potentiometric head) will be evaluated by air injection, pumping, or bailing the borehole clear and measuring recovery of the water level. If groundwater elevations do not fall within the regional unconfined groundwater elevation of approximately 16-20 ft msl, indicating non-water table conditions, the borehole will be extended and tested until communication with the basal basalt aquifer is observed. If the water level is confirmed to be outside this range, a confined or elevated head condition may be present, and the proposed well screen interval may require adjustment to ensure that the well is in good hydraulic communication with the basal aquifer.

If confined conditions are confirmed, drilling will advance until the water level in the borehole stabilizes at approximately 16–20 ft msl, and the initial rate of water recovery in the borehole is greater than 0.5 gallon per minute (gpm) after the hole is cleared by air injection, pumping, bailer, or other acceptable method. Water level recovery data will be evaluated further to recommend a revised well screen depth. Construction of temporary wells in the borehole or temporary conductor casing with seals may be required to evaluate true groundwater elevation for a depth interval without the borehole water level being affected by upper intervals.

4.4.3 Perched or Elevated Head Conditions

During coring, the drill rod and open bit stabilize the hole and allow direct measurement of water levels. Water levels will be measured in the corehole at the beginning and end of each day, and a transducer will be deployed overnight, where practicable. A bailer jar headspace test will be conducted each morning. The drilling log will record totalizer readings and an average gallons per foot of drilling water added to the borehole.

During well borehole drilling, downhole tools prevent direct measurement of water levels; however, the discharge will be monitored for signs of groundwater infiltration into the borehole. If inflow of groundwater to the borehole is suspected above the basal aquifer, the hole will be cleared by air injection, pumping, bailer, or other acceptable method and a jar headspace sample will be collected from the discharged water to evaluate the presence of contamination. During air drilling, groundwater in the borehole will be cleared and observations conducted at the start of each day and at approximately 40-ft intervals while drilling. If water is present in the hole at the end of the day and the hole is apparently stable, a pressure transducer will be deployed overnight. The drilling log will record water loss totalizer readings and an average gallons per foot for each core run or drilling rod.

In well boreholes and coreholes testing and evaluation will be conducted at a depth equal to approximately 30 ft msl to evaluate the potential for water from the vadose zone to impact the basal aquifer. Testing will include removal of water by air injection, pumping, or bailing and recovery. Discharged water quality parameters will be evaluated and PID jar headspace tests and visual inspection will be conducted. If groundwater inflow is detected from perched groundwater interval(s), a video borehole inspection may be conducted (Section 4.3). Procedures for evaluating the bailer jar headspace tests and required actions and notifications are described in Section 6.

4.4.4 Evaluation of Groundwater Conditions

Bailer jar headspace tests are used to evaluate whether there are indications of potential perched water contamination. Drilling will then proceed as follows:

- No Signs of Perched Water or Contamination
  - If perched water or evidence of contamination is not observed at 30 ft msl, PQ coring will be conducted until the target depth is reached.
  - After PQ rock coring is complete, the borehole will be reamed to total depth using a reaming tool with a pilot bit to increase the borehole diameter.

- Perched Water and No Signs of Contamination
  - If perched water is suspected in the vadose zone and there are no signs of contamination, the interval of suspected perched water will be sealed off by grouting with neat cement, cement-bentonite grout, or sand-cement slurry, or casing cement to surface, if applicable. The interval will be re-drilled with the original bit. If grouting the suspected interval is successful in stopping the inflow of perched water, drilling of the borehole may proceed.
  - At a borehole depth equal to an elevation of 30 ft msl, drilling will pause, and the core and any fluids in the borehole will be evaluated for contamination as indicated by PID readings of core and bailed jar headspace tests.
  - If there are no indications of contamination, the borehole will be cleaned out and advanced into the basal aquifer without installing conductor casing and reamed, and a well will be constructed.
- Continued Perched Water or Suspected Perched Water Contamination
  - If grouting of the hole is unsuccessful in stopping the inflow of perched water, the borehole may be reamed to 3 ft below the base of the suspected perched water, and the suspected interval of perched water will be grouted using a tremie pipe. The interval will be re-drilled with the original bit.
  - If grouting the suspected interval is successful in stopping the inflow of perched water, drilling with the original dill bit will proceed.
  - At a borehole elevation of 30 ft msl, drilling will pause, the core and any fluids in the borehole will be evaluated for contamination as indicated by PID readings of core and bailer jar headspace tests.
  - If there are no indications of contamination, the borehole will be reamed.
  - When the borehole depth reaches an elevation of approximately 30 ft msl drilling will pause, any fluids in the borehole will be evaluated for contamination.
  - If results indicate contamination of the basal aquifer is not likely to occur, the borehole will be advanced, reamed, and the 2-inch-diameter polyvinyl chloride (PVC) well will be constructed, in accordance with well construction standards specified by DLNR (2004).
- Additional Intervals of Contamination or Perched Water
  - If additional contaminated intervals (i.e., visual, olfactory, sustained PID readings above ambient background conditions, or staining on drill cuttings and recovered rock cores) of unconsolidated material or perched groundwater are subsequently observed, the boring will be abandoned by grouting as described in Section 4.8.
  - If practicable, a new boring will then be advanced with permanent conductor casing set below the depth of the deepest contamination encountered and in a low-permeability zone (e.g., clay, silt, or low-porosity basalt layer).

4.5 CONDUCTOR CASING

Conductor casing may be required at some locations to provide a pipe connection (diverter) between the borehole and the discharge line for drill cuttings, to stabilize unconsolidated materials or to seal intervals where contaminated perched groundwater, confined conditions, depressed or elevated heads area encountered. A diverter casing is required for air drilling methods but in some cases a temporary casing can be used and removed before well surface completion. Temporary conductor casings installed without a grouted annular space will be removed in a manner that will permit complete grouting of the annular space between the permanent casing and drilled hole to the ground surface.

If conductor casing is required due to contaminated soil or contaminated perched groundwater (as described in Section 6) in the well borehole, the well borehole may be reamed or plugged back and over drilled, and conductor casing installed to seal the intervals of contaminated perched groundwater. Alternatively, the well bore may be abandoned in accordance with DLNR (2004) standards and re-drilled near the same location to a larger diameter to accommodate the surface casing.

If conductor casing is required, the rationale for determining the depth to set conductor casing in the vadose zone would be the deepest of the following conditions:

- Should extend to a minimum depth of 20 ft bgs or top of bedrock if <20 ft bgs.
- Should extend through any contaminated perched groundwater with PID readings greater than 10 parts per million by volume (ppmv) detected above 30 ft msl where significant inflow to the borehole (e.g., >5 gpm) cannot be prevented by grouting the perched water interval.
- Should extend through any observed vadose zone contamination above 30 ft msl.

If used, conductor casing will be installed in accordance with DLNR (2004) standards with a minimum 1.5-inch-thick annular seal composed of neat cement, cement-bentonite grout, or sand-cement slurry. If the annular space is less than 2 inches thick, grout must be emplaced using positive displacement methods, such as injecting grout from the bottom up using a tremie pipe in the annulus. The conductor casing will be installed under tension with centralizers at 40-ft maximum spacing. An initial interval of 3–5 ft of cement plug will be installed at the base of the casing and allowed to cure to prevent cement from entering the inside of the casing.

If the required grout volume is more than 150 percent of the calculated borehole volume due to voids in the formation, then gravel, bentonite chips, or uncoated bentonite pellets can be used to fill up to a 10-ft vertical interval of the borehole.

4.6 WELL DESIGN AND COMPLETION

4.6.1 Well Design

Proposed wells will be installed as single-screen monitoring wells in perched groundwater conditions or screened across or below the approximate elevation of the regional basal aquifer (water table conditions).

Typical monitoring well designs are shown on the following figures:

- Figure 1 for unconfined conditions, with 10 ft of slotted screen above and 20 ft of slotted screen below the basal aquifer water level.
- Figure 2 for unconfined conditions with 20 ft of screen installed considerably below the basal aquifer water level.
- Figure 3 for confined conditions, with 20 ft of slotted screen below the potentiometric surface in an interval with good hydraulic communication with the basal aquifer.
- Figure 4 for perched or elevated-head groundwater conditions with submerged screen above (perched condition) or below (elevated-head condition) the basal aquifer potentiometric surface.
- Figure 5 for typical monument style well surface completion.

4.6.2 Well Construction

The field manager or field geologist will oversee all monitoring well construction activities. Following video and geophysical logging, the driller will install monitoring wells in conformance with DLNR (2004) standards and Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Monitoring well completion will include the following:

- *Casing and screen:* The typical well designs use PVC or stainless steel well casing and slotted or wire-wrapped screens. All well designs will be in accordance with the DLNR (2004) well construction standards with a minimum of 1.5-inch-thick annular well seals. To ensure the casing is centered in the borehole, centralizers will be installed at the top and bottom of the screened sections and placed at 30- to 40-ft intervals on the blank casing. Manufacturer-supplied O-rings will be installed on all threaded PVC joints.
- *Annular materials:* During installation of annular materials, the casing and screen will be suspended under tension above the bottom of the borehole. Annular materials will be installed via tremie pipe. Any excess drilled footage more than 8 ft below the target depth (i.e., 5 ft below the bottom of the screen) will be backfilled with uncoated bentonite pellets or sand.
- *Sand filter pack:* Sand will be installed from the bottom of the borehole to above the monitoring well screen. The filter pack will be surged midway and at the top of the interval during placement. The depth to top of the filter pack will be monitored during surging. Additional material will be added if settling occurs.
- *Bentonite seals:* If the top of sand is below water, a 5-ft to 10-ft thick seal (depending on depth) of uncoated bentonite pellets will be emplaced via tremie pipe and allowed to hydrate. If top of sand is above water level, a 5-ft to 10-ft thick seal (depending on depth) of bentonite granules or chips will be emplaced via tremie pipe in two lifts and allowed to hydrate following each lift.
- *Cement seals:* Neat cement, cement-bentonite grout, or sand cement slurry will be installed in stages or lifts to limit potential for casing damage from heat of hydration and excessive hydrostatic pressure. Gravel, bentonite chips, or uncoated bentonite pellets can be used over short intervals to raise the top of the annular materials if the presence of voids or other features would otherwise consume excessive grout.
- *Design variances:* Other designs, well casing and borehole diameters, materials, and screen type and slot sizes may be considered where conditions require modification of the typical design. Stainless steel well casing and screen may be used in place of PVC.

Cement Grout. Grout used for annular seals, filling coreholes, or borehole abandonment will be in accordance with DLNR (2004) standards and Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Specifically, one of the three mixes below will be followed:

- *Neat cement grout:* Neat cement for grouting will be mixed at a ratio of one 94-pound sack of Portland Type I or IL cement to not more than 6 gallons of potable water.
- *Cement-bentonite grout:* A slurry of Type I or Type IL Portland cement, bentonite and water. The amount of bentonite added shall not exceed 8 percent bentonite per dry weight of cement (7.5 pounds of bentonite per 94-pound sack of cement). The volume of additional water used in preparing these slurries is limited to three quarters (0.75) of a gallon per 94-pound sack of cement for each 1 percent of bentonite added.
- *Sand-cement slurry:* Sand-cement for grouting will be mixed at a ratio of not more than one part sand to one part Portland Type I or Type IL cement, by weight, and not more than 6 gallons of potable water per sack of cement.

Excess grout and rinse fluids will be minimized and re-used to the extent practicable. Handling of excess grout and grout rinse fluids is discussed in Section 5.

4.6.3 Surface Completion

Each monitoring well will be completed in accordance with Procedures I-C-1, *Monitoring Well Installation and Abandonment* and I-C-2, *Monitoring Well Development* (DON 2015).

4.6.3.1 Aboveground Completions

Selected monitoring wells will be completed aboveground with a monument-style steel protective casing fitted with a locking, tamper-proof lid that covers the steel protective casing and well head, as shown on Figure 5. The lock will be recessed and covered for added protection, and permanent labels will be applied both inside and outside the casing via painting, marking, or engraving on the protective casing or surface completion. The steel casing will be set in concrete at the well head for strength and security and to provide a continuous cement surface seal. The steel protective casing will be filled with cement grout extending to a level 6 inches below the top of the PVC or stainless steel well casing.

4.6.3.2 Flush-Mount Vaults

Depending on the specific conditions surrounding a well, some wells may require a flush-mount traffic-rated steel cover. The covers will be corrosion resistant, leak resistant, and lockable. The concrete pad surrounding traffic-rated covers will be 0.25 inch above the road surface in paved areas, and 1.5 inches above ground surface in unpaved areas. The cement or grout used in the cover annulus will then be brought to surface or ground level. The vaults will have an H-20 load rating and bolt-down, gasketed covers with recessed padlocks.

4.7 Well Development

Monitoring well development will be performed in accordance with Procedure I-C-2, *Monitoring Well Development* (DON 2015), including surging and bailing, pumping, and monitoring water quality parameters until stabilization is achieved. Well development will not occur until 24 hours after the completion of the annular seal to allow the cement to cure. Well development will consist of a combination of surging and bailing techniques, and pumping groundwater with a submersible pump until fine sediment particles have been removed and the water turbidity is minimized. Development will continue until at least three borehole volumes have been removed, turbidity stabilizes at or below 5 nephelometric turbidity units, and three successive readings taken 5 minutes apart indicate the water quality parameters have stabilized. This ensures that formation water enters the well and that the water affected by drilling is removed. The parameters of dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, specific conductance, and turbidity will be monitored during the development cycle. Because DO and ORP are affected by the agitation of surging and pumping, the values obtained for these parameters during development may vary and may not be representative of the aquifer water. The alternative criteria provided in Procedure I-C-2 Section 5.7.1 may be employed for low-yield wells.

The well development activities will be documented in the field book and on well development forms.

4.8 Borehole, Corehole, and Well Abandonment

Borehole, corehole, or well abandonment may be required for test borings or any borehole or well that cannot be completed. Abandonment will be performed in accordance with DLNR (2004) well construction standards and Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Wells and boreholes will be sealed with neat cement, cement-bentonite grout, concrete, or sand-cement slurry. The grout will be emplaced with a tremie pipe from the bottom of the boring to within a minimum of 2 ft bgs. Additional grout may need to be placed if significant settlement occurs. If the required grout volume is more than 150 percent of the calculated borehole volume due to voids in the formation, then gravel, bentonite chips, sand, or uncoated bentonite pellets can be used to fill intervals of borehole to bring the annular materials above the top of voids.

5. IDW Management and Disposal

Solid, liquid, and mud IDW generated during monitoring well installation and development activities will be collected as it is generated. The IDW will be handled, stored, and labeled in accordance with Procedure I-A-6, *Investigation-Derived Waste Management* (DON 2015). Bulk containers and drums will be segregated according to matrix, and at least one composite IDW sample will be collected from each grouping for waste characterization in accordance with Procedure I-D-1, *Drum Sampling* (DON 2015). IDW characterization samples will be submitted for analysis to a laboratory certified by the Department of Defense Environmental Laboratory Accreditation Program. Waste profile forms will be prepared and submitted to potential disposal facilities for approval. The IDW will be kept at a staging area until the IDW analytical data are received and associated waste profile forms are approved by the disposal facilities and the Navy. The IDW will then be removed from the staging area, transported to, and disposed of at the approved disposal facilities. IDW will be disposed of within 90 calendar days of the generation date. Disposable personal protective equipment, clean disposable well construction materials, and disposable sampling equipment will be collected in plastic trash bags and disposed of as municipal solid waste.

Excess grout and grout-rinse fluids will be minimized and re-used to the extent practicable. Grout fluids and rinse water will be labeled as process water for subsequent mixing of grout. When grout-impacted fluids are no longer needed as process water for mixing grout, residual fluids with be solidified, and excess grout-impacted fluids will be labeled as waste and neutralized, if necessary, in accordance with the Standard Operating Procedure for Waste Management of Residual Grout and Grout Rinse Water (DON 2025).

6. Contamination Scenarios, Notifications, and Response Actions

Four scenarios are identified to address anticipated conditions encountered during drilling and notifications and response actions associated with each are listed below. PID readings can be collected from bailer jar headspace tests, borehole headspace, mud pan, roll-off bins, rock cores, or drill cuttings. The four scenarios include:

- *Scenario 1:* PID Reading <10 ppmv, No Contamination Observed
- *Scenario 2:* PID Reading >10 ppmv but <50 ppmv, No Contamination Observed
- *Scenario 3:* Moderate Contamination Observed and PID <50 ppmv
- *Scenario 4:* Moderate Contamination Observed and PID >50 ppmv
- *Scenario 5:* Gross Contamination

Details are summarized below regarding notification requirements and response actions for each scenario where groundwater inflow or soil contamination are observed.

6.1 Scenario 1: PID Reading <10 ppmv, No Contamination Observed

In this scenario:

- Navy will notify the Regulatory Agencies weekly via email regarding progress and observations and provide tabulated data.
- Drilling will continue.

- If inflow is >5 gpm, attempts will be made to seal the hole by grouting, and conductor casing may be required.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.2 Scenario 2: PID Reading >10 ppmv but <50 ppmv, No Contamination Observed

In this scenario:

- Navy will notify the Regulatory Agencies weekly via email regarding progress and observations and provide tabulated data.
- Drilling will continue.
- If inflow is >5 gpm after grouting attempts, conductor casing will be used to isolate groundwater inflow.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.3 Scenario 3: Moderate Contamination Observed and PID <50 ppmv

Moderate levels of contamination observed (e.g., with evidence of olfactory or visual oily staining or sheen on rock core or drill cuttings and PID readings less than 50 ppmv). In this scenario:

- Navy will notify the Regulatory Agencies via email within 1 week after contamination is encountered.
- Drilling will continue.
- If applicable, soil or groundwater (or other liquid if groundwater is not present) sampling will occur.
- Conductor casing or grouting will be used to isolate contaminated soil and contaminated perched water with inflow >5 gpm.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.4 Scenario 4: Moderate Contamination Observed and PID >50 ppmv

Moderate levels of contamination observed (e.g., with evidence of olfactory or visual oily staining or sheen on rock core or drill cuttings) and PID readings >50 ppmv. In this scenario:

- Navy will notify the Regulatory Agencies via email within 24 hours after contamination is encountered.
- Drilling will continue.
- If applicable, soil or groundwater (or other liquid if groundwater is not present) sampling will occur. Conductor casing or grouting will be used to isolate contaminated soil and contaminated perched water with inflow >5 gpm.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.5 Scenario 5: Gross Contamination

Gross contamination is defined as visual observation of mobile fuel product. In this scenario:

- Drilling will be discontinued, borehole will be stabilized, and the Navy COR will be immediately contacted for collaboration.
- Upon discovery of oily staining or sheen/observation of mobile fuel product the Navy will verbally notify Navy Leadership and the Regulatory Agencies within 24 hours of discovery and before advancing the boring further for collaboration to determine next steps.
- If applicable, soil or groundwater (or other liquid if groundwater is not present) sampling will occur.
- Navy will provide the Regulatory Agencies with written confirmation of the results and a description of how drilling will proceed (e.g., with borehole abandonment or completion of the well with conductor casing) within 30 days of the discovery of the impacted soil, sent with proof of delivery.

7. References

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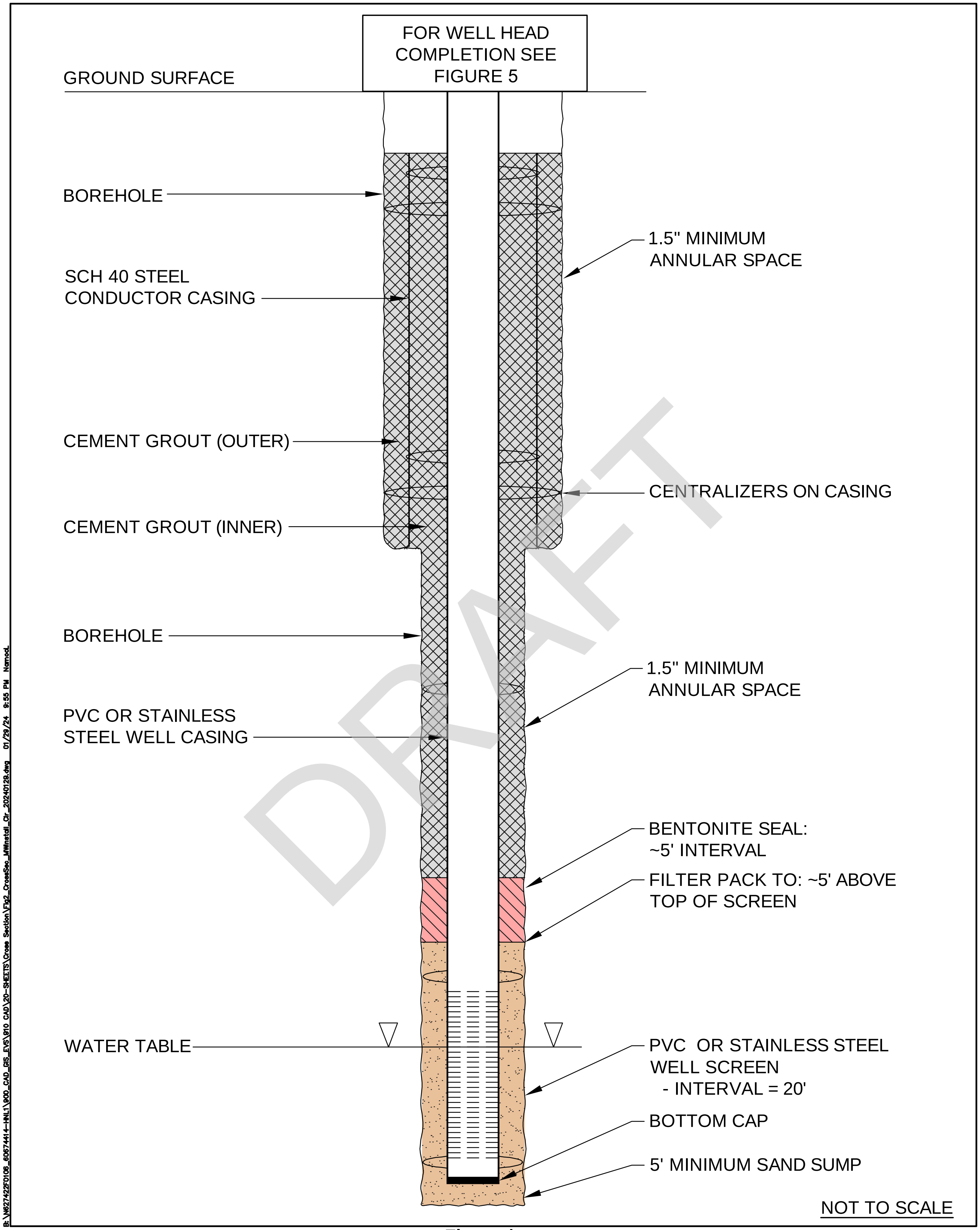


Figure 1

Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions)

Appendix C - Monitoring Well Installation Procedure

Holding Tank - Leach Tank Site Characterization Work Plan

Red Hill Bulk Fuel Storage Facility JBPHH, O'ahu, Hawai'i

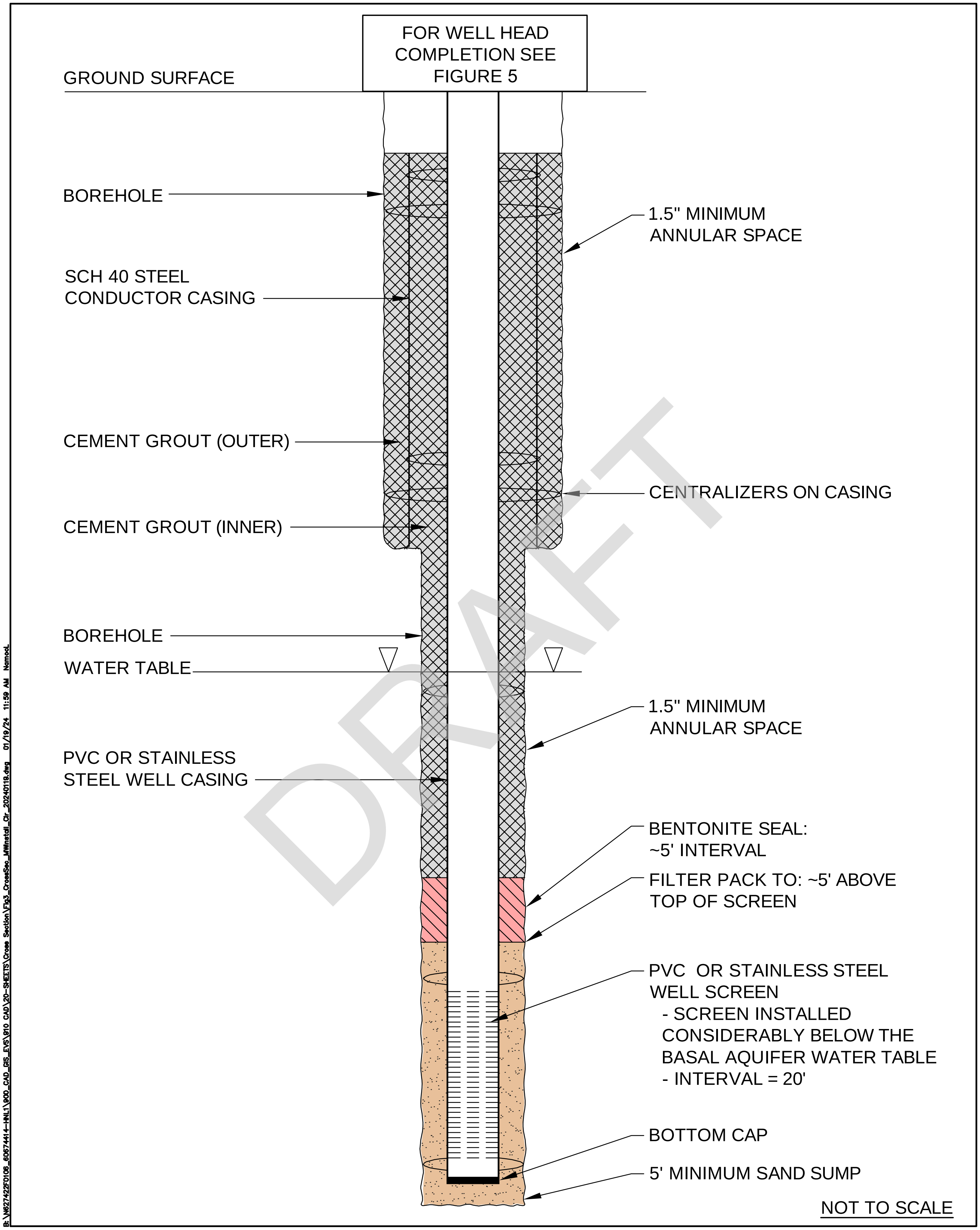


Figure 2

Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions - Deep Well)

Appendix C - Monitoring Well Installation Procedure

Holding Tank - Leach Tank Site Characterization Work Plan

Red Hill Bulk Fuel Storage Facility

JBPHH, O'ahu, Hawai'i

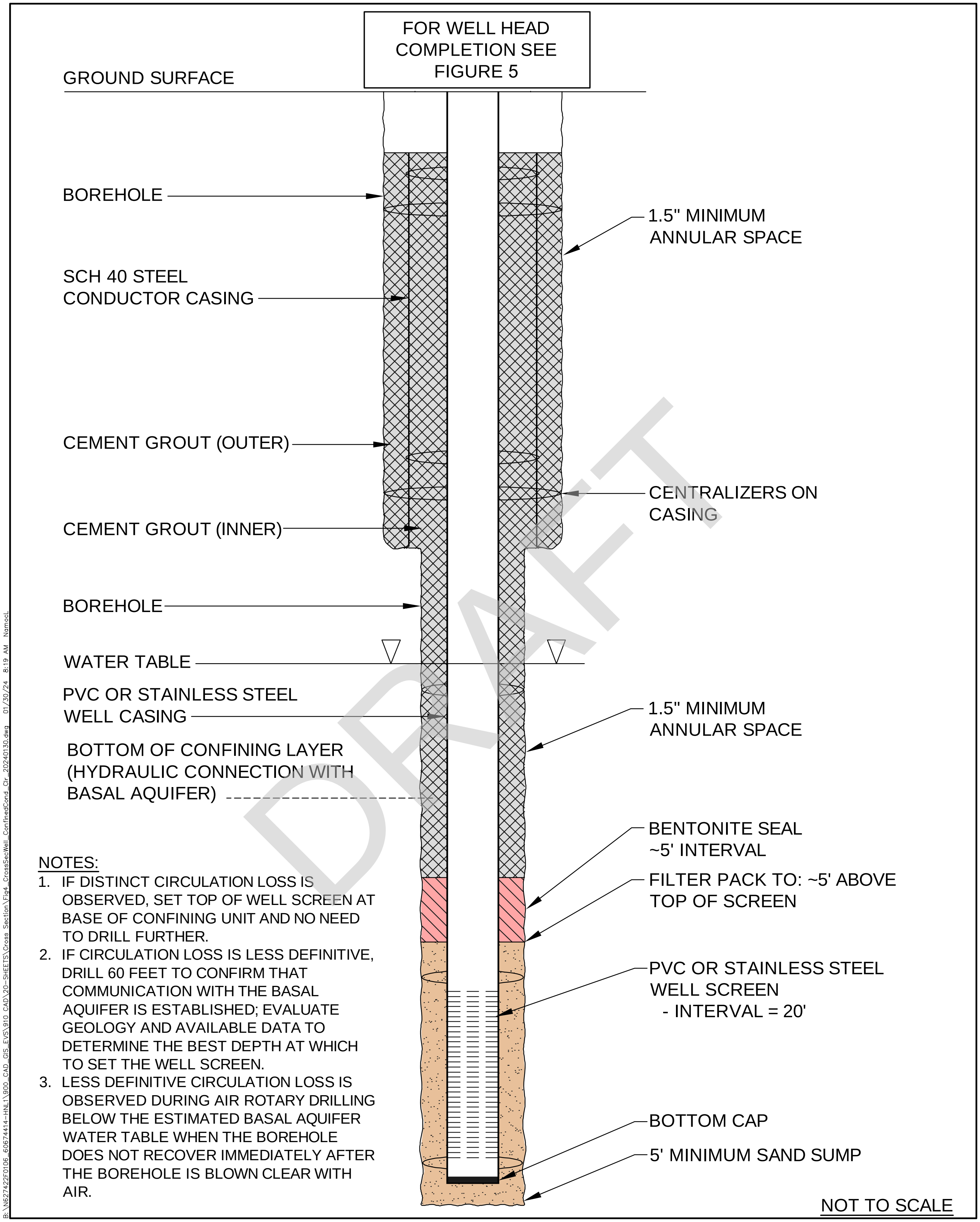
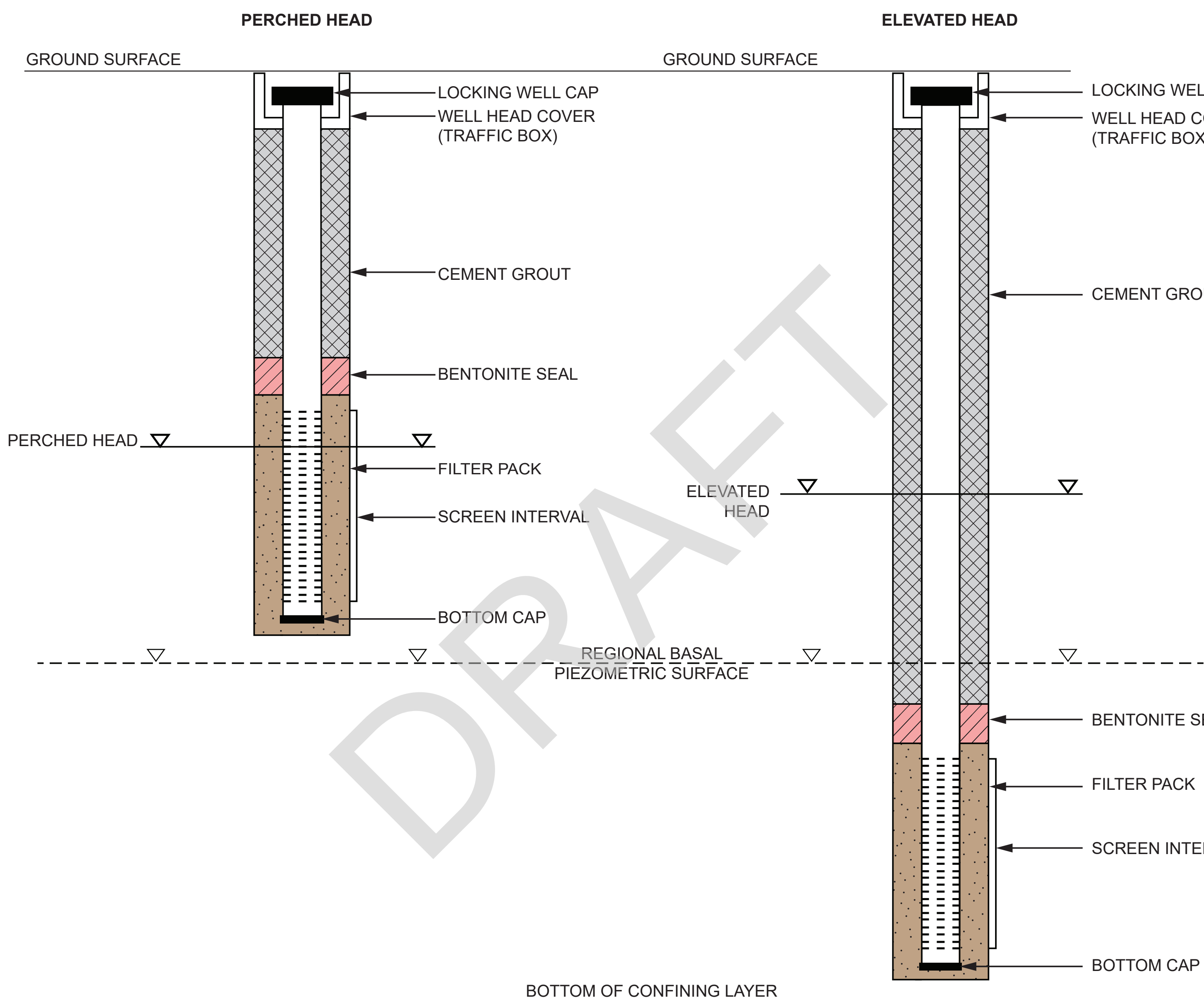


Figure 3
Typical Well Construction Diagram for Monitoring Well (Confined Conditions)
Appendix C - Monitoring Well Installation Procedure
Holding Tank - Leach Tank Site Characterization Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



NOT TO SCALE

Figure 4
Typical Well Construction Diagram for Perched and Elevated Head Aquifers
Appendix C - Monitoring Well Installation Procedure
Holding Tank - Leach Tank Site Characterization Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

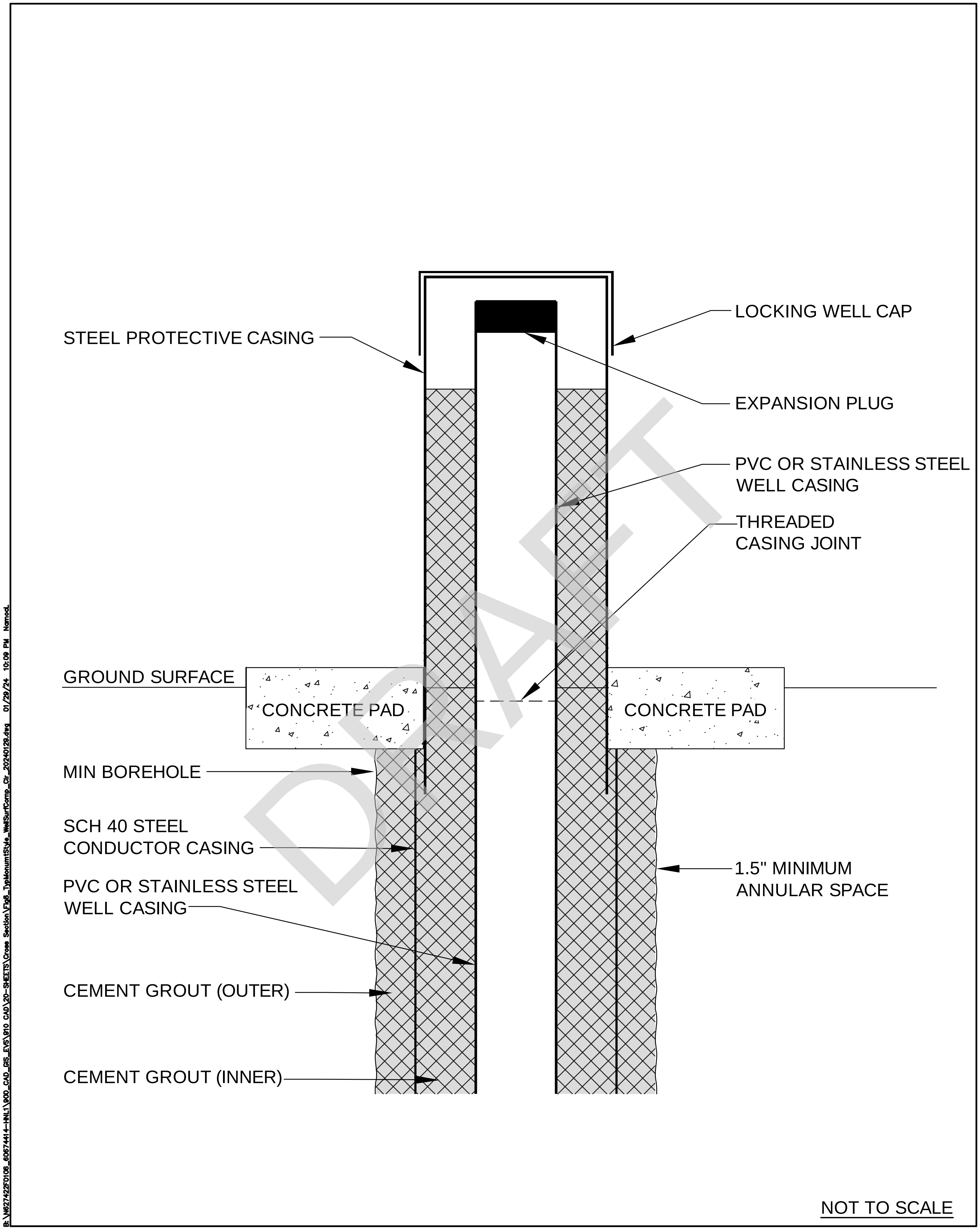


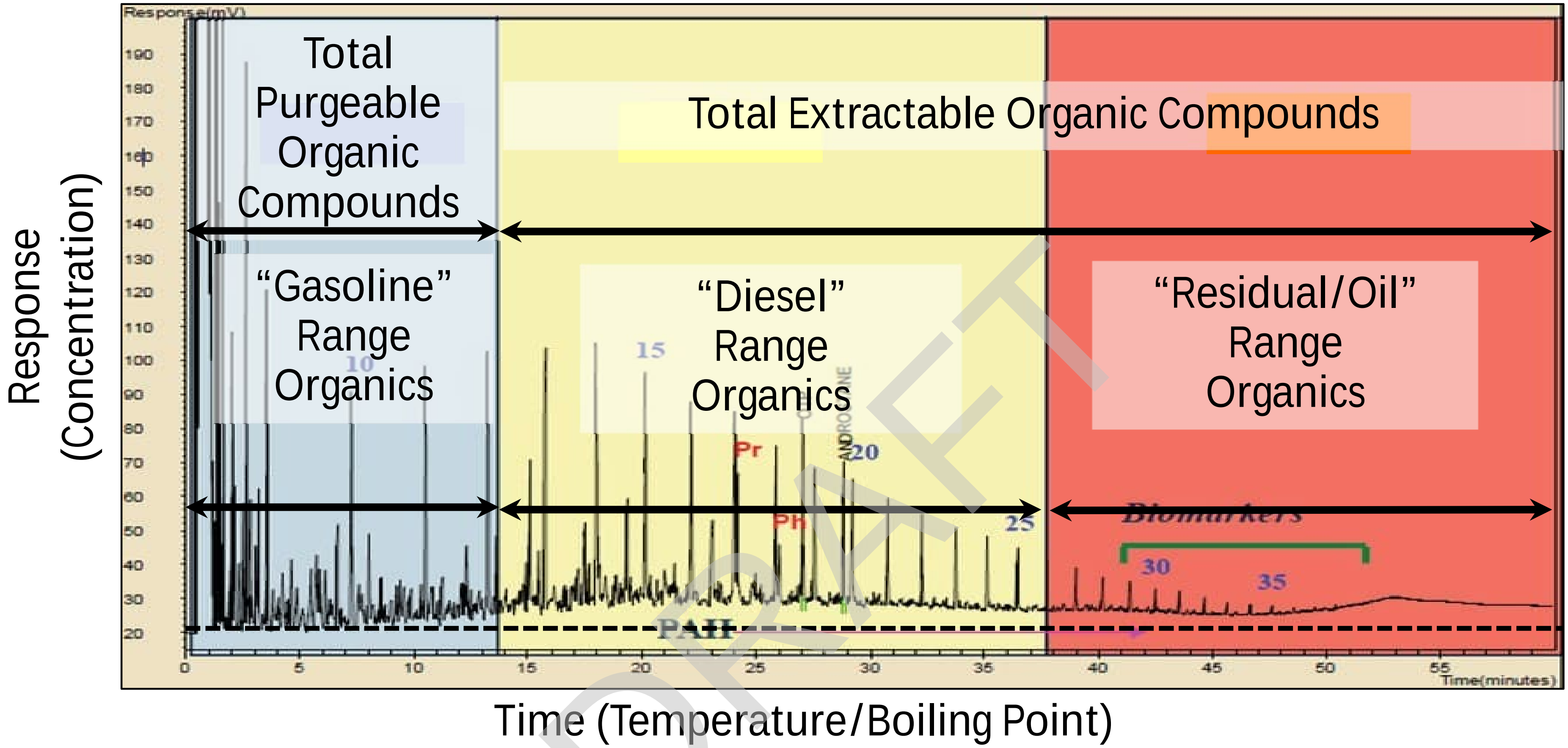
Figure 5
Typical Monument Style Well Surface Completion
Appendix C - Monitoring Well Installation Procedure
Holding Tank - Leach Tank Site Characterization Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

Attachment 1:
Acceptable Drilling Materials and Additives
(as of January 25, 2024)

Product Type	Product Name	Product Manufacturer
Thread Joint Compound	Biolube TJC	BioBlend Renewable Resources
Lost Circulation Material (LCM)	N-Seal	Halliburton
Hydraulic Oil	ISO46 & ISO68 Hydraulic Oil	Plews/Edelmann
	ENVIRONM MV 32, 46	Petro-Canada
	MOBILFLUID 424	ExxonMobil
Hammer Oil/Rock Drill Oil	RDO 302 ES	Control Chemical/MATEX
Hammer Oil	BioLube RDP	BioBlend Renewable Resources
Biodegradable Penetrating Oil Aerosol	BioBlend PO Aerosol	BioBlend Renewable Resources
Food Grade Grease	Food grade Gear Oil SAE 90	CRC Industries
	SoyGrease Food Machinery/UltraLube	Environmental Lubricants Manufacturing, Inc.
	Clarion Food Machinery Grease No. 2	CITGO Petroleum
Drill Foam	Foamer ES	Control Chemical/MATEX
Defoamer	Xiameter AFE-150 Antifoam Emulsion	Xiameter (Dow Corning)

Appendix D:
Tiered Forensic Assessment of Total Petroleum Hydrocarbons

Laboratory Measurement of “Total” TPH in Samples

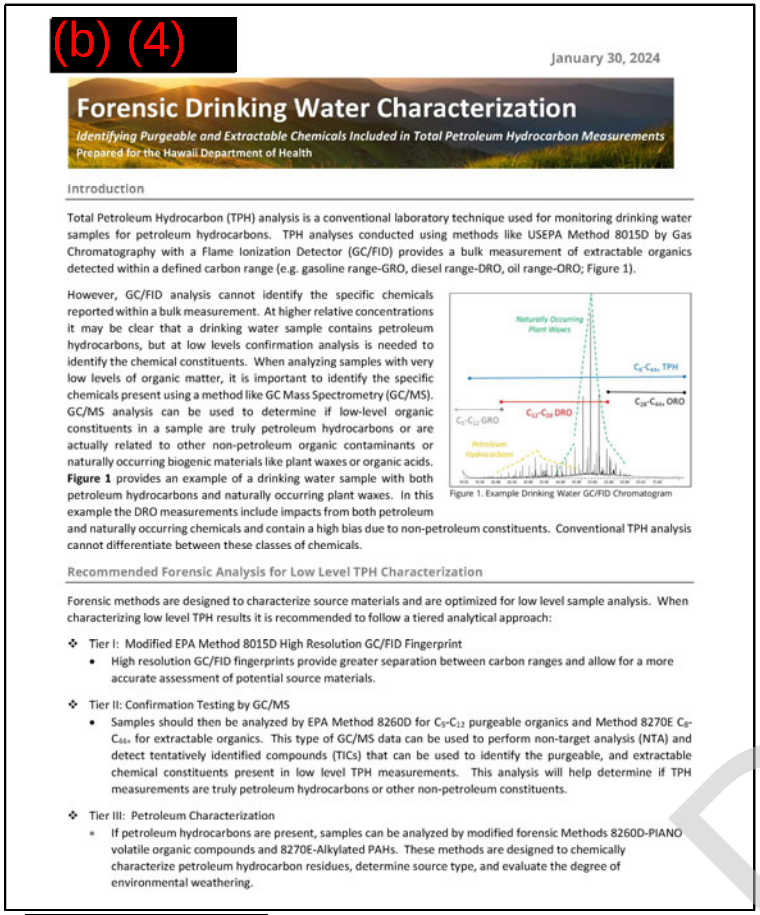


Purge and Trap: Method 8015/8260 (GC/GC-MS)
Extraction: Method 8015 (GC Only)

“Total” TPH Concentration for a Sample = Detected TPOC + TEOC

(previous terminology)
TPH = “GRO” + “DRO” + “RRO”

Forensic Assessment of “TPH” Below the MRL (e.g., TEOC <200 µg/L)



(b) (4)

January 30, 2024

Forensic Drinking Water Characterization

Identifying Purgeable and Extractable Chemicals Included in Total Petroleum Hydrocarbon Measurements

Prepared for the Hawaii Department of Health

Introduction

Total Petroleum Hydrocarbon (TPH) analysis is a conventional laboratory technique used for monitoring drinking water samples for petroleum hydrocarbons. TPH analyses conducted using methods like USEPA Method 8015D by Gas Chromatography with a Flame Ionization Detector (GC/FID) provides a bulk measurement of extractable organics detected within a defined carbon range (e.g. gasoline range-GRO, diesel range-DRO, oil range-ORO; Figure 1).

However, GC/FID analysis cannot identify the specific chemicals reported within a bulk measurement. At higher relative concentrations it may be clear that a drinking water sample contains petroleum hydrocarbons, but at low levels confirmation analysis is needed to identify the chemical constituents. When analyzing samples with very low levels of organic matter, it is important to identify the specific chemicals present using a method like GC Mass Spectrometry (GC/MS). GC/MS analysis can be used to determine if low-level organic constituents in a sample are truly petroleum hydrocarbons or are actually related to other non-petroleum organic contaminants or naturally occurring biogenic materials like plant waxes or organic acids. **Figure 1** provides an example of a drinking water sample with both petroleum hydrocarbons and naturally occurring plant waxes. In this example the DRO measurements include impacts from both petroleum and naturally occurring chemicals and contain a high bias due to non-petroleum constituents. Conventional TPH analysis cannot differentiate between these classes of chemicals.

Figure 1. Example Drinking Water GC/FID Chromatogram

Recommended Forensic Analysis for Low Level TPH Characterization

Forensic methods are designed to characterize source materials and are optimized for low level sample analysis. When characterizing low level TPH results it is recommended to follow a tiered analytical approach:

- Tier I: Modified EPA Method 8015D High Resolution GC/FID Fingerprint
  - High resolution GC/FID fingerprints provide greater separation between carbon ranges and allow for a more accurate assessment of potential source materials.
- Tier II: Confirmation Testing by GC/MS
  - Samples should then be analyzed by EPA Method 8260D for C_5-C_{12} purgeable organics and Method 8270E C_8-C_{44+} for extractable organics. This type of GC/MS data can be used to perform non-target analysis (NTA) and detect tentatively identified compounds (TICs) that can be used to identify the purgeable, and extractable chemical constituents present in low level TPH measurements. This analysis will help determine if TPH measurements are truly petroleum hydrocarbons or other non-petroleum constituents.
- Tier III: Petroleum Characterization
  - If petroleum hydrocarbons are present, samples can be analyzed by modified forensic Methods 8260D-PIANO volatile organic compounds and 8270E-Alkylated PAHs. These methods are designed to chemically characterize petroleum hydrocarbon residues, determine source type, and evaluate the degree of environmental weathering.

(b) (4) 2024 (in prep)

<u>Tier I: Modified Method 8015D High Resolution GC/FID:</u>

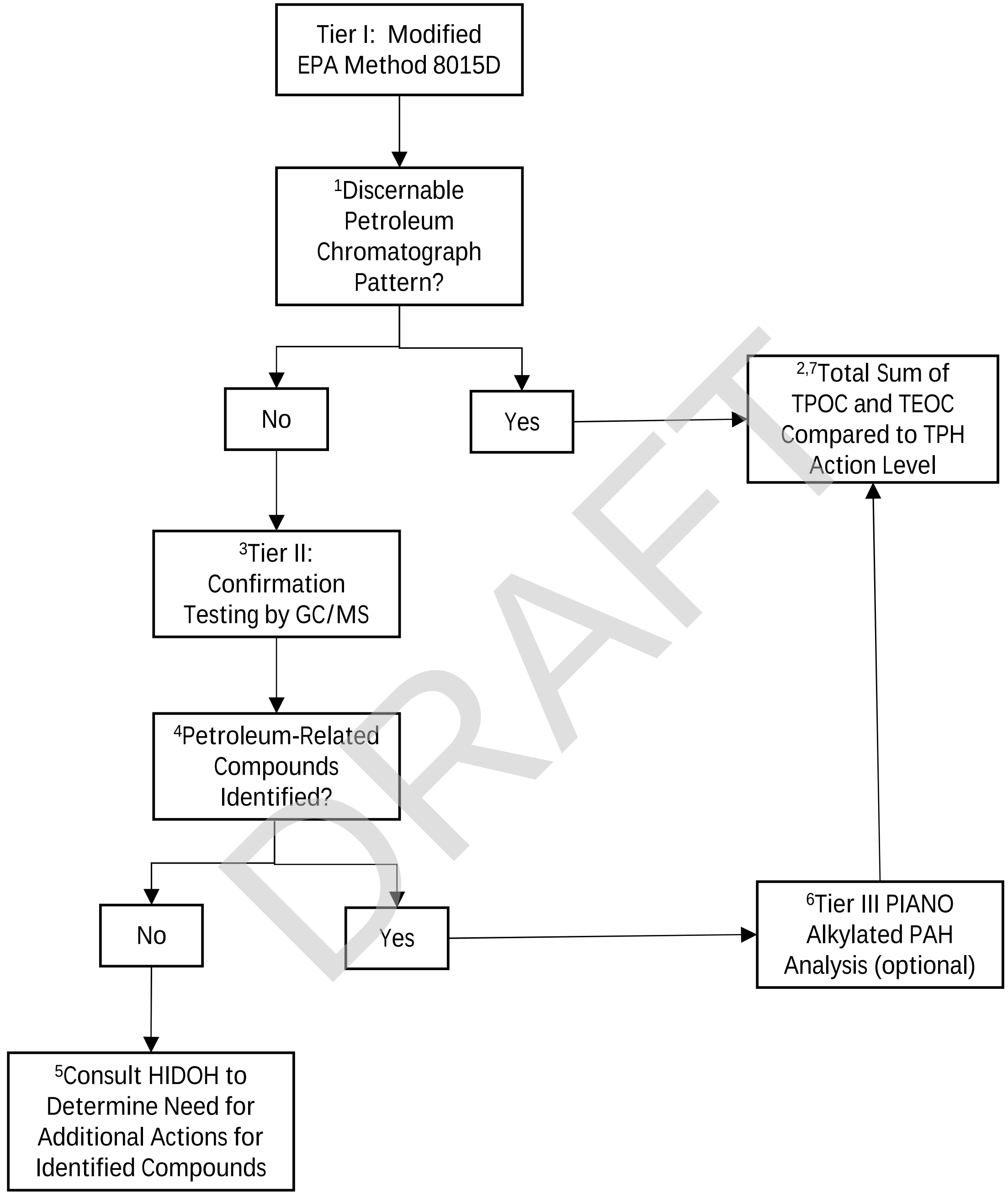
- Fuel fingerprint;
- Allows more accurate assessment of potential source materials.

<u>Tier II: Confirmation Testing by GC/MS (qualitative):</u>

- Tier 1 identifies Total Extractable Organics (TEOs) but fuel fingerprint inconclusive chromatogram pattern;
- GC/MS Method 8260D for C5-C12 purgeable organics;
- GC/MS Method 8270E C8-C44+ for extractable organics;
- +/- Non-Target Analysis (NTA) for tentatively identified compounds (TICs);
- Used to determine if TEOC measurements are truly petroleum hydrocarbons or other non-petroleum constituents.

<u>Tier III: Petroleum Characterization:</u>

- Tier II test identifies apparent petroleum-related compounds;
- Modified forensic Methods 8260D-PIANO volatile organic compounds and 8270E-Alkylated PAHs;
- Data used to chemically characterize petroleum hydrocarbon residues, determine source type, and evaluate the degree of environmental weathering.


Tier I: Modified EPA Method 8015D
[1]Discernable Petroleum Chromatograph Pattern?
No
Yes
[2,7]Total Sum of TPOC and TEOC Compared to TPH Action Level
[3]Tier II: Confirmation Testing by GC/MS
[4]Petroleum-Related Compounds Identified?
No
Yes
[6]Tier III PIANO Alkylated PAH Analysis (optional)
[5]Consult HIDOH to Determine Need for Additional Actions for Identified Compounds

Appendix E:
Response to Comments

Appendix E.1:
DOH

Enclosure (2) - Response to DOH Comments on Draft Site Characterization Work Plan, Holding Tank-Leach Tank

1. ***In reference to Section 4.3, Enclosure (1) states that, "the collection of incremental subsurface soil samples at the site is impractical due to numerous cobbles and boulders in this area (refusal was frequently encountered during the previous phase of sampling and it is very unlikely that additional borings than those currently proposed could be completed)." In the event of refusal, conduct step-out borings and document the refusals.***

   NCTF - RH Response – The Navy's preference is to retain the approach that is currently stated in Section 4.3 of the work plan: "If the borehole cannot be advanced, then the borehole will be abandoned and re-attempted within 3 horizontal ft of the original." The Navy would like to conduct another boring before conducting step-out borings. All refusals will be documented.

2. ***Make the following revisions to the HT-LT Work Plan Section 4.4 (PDF page 18) (red italicized indicates new text, ~~strikethrough~~ indicates text to remove).***
   1. ***If COPC concentrations in the subsurface are not detected at a concentration above the most conservative DOH Tier 1 ~~Environmental Action Level (~~EAL~~)~~ ~~soil do not exceed PSLs~~ in any sampling location, then recommend ~~no further action~~ no further sampling unless reasonable evidence indicates additional sampling is needed (e.g., data gaps remaining, field observations).***
      If COPC concentrations in subsurface soil are detected at concentrations above the most conservative DOH Tier 1 EALs ~~exceed PSLs~~, then evaluate if exceedances are delineated laterally and vertically with additional borings. If exceedances are delineated, then no additional subsurface soil sampling will be conducted unless other reasonable evidence or reasoning indicates additional sampling is needed (e.g., data gaps remaining, field observations).
      If exceedances are not delineated, then conduct step-out borings to further delineate the lateral extent of contamination, or deeper borings to further delineate the vertical extent of contamination.

      NCTF - RH Response – Acknowledged and partially accepted; the work plan was updated to replace the reference to PSLs with "the most conservative DOH Tier 1 EAL". However, the Navy believes that any reasonable circumstances which might indicate a need for additional sampling are covered in the existing Decision Rules, such as conducting step-out or deeper borings when exceedances are not clearly delineated.

   2. ***If none of the COPC concentrations in perched groundwater samples collected during 1 year of quarterly monitoring ~~do not exceed PSLs~~ are ~~not~~ detected above the most conservative DOH Tier 1 EALs, then recommend no further ~~action~~ sampling unless reasonable evidence indicates additional sampling is needed.***

If COPC concentrations in perched groundwater exceed ~~PSLs~~ the most conservative DOH Tier 1 EALs, then conduct a longer temporal study or install additional step-out perched groundwater monitoring wells down gradient of the source area to define the extent of perched groundwater impacts.

If COPC concentrations in basal groundwater exceed ~~PSLs~~ the most conservative DOH Tier 1 EALs, then conduct an expanded study to include more existing basal wells at the Facility and install more basal groundwater monitoring wells downgradient of the source area to define the extent of basal groundwater impacts.

NCTF - RH Response – Acknowledged and partially accepted; the work plan was updated to replace the reference to PSLs with "the most conservative DOH Tier 1 EAL" and to insert "perched" before groundwater. However, the Navy believes that any reasonable circumstances which might indicate a need for additional sampling are covered in the existing Decision Rules.

3. ***If quarterly perched groundwater level monitoring for 1 year indicates that the elevation of South Halawa Stream is higher than the elevation of the perched groundwater (i.e., the stream is not receiving water from the perched groundwater due to relative elevation), then recommend no further action unless other reasonable evidence indicates that further action is needed. ~~If the elevations of South Halawa Stream and perched groundwater indicate that the stream is gaining (i.e. perched groundwater is seeping into the stream),~~ If water levels indicate that the perched groundwater is seeping into the stream, then collect surface water samples at the locations most likely influenced by this seepage for analysis of COPCs.***

   NCTF - RH Response – Acknowledged and partially accepted; the work plan was updated to reflect the proposed changes related to seepage. However, the Navy believes that any reasonable circumstances which might indicate a need for additional sampling are covered in the existing Decision Rules.

Appendix E.2:
EPA

Enclosure (2) - Response to EPA Comments on Draft Site Characterization Work Plan, Holding Tank Leach Tank Dated May 2025

1. ***Please include dissolved lead in the analyte list for groundwater samples and total lead in the analyte list for soil samples. Should lead be detected in groundwater and/or soil, please include dissolved lead in the analyte list for surface water. (Section 4.2, 5.2, 5.4, 5.5)***

   NCTF - RH Response- Acknowledged, but the Navy will add Tetraethyl Lead as an analyte instead. Currently Lead Scavenger Fuel Additives (EDB, 1,2DCE) are included in this work plan. When taking into consideration the Hawaii Environmental Background Metal Concentrations, these Lead Scavenger Fuel Additives will be a better indicator of contamination from a petroleum source. To address concerns of product release from the AVGAS Line, Tetraethyl Lead was added as a COPC in the above noted sections in lieu of testing for total or dissolved lead.

2. ***Please expand the area of investigation to include soil at 5-12 feet below ground surface that exceeded direct exposure criteria for TPH-g and TPH-o, as identified in Enclosure 2 of EPA's letter dated October 29, 2024.). (Section 5.2, Figure4)***

   NCTF - RH Response – Acknowledged; Proposed soil sample boring locations are outside of all the areas requiring further delineation outlined in Enclosure 2 of the 10/29/2024 EPA Letter. Each boring will advance to the perched capillary fringe or will continue to advance to 45 ft if capillary fringe is not encountered. Please refer to Attachment A which displays the areas requiring further delineation and which proposed soil sample borings will address the areas. Please note that proposed soil sample borings are located outside of the area in which soil was previously excavated to 12 feet.

3. ***Please ensure the problem statement in Section 4.1 considers "petroleum" and "petroleum contamination or degradation" rather than just "JP-5 contamination or degradation". Historic releases may have impacted this area directly or been mobilized to impact this area during the 2021 releases. (Section 4.1)***

   NCTF - RH Response – Concur and Edits Accepted; Revised in document to state "Petroleum" or "Petroleum Contamination" versus "JP-5" in PSQs.

4. ***Please update the "TBD" designations with actual parameters as they become available. For example, Laboratory-Specific Limits in Table B-2 should be documented before beginning work. (Appendix B)***

   NCTF - RH Response – Concur; Will address upon completion of site survey and procurement of Laboratory Services.

Enclosure (2) - Response to EPA Comments on Draft Site Characterization Work Plan, Holding Tank Leach Tank Dated May 2025

5. ***Many of the well installation procedures seem to be copied from an earlier version of the Red Hill Monitoring Well Installation Work Plan. Instead, please reference the January 2025 MWIWP. (Appendix C)***

   NCTF - RH Response – Concur; Updated Appendix C to mirror January 2025 MWIWP where applicable with site/project specific variables taken into consideration.

6. ***Navy proposes to utilize the tiered forensic analysis to screen low level detections of total petroleum hydrocarbons. The work plan indicates that the analysis will be used to identify sources of petroleum hydrocarbon detections. If these evaluations will be used to rule out detections for further evaluation or corrective action, additional lines of evidence will be needed. Prior to making decisions based on these evaluations, please schedule a special purpose meeting to discuss the findings and recommendations. (Appendix D pages 408-410)***

   NCTF - RH Response – Acknowledged; A special purpose meeting will be scheduled.

7. ***Please correct the Well ID in the last sentence of the Sampling Rationale column. It currently states "HTLTMW02B" but should be "HTLTMW02A". (Table 5-1. Second Row)***

   NCTF - RH Response – Edits Accepted.

Attachment A: EPA October 29, 2024 Enclosure 2

Enclosure (2) - Response to EPA Comments on Draft Site Characterization Work Plan, Holding Tank Leach Tank Dated May 2025

Enclosure 2: Further Investigation Required

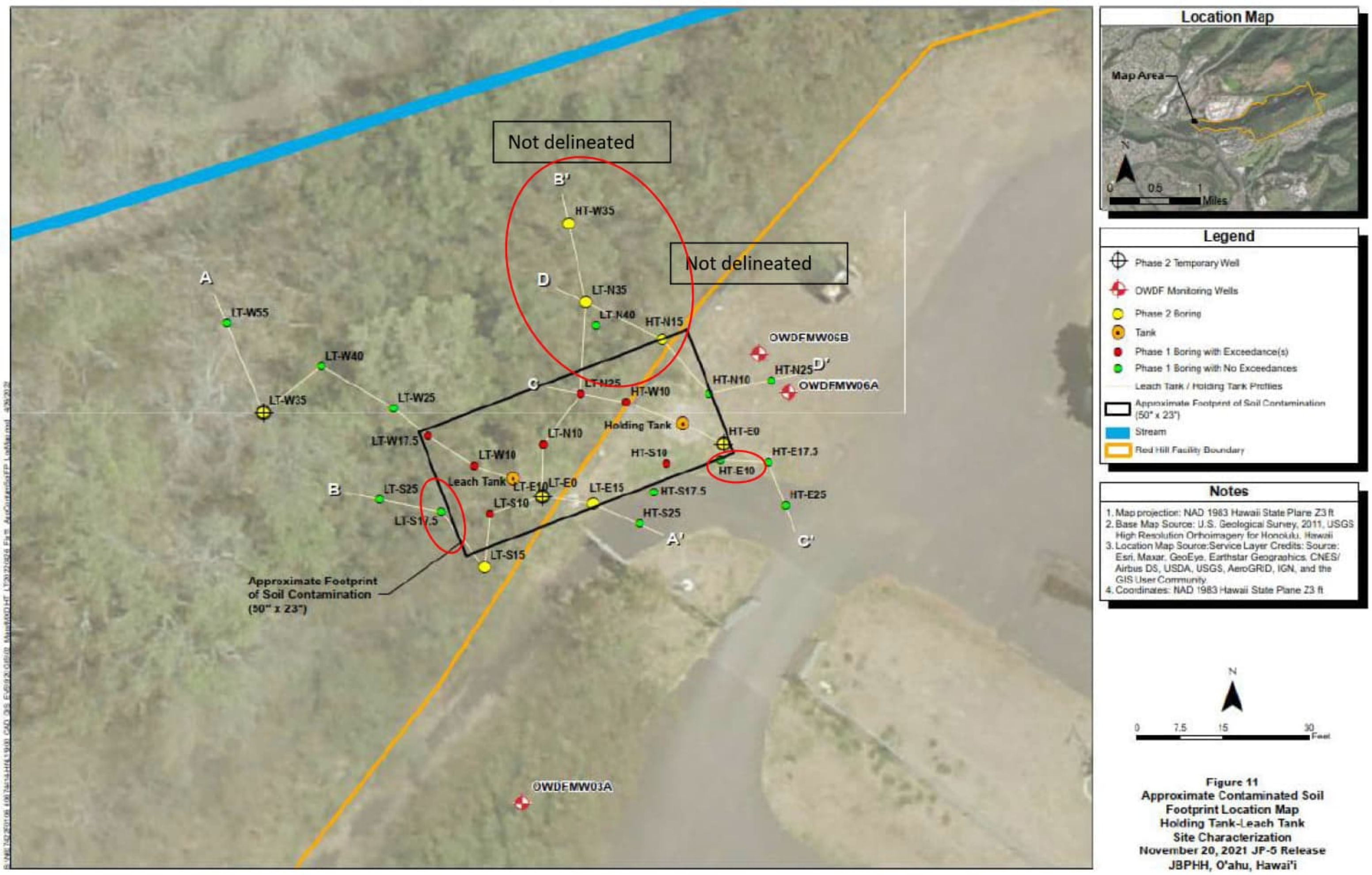


Figure 11: Approximate Contaminated Soil Footprint Location Map

Note: ⬭ = needs further investigation

Attachment B:
Site Characterization Work Plan
Holding Tank-Leach Tank Figure 4

(b) (3) (B)

[redacted]

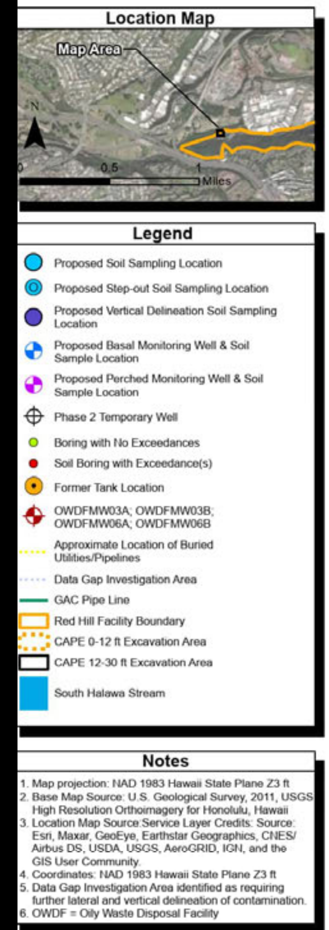


Figure 4
Proposed Soil Sampling Locations
Site Characterization Work Plan
Holding Tank-Leach Tank
JBPHH, Oahu, Hawaii