



DEPARTMENT OF THE NAVY

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Ser N4/0403
January 3, 2017

CERTIFIED NO: 7015 0640 0002 4674 2347

Mr. Bob Pallarino
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

Mr. Steven Y.K. Chang, P.E., Chief
State of Hawaii Department of Health
Environmental Management Division
Solid and Hazardous Waste Branch
919 Ala Moana Boulevard, Room 210
Honolulu, HI 96814

Dear Mr. Pallarino and Mr. Chang:

**SUBJECT: ADMINISTRATIVE ORDER ON CONSENT STATEMENT OF WORK
SECTION 6 AND SECTION 7 MONITORING WELL INSTALLATION WORK
PLAN ADDENDUM NO. 1 FOR REGULATORY AGENCY REVIEW, RED
HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR
HICKAM, OAHU, HAWAII**

The Monitoring Well Installation (MWI) Work Plan (WP) Addendum No. 1 for Red Hill pursuant to the Administrative Order on Consent (AOC) Statement of Work (SOW) Section 6, Investigation and Remediation of Releases, and Section 7, Groundwater Protection and Evaluation is enclosed.

This work plan is an addendum to the August 29, 2016 MWI WP and details the proposed approach for installing replacement wells for existing monitoring wells, RHMW01 and OWDFMW01, at the Red Hill Bulk Fuel Storage Facility. As previously discussed with the Regulatory Agencies, the screened intervals of RHMW01 and OWDFMW01 currently do not bracket the water table surface which may limit assessment of the potential presence of non-aqueous phase liquid at these monitoring well locations. Therefore, the Department of Navy (Navy) and the Defense Logistics Agency (DLA) hereby submit the MWI WP Addendum No. 1 which includes the design and rationale of proposed replacement well installation.

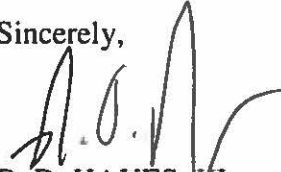
The Navy/DLA acknowledge the Regulatory Agencies' question on the utility of installing replacement wells for existing wells OWDFMW01 and RHMW01 as stated in the December 5, 2016 letter conditionally approving the AOC SOW Section 6 and Section 7 Work Plan/Scope of Work. We respectfully request that you review the MWI WP Addendum No. 1 and forward any

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comments as soon as possible to maintain an expedited timeline. The Navy/DLA also requests a meeting with the Regulatory Agencies to further discuss this issue.

If you have any questions, please contact Aaron Y. Poentis of our Regional Environmental Department at (808) 471-3858 or at aaron.poentis@navy.mil.

Sincerely,



R. D. HAYES, III
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

Enclosure: Monitoring Well Installation Work Plan, Addendum 01, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, January 4, 2017

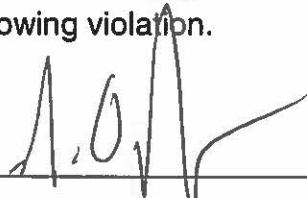
Red Hill Administrative Order on Consent,
Monitoring Well Installation Work Plan Deliverable

Section 6.2 Investigation and Remediation of Releases Scope of Work
Section 7.1.2 Groundwater Flow Model Report Scope of Work
Section 7.2.2 Contaminant Fate and Transport Model Report Scope of Work
Section 7.3.2 Groundwater Monitoring Well Network Scope of Work

In accordance with the Red Hill Administrative Order on Consent, paragraph 9,
DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fines and imprisonment for knowing violation.

Signature:



CAPT Richard Hayes III, CEC, USN
Regional Engineer, Navy Region Hawaii

Date:

1/3/2017

Monitoring Well Installation Work Plan Addendum 01, Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM, O'AHU, HAWAI'I

January 4, 2017



**Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-12-D-1829, CTO 0053**

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1 **Monitoring Well Installation**
2 **Work Plan Addendum 01, Red Hill**
3 **Bulk Fuel Storage Facility**
4 **JOINT BASE PEARL HARBOR-HICKAM, O‘AHU, HAWAI‘I**

5 **January 4, 2017**

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16 **Comprehensive Long-Term Environmental Action Navy**
17 **Contract Number N62742-12-D-1829, CTO 0053**

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ACRONYMS AND ABBREVIATIONS

1		
2	%	percent
3	°C	degree Celsius
4	AOC	Administrative Order on Consent
5	APPL	Agriculture & Priority Pollutants Laboratories, Inc.
6	bgs	below ground surface
7	CoC	chain of custody
8	COLIWASA	composite liquid waste sampler
9	COPC	chemical of potential concern
10	COR	contracting officer's representative
11	CTO	contract task order
12	DLA	Defense Logistics Agency
13	DoD	Department of Defense, United States
14	DOH	Department of Health, State of Hawai'i
15	DON	Department of the Navy, United States
16	DQI	data quality indicator
17	ELAP	Environmental Laboratory Accreditation Program
18	EPA	Environmental Protection Agency, United States
19	ft	foot or feet
20	GPS	Global Positioning System
21	ID	identification
22	IDW	investigation-derived waste
23	Investigation WP/SOW	Investigation and Remediation of Releases and Groundwater Protection and
24		Evaluation Work Plan and Scope of Work
25	JBPHH	Joint Base Pearl Harbor-Hickam
26	LOQ	limit of quantitation
27	mL	milliliter
28	msl	mean sea level
29	MWIWP	Monitoring Well Installation Work Plan
30	N/A	not applicable
31	NAD	North American Datum
32	NAPL	non-aqueous-phase liquid
33	NAVFAC	Naval Facilities Engineering Command
34	Navy	Department of the Navy, United States
35	OD	outer diameter
36	OWDF	Oily Waste Disposal Facility
37	PAH	polynuclear aromatic hydrocarbon
38	PID	photoionization detector
39	PVC	polyvinyl chloride
40	QC	quality control
41	RPD	relative percent difference
42	SAP	sampling and analysis plan
43	SOP	standard operating procedure
44	SOW	scope of work
45	TBD	to be determined
46	TGM	Technical Guidance Manual
47	TOC	top of casing

1	TPH	total petroleum hydrocarbons
2	TPH-d	total petroleum hydrocarbons – diesel range organics
3	TPH-g	total petroleum hydrocarbons – gasoline range organics
4	TPH-o	total petroleum hydrocarbons – residual range organics (i.e., TPH-oil)
5	U.S.	United States
6	VOA	volatile organic analyte
7	VOC	volatile organic compound

1 **1. Introduction**

2 This Monitoring Well Installation Work Plan (MWIWP) Addendum documents the proposed
3 approach for installing replacement wells for existing monitoring wells RHMW01 and
4 OWDFMW01 at the Red Hill Bulk Fuel Storage Facility (the "Facility"). The screened intervals of
5 these wells do not bracket the across the water table surface, and consequently may limit assessment
6 of the potential presence of non-aqueous-phase liquid (NAPL) or concentrations of dissolved-phase
7 fuel constituents in groundwater. This MWIWP Addendum intends to serve as a streamlined guide,
8 and supplements information in the MWIWP dated August 29, 2016 (DON 2016b).

9 This MWIWP Addendum includes the design and rationale of proposed replacement well installation
10 including sampling methods for subsurface unconsolidated material and applicable references.
11 Detailed site background and project quality objectives are provided in the MWIWP and are not
12 covered in this MWIWP Addendum. Additionally, methods and procedures for collecting
13 groundwater samples from the monitoring wells, analyzing the groundwater for the chemicals of
14 potential concern (COPCs), and conducting other investigation activities and analyses are addressed
15 in the project *Work Plan/Scope of Work, Investigation and Remediation of Releases and*
16 *Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility* (the "Investigation
17 *WP/SOW*") (DON 2016c), and the forthcoming project *Sampling and Analysis Plan (SAP)*.

18 The activities proposed under this MWIWP Addendum 01, the MWIWP (DON 2016b), and the
19 Investigation WP/SOW (DON 2016c) are part of an investigation being performed by the United
20 States (U.S.) Department of the Navy (DON; "Navy") and Defense Logistics Agency (DLA) in order
21 to address the requirements and achieve the objectives of the Administrative Order on Consent
22 (AOC) issued by the U.S. Environmental Protection Agency (EPA) Region 9 and the State of
23 Hawai'i Department of Health (DOH) (EPA Region 9 and DOH 2015). The investigation
24 specifically addresses the AOC Statement of Work Section 6, Investigation and Remediation of
25 Releases, and Section 7, Groundwater Protection and Evaluation. The monitoring well installation
26 activities proposed under this MWIWP Addendum will be conducted as part of Task 4 *Expand the*
27 *Monitoring Well Network* presented in the Investigation WP/SOW (DON 2016c, Section 3.4).

28 **2. Replacement Well Rationale and Design**

29 This section describes the rationale to install two replacement monitoring wells (RHMW01R and
30 OWDFMW01R) for existing wells RHMW01 and OWDFMW01 and the design for each well,
31 including drilling, unconsolidated material sampling, rock coring, well installation, and development.
32 The design and rationale for subsequent groundwater sampling and analysis are described in the
33 Investigation WP/SOW (DON 2016c) and the forthcoming project SAP.

34 **2.1 RATIONALE FOR REPLACEMENT MONITORING WELL INSTALLATION**

35 Monitoring wells RHMW01 and OWDFMW01 are included in the existing Red Hill groundwater
36 monitoring well network (Figure 1). Well RHMW01 is located inside the Facility's lower-access
37 tunnel near Tank 1, and well OWDFMW01 is located at the former Oily Waste Disposal Facility
38 (OWDF). Although these monitoring wells comprise important sentinel locations, water table
39 elevations are found to be consistently above the top of well screens in both wells (see Appendix A
40 for well construction logs [DON 2000, 2002]). As shown in Table 2-1, groundwater levels have been
41 measured approximately 5 feet (ft) and 13 ft above the top of screen in wells RHMW01 and
42 OWDFMW01, respectively.

1 **Table 2-1: Well Construction Details**

Well ID	Ground Surface (ft msl)	Top of Casing (ft msl)	Casing Diameter and Type	Estimated Depth to Bedrock (ft)	Ground-water Surface (ft msl) ^a	Well Screen Interval (ft msl)	Top of Filter Pack (ft msl)	Borehole Bottom Depth (ft bgs)	Borehole Bottom Elevation (ft msl)
Existing Wells									
RHMW01	102.51	102.41 ^b	1" SCH 80	N/A	19.54	12.61 to 2.61	15.66	100	2.51
OWDFMW01	136.18	138.57 ^b	4" SCH 80	49	17.97	4.16 to -5.84	16.74	143	-4.06
Proposed Replacement Wells									
RHMW01R	103	TBD	4" SCH 80 ^c	N/A	19.54	28 to -2	33	106	-3
OWDFMW01R	139	TBD	4" SCH 80	49	17.97	28 to -2	33	142	-3

2 bgs below ground surface (for RHMW01, below the tunnel floor)

3 msl mean sea level

4 N/A not applicable

5 PVC polyvinyl chloride

6 SCH Schedule

7 TBD to be determined

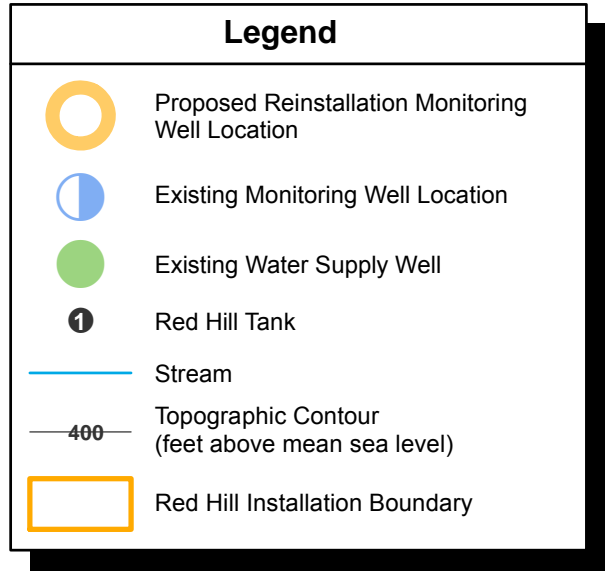
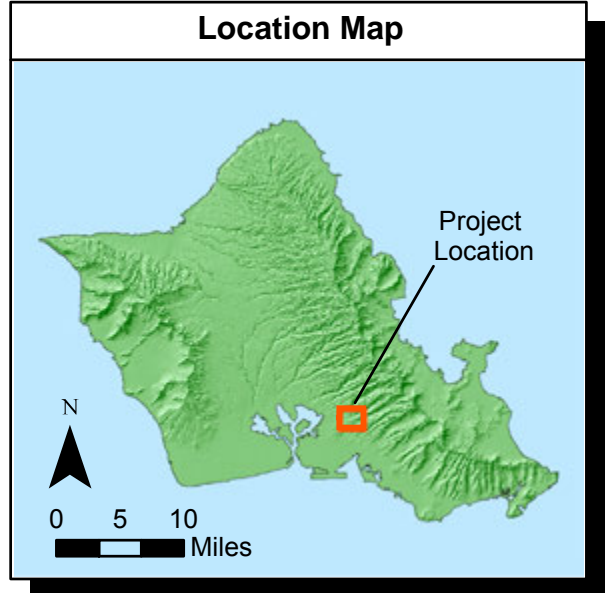
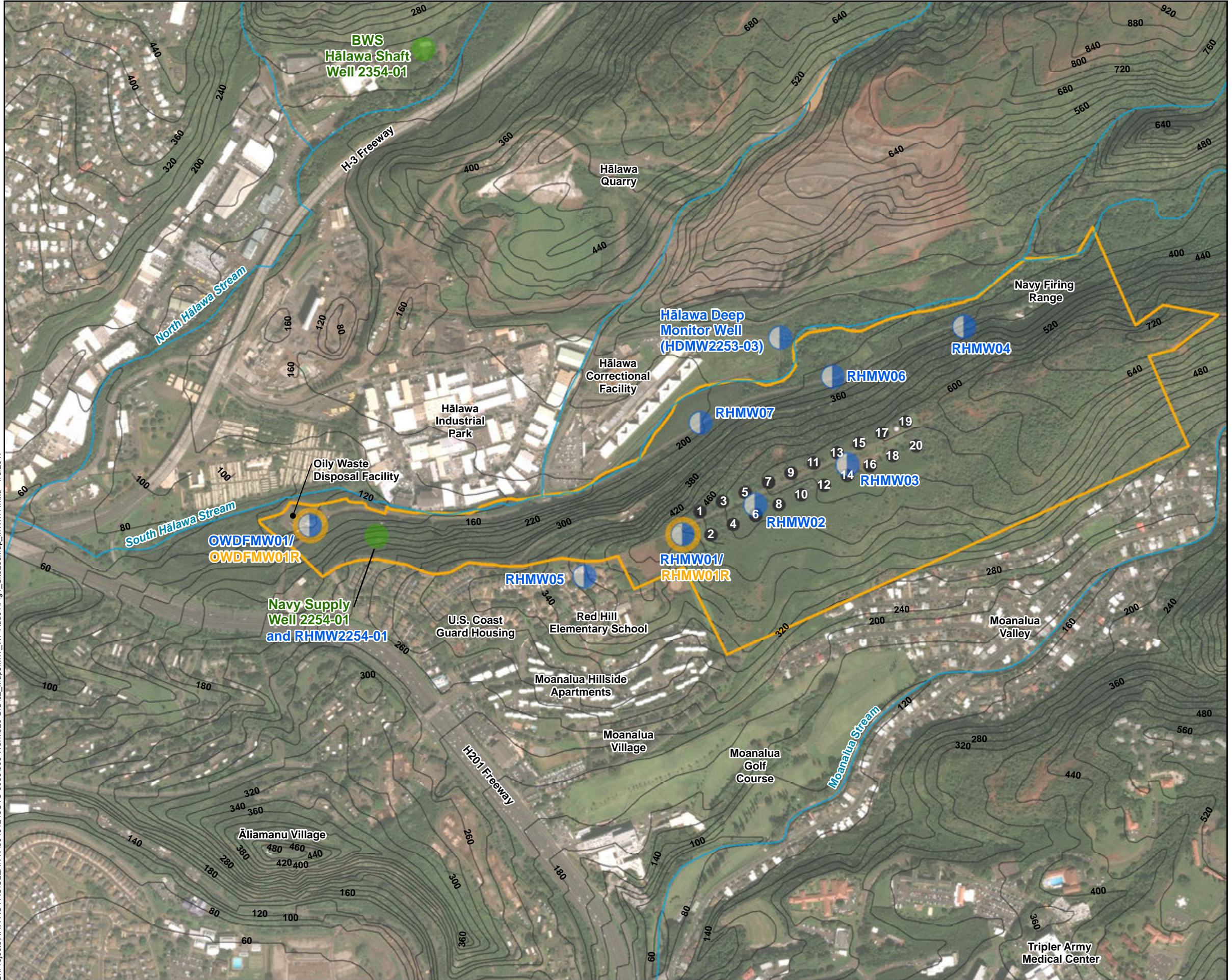
8 ^a Source: Department of the Navy. 2016. Final Third Quarter 2016 - Quarterly Groundwater Monitoring Reports for Inside
9 Tunnel and Outside Tunnel Wells. Prepared by Element Environmental, LLC for Naval Supply Systems Command
10 (October).11 ^b Source: DON 2007.12 ^c 1-inch Schedule 80 PVC may be installed if installation through 4-inch Schedule 80 PVC conductor casing is required, as
13 noted in Section 3.3.1.2.

14 If the water table surface occurs above the saturated portion of screen, then unrepresentative
15 assessments may be made of the potential presence of NAPL or concentrations of dissolved-phase
16 fuel constituents in groundwater at these locations.

17 Prior to drilling RHMW01R, a downhole video survey will be conducted to confirm that the entire
18 RHMW01 well screen is in fact saturated since well records indicate that the water table is
19 approximately 5 ft above the top of the slotted screen interval. If the downhole video confirms that
20 the water table is actually below the slotted screen interval, then replacement of RHMW01 will not
21 be required. Since well installation records indicate that the difference between the groundwater
22 surface and the slotted screen interval at OWDFMW01 is significantly greater and it is highly
23 unlikely that the slotted screen interval could intersect the groundwater surface, video confirmation
24 of OWDFMW01 will not be conducted.

25 If the entire screened interval at RHMW01 is saturated and is confirmed based on the video survey,
26 or if the survey is inconclusive, then both replacement wells (RHMW01R and OWDFMW01R) will
27 be installed. Replacement wells will be constructed with screened intervals fully spanning the
28 anticipated seasonal range of groundwater surface elevations. Based on groundwater elevation data
29 collected during quarterly groundwater monitoring, the maximum fluctuation was 2.45 ft at
30 RHMW01 since 2007 and 1.71 ft at OWDFMW01 since 2011. Consequently, more representative
31 data will be obtained from the replacement wells to achieve the objectives summarized in Table 2-2.

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Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015

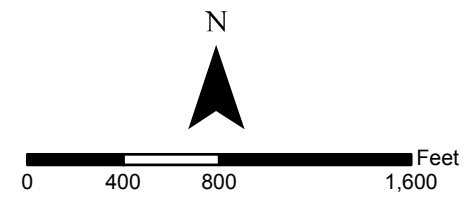


Figure 1
Site Location Map
Monitoring Well Installation
Work Plan Addendum 01
Red Hill Bulk Fuel Storage Facility
JBPBH, O'ahu, Hawai'i

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1 **Table 2-2: Proposed Well and Objectives Matrix**

Well ID	Objective 1: Sentinels	Objective 2: Characterize Flow	Objective 3: Characterize Chemistry	Objective 4: Characterize Matrix	Objective 5: Other Uses
RHMW01R	✓	✓	✓		✓
OWDFMW01R	✓	✓	✓	✓	✓

2 ID identification

3 Objectives:

- 4 1. *Sentinels* – Provide monitoring points between the Red Hill tanks or areas within the Facility boundaries where COPCs
5 have been detected in groundwater and receptors potentially exposed via the drinking water supply system.
- 6 2. *Characterize Flow* – Provide additional groundwater elevation data to evaluate groundwater flow patterns in the vicinity of
7 the Red Hill Facility and refine and calibrate the groundwater flow model.
- 8 3. *Characterize Groundwater Chemistry* – Provide water quality data and evaluate presence or absence of NAPL, COPC
9 concentrations and natural attenuation parameters.
- 10 4. *Characterize Matrix* – Further characterize the stratigraphy and properties of the valley fill, caprock, and saprolite layers.
- 11 5. *Other Uses* – Provide potential monitoring and access points for other activities, such as a tracer study or augmentation, if
12 warranted upon completion of other field activities.

13 **2.2 PROPOSED REPLACEMENT WELL DESIGN AND INSTALLATION PROCEDURES**

14 Several drilling technologies will be required to install the replacement wells. Proposed drilling
15 technologies include hollow-stem auger, wet rotary coring, and air rotary drilling. Based on
16 accessibility to the locations and existing borehole logs for RHMW01 and OWDFMW01
17 (Appendix A), the types of equipment used and subsurface conditions at each location will be
18 different. Sections 2.2.1 and 2.2.2 describe the design and installation methods anticipated for the
19 installation of RHMW01R and OWDFMW01R, respectively. Details regarding the procedures to be
20 followed during the installation of the replacement wells are presented in Section 3.

21 Due to the heterogeneous nature of the subsurface geology at the site, samples of unconsolidated
22 material and continuous core samples of the basalt bedrock will be collected to further characterize
23 subsurface conditions. If subsurface conditions or site characteristics differ from what is currently
24 understood, then alternative drilling approaches may be required.

25 Subsurface geotechnical samples of unconsolidated material will be collected if zones of
26 unconsolidated material or significant layers of clay or low-permeability zones are encountered in
27 the vadose zone. Additionally, if unconsolidated material is present at depths below the bottom of the
28 tanks (120 ft above mean sea level [msl]), or if any contaminated unconsolidated material is
29 observed in the vadose zone, then samples of subsurface unconsolidated material will be collected
30 for laboratory analysis of COPCs to provide additional data on the level of contamination present in
31 the area. Like the rock cores, the subsurface unconsolidated material samples will be inspected for
32 evidence of contamination (visual, olfactory, or elevated photoionization detector [PID] readings) in
33 order to characterize the lithology and evaluate the potential migration of NAPL and associated
34 constituents.

35 If perched water or evidence of contamination (i.e., visual, olfactory, or elevated PID readings) is
36 observed during drilling, then coring will be stopped after drilling past the perched water zone or
37 contaminated interval so that permanent conductor casing can be installed.

38 Although the DOH *Technical Guidance Manual for the Implementation of the Hawaii State*
39 *Contingency Plan* (TGM) (DOH 2016) generally recommends 10-ft well screens, previous
40 investigators have reported difficulties in accurately determining the groundwater depth during
41 drilling (prior to setting the wells), which likely resulted in existing wells RHMW01 and

1 OWDFMW01 being screened at elevations below the current groundwater surface elevation.
2 Therefore, 30-ft screens are recommended for the replacement wells to:

- 3 • Accommodate potentially large variations in water levels due both to natural forces (such as
4 seasonal variations and drought conditions) and induced forces (such as variable supply well
5 pumping rates that can impose variable drawdown conditions).
- 6 • Ensure that NAPL, if present, can accumulate within the well under these variable
7 conditions.
- 8 • Maintain consistency with other recently installed site monitoring wells (i.e., to sample from
9 comparable intervals).

10 The wells will be installed with approximately 20 ft of slotted screen below and 10 ft of slotted
11 screen above the water table surface; however, there may be additional variation required at
12 OWDFMW01 if the boring yields no apparent groundwater or volumes determined to be insufficient
13 for sampling within 20 ft below the groundwater surface.

14 After completion, the measuring point of each well will be surveyed using first order survey
15 techniques, as described in the Investigation WP/SOW (DON 2016c) and the forthcoming project
16 SAP.

17 **2.2.1 RHMW01R Design and Installation Procedures**

18 RHMW01R will be drilled in the vicinity (10–20 ft) of RHMW01, which is located inside the
19 lower-access tunnel.

20 Accessing the RHMW01R drilling location will require the use of a specialized compact electrically
21 operated (45 kW, 380V) diamond core drill designed to operate underground or similar drill rig to
22 accommodate the lower-access tunnel train transport requirements and limited overhead conditions.
23 This drill rig will initially be used to core through solid basalt rock, anticipated to be directly below
24 the tunnel concrete floor, using wet rotary drilling methods. Coring will be conducted to
25 approximately 106 ft beneath the tunnel floor surface.

26 If perched water or evidence of contamination is observed, then coring will be discontinued and
27 conductor casing will be installed to seal off the zone of perched water or contamination. The
28 conductor casing will be permanently grouted in place. After installation of the conductor casing,
29 continuous coring will resume through the conductor casing to approximately 106 ft beneath the
30 tunnel floor.

31 After rock coring is complete, the borehole will be reamed to a larger diameter for well installation
32 using rotary drilling techniques. Well installation will include either a 4-inch-diameter polyvinyl
33 chloride (PVC) well if no conductor casing is installed, or a 1-inch-diameter PVC well if it is
34 installed through 4-inch-diameter PVC conductor casing. The well will be completed with slotted
35 PVC screen. Coarse silica sand filter pack will be placed around the screen interval, and the well will
36 be sealed with a bentonite pellet seal followed by bentonite slurry and cement-bentonite grout. The
37 well will be completed as flush mount due to the limited access area within the tunnel to avoid
38 potential interference with Facility operations. Figure 2 shows the general proposed well
39 construction details for RHMW01R.

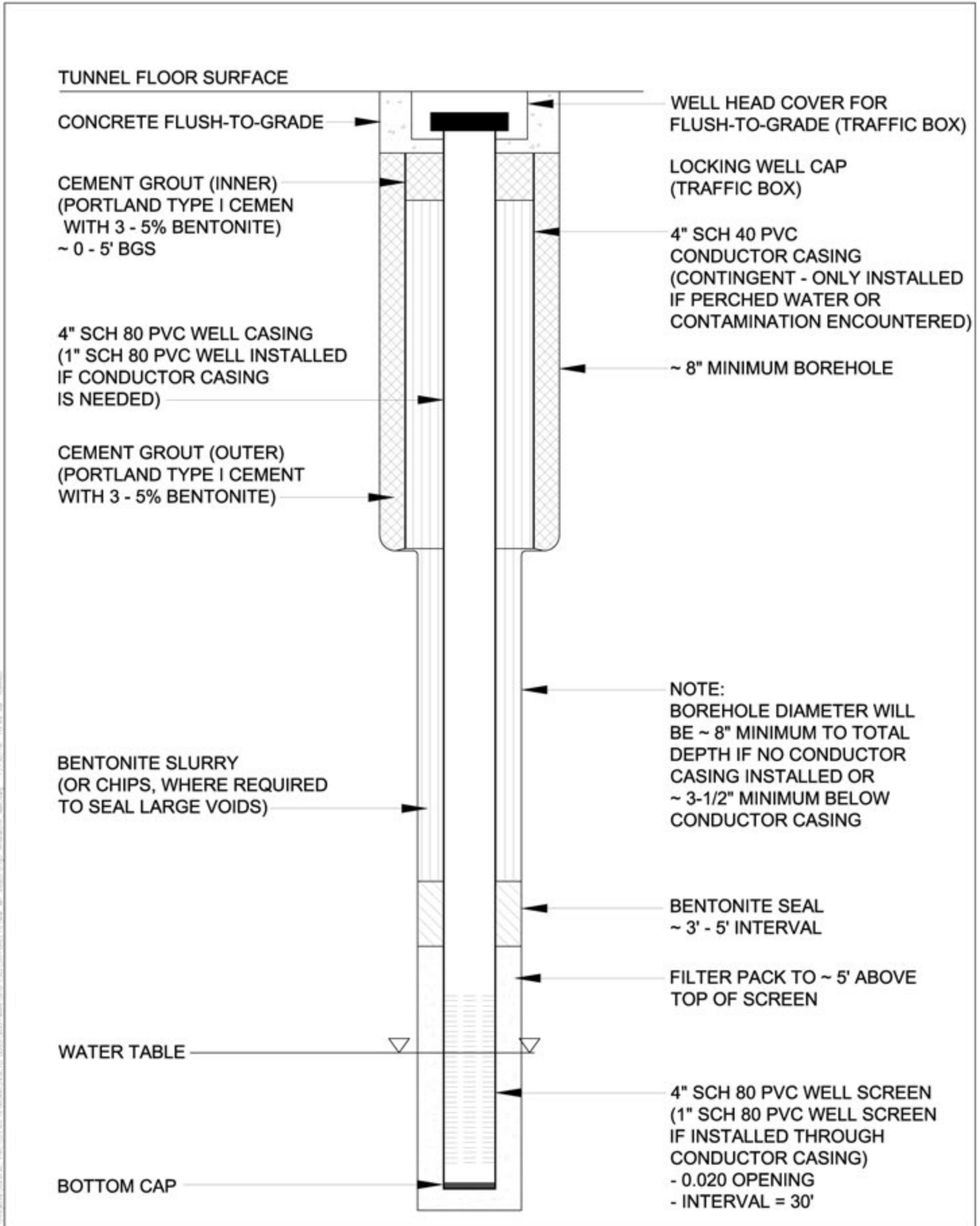


Figure 2
Cross Section of RHMW01R Monitoring Well
Monitoring Well Installation Work Plan Addendum 01
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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2.2.2 OWDFMW01R Design and Installation Procedures

During previous drilling activities at the OWDF, perched groundwater conditions were encountered and are associated with the presence of low-permeability volcanic tuff and unconsolidated layers (silt and clay). The occurrence of these low-permeability layers are localized, and they were not observed at all drilling locations across the site (DON 2000). During the installation of well OWDFMW01 (previously referred to as MW08), perched groundwater conditions were not observed; however, a low-permeability basalt interval was encountered at the depth where the water table was expected to occur (115 ft below ground surface [bgs]). Drilling continued to 138.5 ft bgs before groundwater was observed, and the groundwater level subsequently stabilized at approximately 122 ft bgs (DON 2000). It is proposed that OWDFMW01R be installed within 20 ft of OWDFMW01 to maintain consistency with the location where groundwater samples have been collected during previous sampling events. Figure 3 shows the general proposed well installation details for OWDFMW01R.

Based on existing information, it is anticipated that up to approximately 50 ft of unconsolidated material and layers of basalt or basalt boulders will be encountered at OWDFMW01R. If boulders or layers of basalt are encountered that result in hollow-stem auger refusal, then drilling techniques may be switched between hollow-stem auger and downhole hammer air rotary methods until competent bedrock is encountered. The borehole will be drilled to refusal or solid basalt bedrock using hollow-stem augers for the collection of soil samples for lithological characterization and chemical analyses if unconsolidated material is encountered below 100 ft msl or observed to be contaminated (i.e., visual, olfactory, or elevated PID readings).

If perched water or evidence of contamination (i.e., visual, olfactory, or elevated sustained PID readings above ambient background conditions) is observed during drilling (i.e., hollow-stem auger, air rotary, coring), then drilling will be stopped so that permanent conductor casing can be installed to seal off the perched water or contaminated interval. The conductor casing will be permanently grouted in place.

Solid basalt bedrock will be continuously cored using wet rotary drilling techniques. After rock coring is complete, the borehole will be reamed to a larger diameter using air rotary drilling techniques for well installation. The well will be installed as a 4-inch-diameter PVC well and completed with 30 ft of slotted PVC screen placed across the groundwater surface. A coarse silica sand filter pack will be placed around the slotted screen interval, and the well will be sealed with a bentonite pellet seal, bentonite slurry and cement-bentonite grout. The well will be completed as an aboveground well with a protective steel cover.

3. Field Project Implementation

3.1 PROJECT PROCEDURES

All drilling, monitoring well installation, and other field activities will be conducted in accordance with the DOH TGM (DOH 2016) and the standard operating procedures (SOPs) summarized in Table 3-1, which are from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, Naval Facilities Engineering Command [NAVFAC], Pacific* (DON 2015). These SOPs are presented in Appendix A of the MWIWP (DON 2016b). Additionally, Appendix B of the MWIWP presents the project organizational chart and communication pathways that will be maintained in order to ensure proper oversight and communication throughout all planned field activities. A Health and Safety Plan has been prepared under separate cover to address potential health and safety concerns that may arise during field work (DON 2016a).

1 **Table 3-1: Field SOPs Reference Table**

Reference Number	Title, Revision Date and/or Number ^a	Originating Organization of Sampling SOP	Equipment Type
I-A-5	<i>Utility Clearance</i>	NAVFAC Pacific	Geophysical equipment (electromagnetic, magnetic, and ground-penetrating radar)
I-A-6	<i>Investigation Derived Waste Management</i>	NAVFAC Pacific	N/A
I-A-8	<i>Sample Naming</i>	NAVFAC Pacific	N/A
I-B-1	<i>Soil Sampling</i>	NAVFAC Pacific	Split-spoon sampler and liners with hollow-stem or solid-stem auger
I-B-2	<i>Geophysical Testing</i>	NAVFAC Pacific	Low frequency electromagnetic induction, magnetometers, and ground-penetrating radar
I-C-1	<i>Monitoring Well Installation and Abandonment</i>	NAVFAC Pacific	Continuous coring drill rig
I-C-2	<i>Monitoring Well Development</i>	NAVFAC Pacific	Surge block or submersible pump
I-D-1	<i>Drum Sampling</i>	NAVFAC Pacific	COLIWASA or glass thieving tubes
I-E	<i>Soil and Rock Classification</i>	NAVFAC Pacific	N/A
I-F	<i>Equipment Decontamination</i>	NAVFAC Pacific	N/A
I-I	<i>Land Surveying</i>	NAVFAC Pacific	Theodolite - horizontal and vertical control; GPS
III-A	<i>Laboratory QC Samples (Water, Soil)</i>	NAVFAC Pacific	N/A
III-B	<i>Field QC Samples (Water, Soil)</i>	NAVFAC Pacific	N/A
III-D	<i>Logbooks</i>	NAVFAC Pacific	N/A
III-E	<i>Record Keeping, Sample Labeling, and Chain of Custody</i>	NAVFAC Pacific	N/A
III-F	<i>Sample Handling, Storage and Shipping</i>	NAVFAC Pacific	N/A

2 COLIWASA composite liquid waste sampler
 3 GPS Global Positioning System
 4 N/A not applicable
 5 QC quality control
 6 ^a Applicable procedures from the *Project Procedures Manual* (DON 2015).

7 **3.2 SITE SURVEYS AND PREPARATION**

8 **3.2.1 Video Inspection of Existing Well RHMW01**

9 Well RHMW01 is constructed as a 1-inch-diameter PVC well, and the groundwater surface at this
 10 location is presumed to be approximately 5 ft above the slotted portion of screen, based on available
 11 well records. The objective of videoing RHMW01 is to visually confirm the location of the slotted
 12 screen relative to the groundwater surface. A downhole camera will be deployed in the well to
 13 visually record and document the groundwater surface and well construction. The video recorder will
 14 log the depth as the inside of the well is photographed, and the camera will be run to the bottom of
 15 the well to document the total depth of the well and ensure the depths recorded are accurate. The
 16 video will be downloaded on mp4 or similar file format so that it can be viewed on computer after
 17 filming is complete.

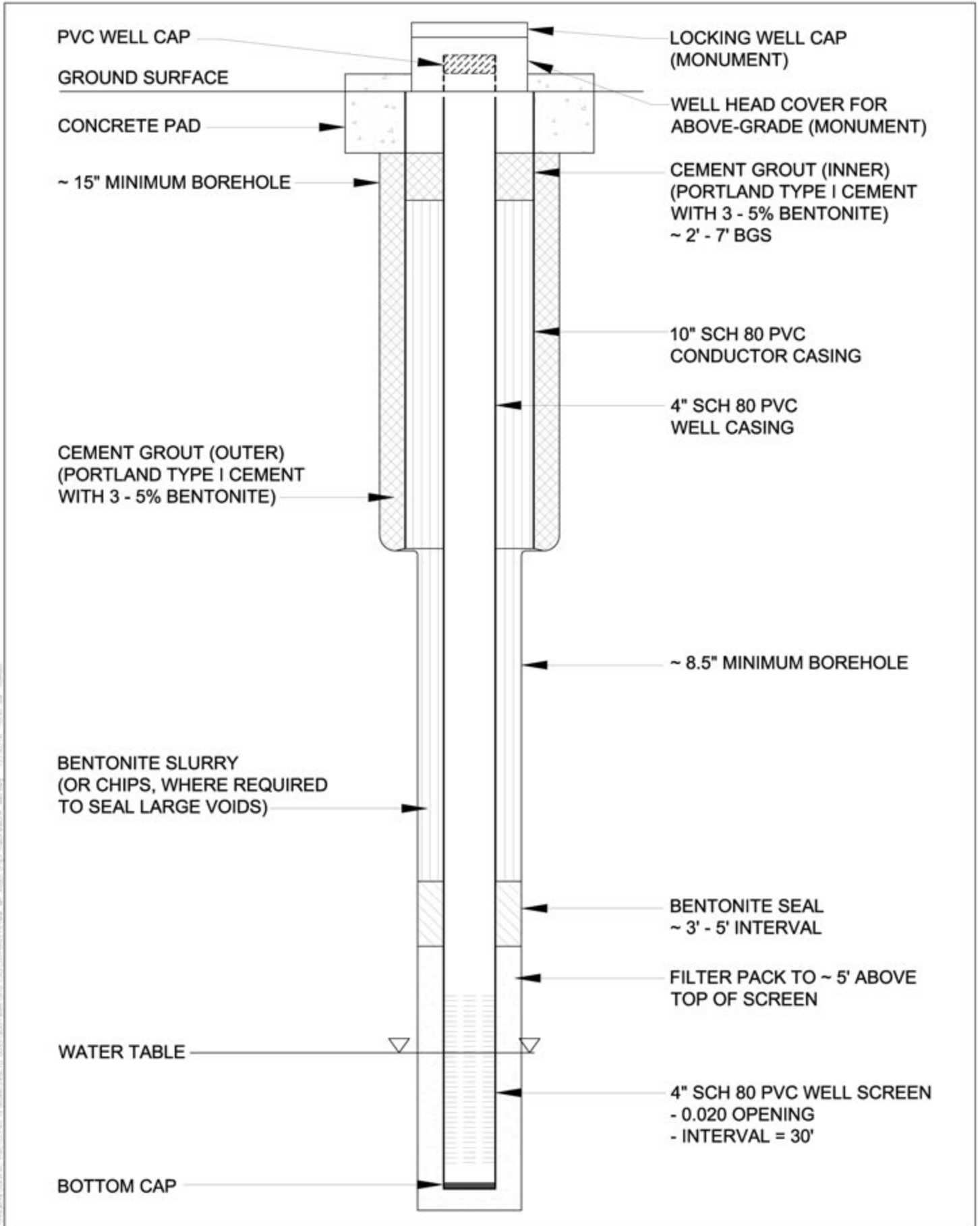


Figure 3
Cross Section of OWDFMW01R Monitoring Well
Monitoring Well Installation Work Plan Addendum 01
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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1 **3.2.2 Site Preparation**

2 Existing monitoring wells RHMW01 and OWDFMW01 will be located by the field team, and
3 proposed monitoring well reinstallation locations will be marked with white paint and/or wooden
4 stakes. The replacement wells will be placed approximately 20 ft away from RHMW01 and
5 OWDFMW01; however, if the locations need to be adjusted due to unanticipated conditions, they
6 will be located no closer than 10 ft to the existing monitoring wells to avoid interferences during
7 installation. Site preparation will include cutting or coring of concrete, as required to facilitate
8 drilling and well completion. Each borehole location will be marked once the area is cleared and the
9 staging area is established.

10 **3.2.3 Utility Clearance**

11 Utility clearance procedures are presented in the MWIWP (DON 2016b).

12 **3.2.4 Drill Rig Access**

13 Proposed monitoring well RHMW01R will require drill rig and associated equipment/materials
14 access via the lower-access tunnel train system. Proposed monitoring well OWDFMW01R is located
15 outside of the tunnels and will be accessed by a standard truck-mounted drill rig.

16 **3.3 DRILLING AND WELL INSTALLATION**

17 Solid basalt bedrock is anticipated to be encountered at shallow depths at proposed well locations
18 RHMW01R and OWDFMW01R (i.e., directly below surface and 50 ft bgs, respectively).
19 Anticipated drilling activities include:

- 20 • Hollow-stem auger drilling through soil overburden at OWDFMW01R
- 21 • Rock coring using wet rotary wireline methods at RHMW01R and OWDFMW01R
- 22 • Air rotary drilling to increase borehole diameter for well installation at RHMW01R and
23 OWDFMW01R

24 All onsite activities must be coordinated with the Navy contract task order (CTO) contracting
25 officer's representative (COR) to ensure that all requirements such as obtaining site access, working
26 hours, use/accessing potable water supply sources, and other requirements are understood and
27 followed. Prior to any drilling, a hand auger or other hand tool will be used if there is overburden
28 present at the drilling location to manually advance the borehole to 5 ft bgs to ensure the location is
29 cleared of utilities.

30 The drill rig will be leveled at least twice a day to prevent potential borehole deviation. In addition,
31 the well borings will initially be cored, which will help ensure that the initial borings are straight.
32 After coring, the borehole will be reamed to a larger diameter, during which a pilot bit will be used
33 below the primary bit to ensure that the boring follows and is centered over the core hole. After the
34 well construction is completed, a quantitative true vertical depth analysis using a gyroscopic
35 alignment instrument will be performed so appropriate corrections can be made to wireline-measured
36 depth to water. The gyroscopic alignment will be conducted on all wells within the Red Hill
37 groundwater monitoring program; details regarding the procedures to be followed will be presented
38 in the forthcoming project SAP (see DON 2016c).

39 Perched water or evidence of contamination (i.e., visual, olfactory, or elevated PID readings) may be
40 encountered in the vadose zone. To facilitate identification of perched groundwater or subsurface
41 contamination, the borehole will be checked for standing water using an interface probe at least four

1 times a day during drilling. Measurements will be made at least at the beginning and end of each
2 shift (i.e., twice before and twice after lunch), but also more frequently based on the presence of
3 features that may suggest perched water (e.g., porous zones [e.g., saturated soil cuttings, sand,
4 gravel, or clinker zones] overlying lower permeability zones [i.e., silt, clay, low-porosity basalt
5 layer]) based on visual observation. A bailer and an oil/water interface probe will also be used to
6 check for the presence of a sheen or NAPL at the same frequency as water level measurements are
7 made. Additionally, the presence of contamination may be indicated by staining on drill cuttings and
8 recovered rock cores and by sustained PID readings above ambient background conditions. This
9 information will be recorded in the project field book.

10 Sounding tubes are not proposed for installation at either replacement well location. Well diameters
11 have been selected that will allow the installation of equipment for well gauging and sampling.
12 However, if conductor casing is required for RHMW01R, then a smaller-diameter well will be
13 installed that may require dedicated sampling equipment be removed to allow for well gauging or
14 other activities. Details regarding the installation of replacement wells RHMW01R and
15 OWDFMW01R are presented in Sections 3.3.1 and 3.3.2, respectively.

16 **3.3.1 RHMW01R Drilling and Well Installation Procedures**

17 **3.3.1.1 RHMW01R DRILLING**

18 Drilling will be conducted in accordance with Procedure I-C-1, *Monitoring Well Installation and*
19 *Abandonment* (DON 2015). Drilling at RHMW01R will be conducted using an electrically operated
20 drill rig equipped with rock coring and wet rotary drilling capabilities. Solid basalt bedrock is
21 anticipated to be encountered directly below the lower-access tunnel floor. Coring will be conducted
22 once competent bedrock is encountered as described in Section 3.3.3.

23 Checks for perched water or evidence of contamination will be made as described in the introductory
24 portion of Section 3.3. If perched water or evidence of contamination is observed, then
25 4-inch-diameter Schedule 40 PVC conductor casing will be installed as described in Section 3.3.4. If
26 perched water or evidence of contamination is not observed, coring will be conducted until the target
27 depth (approximately 106 ft bgs) is reached. After rock coring is complete, the borehole will be
28 reamed to total depth with a conventional, rotary drilling rig to increase the borehole diameter to a
29 minimum of 8 inches (Figure 2). Clean, potable water (and environmentally safe drilling foam, only
30 if pre-approved by the Navy) and bentonite drilling mud will be injected as needed during drilling to
31 mitigate dust, lubricate downhole tools, stabilize the borehole and remove cuttings from the
32 borehole. Attempts will be made to limit fluids injected during drilling, but the amount of fluid used
33 will be dependent on the porosity of the formation being drilled. Prior to use, potable water for
34 drilling will be sampled and analyzed for COPCs as described in the MWIWP (DON 2016b) and
35 Section 4 of this Addendum). Cuttings removed from the boreholes will be collected in 55-gallon
36 drums. Use of wet rotary drilling methods and injection of water during drilling will significantly
37 reduce the generation of dust during drilling.

38 **3.3.1.2 RHMW01R MONITORING WELL INSTALLATION**

39 After the borehole has been reamed with the air rotary drilling equipment, the monitoring well will
40 be installed in accordance with Procedures I-C-1, *Monitoring Well Installation and Abandonment*
41 and I-C-2 *Monitoring Well Development* (DON 2015). Groundwater in the basal aquifer is expected
42 to be encountered at approximately 15–20 ft msl. Within the borehole, 4-inch-diameter, Schedule 80
43 PVC-casing with 30 ft of 0.02-inch slotted screen will be constructed (Figure 2). However, if a
44 4-inch-diameter Schedule 40 PVC conductor casing is required, then a 1-inch-diameter Schedule 80
45 PVC monitoring well will be installed inside the conductor casing. The well will be screened within

1 the basal aquifer approximately 10 ft above and 20 ft below the groundwater surface. The estimated
2 total depth for RHMW01R is approximately 106 ft below the tunnel floor.

3 To ensure that the well casing is centered in the borehole, centralizers will be installed at the top and
4 bottom of screened sections and also placed at 40-ft intervals on blank well casing. The centralizers
5 will be aligned from top to bottom of the casing so that they do not interfere with the insertion and
6 removal of the tremie pipe. All devices used to affix centralizers to the casing will not puncture the
7 casing or contaminate the groundwater with which they come in contact. Centralizers will be
8 constructed of stainless steel. To ensure even distribution of filter pack, bentonite seal, and grout
9 materials around the well within the borehole, the well casing and screen will be suspended with a
10 threaded hoisting plug and not allowed to rest on the bottom of the borehole.

11 Coarse #3 Monterey silica sand will be emplaced via tremie pipe into the borehole annulus to
12 approximately 5 ft above the slotted well screen, followed by a 3- to 5-ft thick bentonite pellet seal,
13 then wet bentonite grout slurry (e.g., Wyo-Ben Enviroplug Grout) to within 5 ft of the ground
14 surface. If large voids are encountered, then bentonite chips may be required to seal the voids. The
15 proposed well construction details for RHMW01R are shown on Figure 2. The bentonite slurry (or
16 chips, where required) will be slowly emplaced via tremie pipe to ensure proper filling of the annulus
17 and to avoid bridging. The slurry will be placed to within approximately 7 ft of the tunnel floor. Dry
18 bentonite chips, where used, will be tremied and hydrated with clean, potable water using at least
19 5 gallons of water per 50-pound bag of chips. The remaining annular space from approximately 7 to
20 2 ft bgs will be finished by grouting with cement bentonite grout. Well construction diagrams will be
21 provided on the geologic logs.

22 Because the rock formation is not pressured, blowouts are not anticipated to occur. However, as
23 described above, voids are anticipated to be encountered and need to be taken into consideration
24 during well installation. In the event that voids or blowouts are encountered, bentonite chips will be
25 emplaced down hole to close out or plug the void.

26 3.3.1.3 RHMW01R MONITORING WELL SURFACE COMPLETION

27 The monitoring well will be completed in accordance with Procedure I-C-1, *Monitoring Well*
28 *Installation and Abandonment*. Monitoring well RHMW01R will be completed flush-mount to avoid
29 obstructing any portion of the lower-access tunnel. The flush-mount surface completion will consist
30 of a 12-inch-diameter, circular steel skirt or rectangular utility-type box with a gasket to prevent
31 leaks and traffic-rated locking lid over the recessed well. The circular skirt or box would be set in
32 concrete flush with the grade surface of the tunnel to provide strength and a watertight surface seal.

33 3.3.2 OWDFMW01R Drilling and Well Installation Procedures

34 3.3.2.1 OWDFMW01R DRILLING

35 The drilling approach for monitoring well OWDFMW01R will be consistent with the methodologies
36 presented in the MWIWP (DON 2016b), including the use of hollow-stem auger drilling to advance
37 through overburden (estimated to be up to approximately 50 ft thick) and down-hole hammer air
38 rotary methods within the underlying rock. However, drilling techniques may be switched between
39 hollow-stem auger and downhole hammer air rotary methods if alternating sequences of soil and
40 rock are encountered.

41 OWDFMW01R will be drilled using a truck-mounted drill rig equipped with hollow-stem augering,
42 rock coring, and air rotary capabilities in accordance with Procedure I-C-1, *Monitoring Well*
43 *Installation and Abandonment* (DON 2015). The borehole will initially be advanced to refusal using

1 a minimum 4¼-inch-inner-diameter hollow-stem augers that can be used as a temporary surface
2 casing during rock coring activities. Characterization samples of unconsolidated material will be
3 collected at 5-ft intervals beginning at 10 ft bgs with 1.5-ft-long, 2-inch-diameter split spoons.
4 A split-spoon will be used to collect unconsolidated material samples after retracting the hammer
5 and running the sampler in the open hole. It is possible that basalt cobbles and boulders will be
6 encountered, making recovery difficult for characterization sampling of unconsolidated material (i.e.,
7 poor recovery) or resulting in refusal, in which case an air hammer may be used to advance the
8 borehole.

9 Checks for perched water or evidence of contamination will be made as described in the introductory
10 portion of Section 3.3. If perched water or evidence of contamination is observed, then conductor
11 casing will be installed as described in Section 3.3.4.

12 Coring will be conducted until the target depth (147 ft bgs) is reached; however, coring may extend
13 beyond the target depth until a fractured or porous interval that yields sufficient quantities of water
14 for the collection of a groundwater sample. After rock coring is complete, the borehole will be
15 reamed to total depth with a conventional, open-hole air rotary drilling rig to increase the borehole
16 diameter to a minimum of 8.5 inches (Figure 3). Clean, potable water (and environmentally safe
17 drilling foam, only if pre-approved by the Navy) and bentonite drilling mud will be injected during
18 drilling to mitigate dust, lubricate downhole tools, stabilize the borehole and remove cuttings from
19 the borehole. Attempts will be made to limit fluids injected during drilling, but the amount of fluid
20 used will be dependent on the porosity of the formation being drilled. Prior to use, potable water for
21 drilling will be sampled and analyzed for COPCs as described in the MWIWP (as noted in
22 Section 3.3.8 of this Addendum). Cuttings removed from the boreholes will be collected in 55-gallon
23 drums or a rolloff container equipped with air stacks to reduce dust.

24 3.3.2.2 OWDFMW01R MONITORING WELL INSTALLATION

25 After the borehole has been reamed with the air rotary drilling equipment, the monitoring well will
26 be installed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment*.
27 Based on the installation history of the original OWDFMW01, care will be taken to allow the water
28 level in the borehole the time to stabilize before installation. Groundwater in the basal aquifer is
29 expected to be encountered at approximately 15–20 ft msl. Within the borehole, a 4-inch-diameter,
30 Schedule 80 PVC-cased monitoring well with 30 ft of 0.02-inch slotted screens will be constructed
31 (Figure 3). The well will be screened within the basal aquifer approximately 5-10 ft above and
32 20-25 ft below the groundwater surface. The estimated total depth OWDFMW01R is 147 ft bgs;
33 however, the depth may be extended if groundwater is not encountered within 5 ft of the proposed
34 target depth.

35 To ensure that the 4-inch-diameter well casing is centered in the borehole, centralizers will be
36 installed at the top and bottom of screened sections and also placed at 40-ft intervals on blank well
37 casing. The centralizers will be aligned from top to bottom of the casing so that they do not interfere
38 with the insertion and removal of the tremie pipe. All devices used to affix centralizers to the casing
39 will not puncture the casing or contaminate the groundwater with which they come in contact.
40 Centralizers will be constructed of stainless steel. To ensure even distribution of filter pack,
41 bentonite seal, and grout materials around the well within the borehole, the 4-inch-diameter well
42 casing and screen will be suspended with a threaded hoisting plug and not allowed to rest on the
43 bottom of the borehole. Coarse #3 Monterey silica sand will be emplaced via tremie pipe into the
44 borehole annulus to approximately 5 ft above the well screen, followed by a 3- to 5-ft thick bentonite
45 pellet seal, then wet bentonite grout slurry (i.e., Wyo-Ben Enviroplug Grout) to within approximately
46 7 ft of the ground surface. If large voids are encountered, then bentonite chips may be required to

1 seal the voids. The proposed well construction details for OWDFMW01R are shown on Figure 3.
2 The bentonite grout slurry (or chips, where required) will be slowly emplaced via tremie pipe to
3 ensure proper filling of the annulus and to avoid bridging. Dry bentonite chips, where used, will be
4 tremied and hydrated with clean, potable water using at least 5 gallons of water per 50-pound bag of
5 chips. The remaining annular space from approximately 7 to 2 ft bgs will be finished by grouting
6 with cement bentonite grout. Well construction diagrams will be provided on the geologic logs.

7 Because the rock formation is not pressured, blowouts are not anticipated to occur. However, as
8 described above, voids are anticipated to be encountered and need to be taken into consideration
9 during well installation. In the event that voids or blowouts are encountered, bentonite chips will be
10 emplaced down hole to close out or plug the void.

11 3.3.2.3 OWDFMW01R MONITORING WELL SURFACE COMPLETION

12 The monitoring well will be completed in accordance with Procedure I-C-1, *Monitoring Well*
13 *Installation and Abandonment* (DON 2015). Monitoring well OWDFMW01R will be completed
14 above ground with an 8-inch-diameter steel protective casing fitted with a locking, tamper-proof lid
15 that covers the protective casing and well head. The lock will be recessed and covered for added
16 protection, and permanent labels will be applied both inside and outside of the casing via painting,
17 marking, or engraving on the protective casing or surface completion. The steel casing will be set in
18 concrete at the well head for strength, security, and to provide a surface seal. A 3.5-ft by 3.5-ft
19 square concrete pad, 2 ft thick, will be installed around the protective steel casing. The minimum
20 stickup height of the steel casing will be 3 ft. Approximately 1 ft of the concrete pad will extend
21 above the ground surface. The protective steel casing will extend above the well casings so that there
22 is approximately 6 inches of clearance between the well head and locking lid. Coarse sand will be
23 poured into the space between the well and protective casing to a level of approximately 6 inches
24 below the well head. Four steel bollards will be placed slightly beyond each corner of the concrete
25 pads. The bollards will extend approximately 2 ft bgs and approximately 3 ft above ground surface,
26 and each will be individually set in concrete. The bollards and protective steel casing will be painted
27 bright yellow for high visibility.

28 3.3.3 Rock Coring

29 In bedrock, subsurface material will be continuously sampled using wet rotary wireline coring to
30 record the lithologic characteristics and sample description of the subsurface material during the
31 drilling of the wells in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Continuous
32 rock cores will be collected as the monitoring well boreholes are advanced through the basaltic
33 bedrock. Rock coring will commence when the borings reach competent bedrock, which is
34 anticipated to occur just beneath the lower-tunnel access concrete floor at RHMW01R and at
35 approximately 50 ft bgs at OWDFMW01R. All drilling in rock will be accomplished by diamond
36 core drilling methods in general accordance with ASTM D2113 (ASTM 2014).

37 The drill rig will be equipped with 5-ft-long, 3.78-inch outer diameter (OD) core barrels (yielding a
38 2.5-inch-diameter rock core [HQ bit size]), and the cores will be recovered with a wireline and
39 quad-latch retrieval system. A 4.83-inch-OD core barrel (yielding a 3.35-inch-diameter rock core
40 [PQ bit size]) may also be used, depending on site conditions. Borings may intersect fault zones
41 where poor rock or difficult drilling conditions may be encountered. All reasonable measures to
42 maximize core recovery will be taken, including timely replacement of worn equipment such as drill
43 bits or core sleeves before wear-induced loss of recovery occurs, and changes in type of drill bit, rate
44 of feed, down-pressure on the drill bit, volume of cooling water, length of coring interval, or type of
45 coring equipment. Grinding of the core after a core barrel has become blocked will not be permitted.

1 A blocked core barrel will be pulled regardless of the interval drilled. Clean water will be brought in
2 from an offsite potable water source for use as circulation fluid during rock coring and drilling.

3 Checks will be made to identify the presence of perched groundwater or contaminated
4 unconsolidated material while drilling as described in the introductory portion of Section 3.3. If
5 perched groundwater conditions or zones of contamination are identified, then permanent conductor
6 casing will be installed as described in Section 3.3.4. If additional intervals of unconsolidated
7 material or groundwater contamination are observed after permanent conductor casing has been
8 installed, then the borehole will be abandoned as described in the MWIWP (as noted in Section 3.3.5
9 of this Addendum), and a new boring will be advanced with permanent conductor casing set below
10 the depth of the deepest contamination encountered and in a low-permeability zone (e.g., clay, silt, or
11 low-porosity basalt layer) based on visual observation of unconsolidated material samples or rock
12 core.

13 The cores will be inspected and logged to characterize the lithology and evaluate potential pathways
14 for migration of NAPL and associated constituents. A summary rock core chart will be used in the
15 field to log the information. In general, each log will note rock-quality designation; rock color;
16 texture; strength; degree and orientation of fracturing; shape, size and volume of voids; weathering;
17 and secondary staining or mineralization. Additionally, details of basalt flow and intraflow structures
18 (e.g., a'ā clinker flow-top breccias [clinker sub-types], accretionary lava clasts, simple vesicular flow
19 tops, vesicular flow lobes, inflated pāhoehoe lobes, spatter deposits, lava tubes, a'ā columnar dense
20 core interiors, a'ā clinker flow-bottom breccias, normal flow bottoms, and flow levees) will be
21 included in logging of the core. Fracture types (i.e., the difference between tectonic fractures,
22 primary cooling joints, and drilling-induced fractures) will also be noted. High-resolution
23 photographs will be taken to photodocument the cores, and detailed photo logs will be prepared. The
24 Geological Society of America rock color chart with Munsell color chips will be used for color
25 characterization (Munsell 2009). Lithologic descriptions, photoionization detector screening results,
26 and other observations will be recorded on the geologic logs in conformance with Procedure I-E, *Soil
27 and Rock Classification* (DON 2015). Discrete subsurface unconsolidated material sampling is
28 described in Section 3.3.9.

29 Cores will be stored in a secure on-island location so that they are available for inspection until the
30 work conducted under AOC Sections 6 and 7 is complete. Storage required beyond the completion
31 of AOC Sections 6 and 7 will be evaluated by the Navy.

32 **3.3.4 Conductor Casing**

33 To minimize the potential for perched water or contaminated media to migrate downward and impact
34 the basal aquifer, which is a drinking water source, conductor casing will be installed if zones of
35 perched water or contamination are identified. The purpose of the conductor casing is to isolate
36 zones of perched water or contaminated media to prevent cross contamination between the perched
37 groundwater/contaminated media and the basal aquifer. The conductor casing will be centered within
38 the borehole using stainless steel centralizers spaced at approximately 40-ft intervals. The
39 centralizers will be aligned so that they do not interfere with the insertion and removal of the tremie
40 pipe, if necessary. The annular space to be grouted will be a minimum of 1.5 inches beyond the
41 casing. The conductor casing will be pressure-grouted in place as soon as possible after installation
42 using a packer assembly and tremie pipe installed inside of the conductor casing that will allow the
43 grout to be pumped through the packer assembly until it rises to the ground surface around the
44 casing, or with tremie placed in the annular space around the casing. The annulus will be sounded to
45 check for settling of the grout within 24 hours of placement. Following the grouting procedure, the

1 grout will be left undisturbed for a minimum of 24 hours for curing. Drilling activities will then be
 2 resumed until the target depth is reached.

3 If permanent casing is installed and a second layer with evidence of contamination (i.e., visual,
 4 olfactory, sustained PID readings above ambient background conditions, or staining on drill cuttings
 5 and recovered rock cores) is encountered, the boring will be abandoned by grouting as described in
 6 the MWIWP (as noted in Section 3.3.5 of this Addendum). A new boring will then be advanced so
 7 that multiple contaminated zones can be cased off. At OWDFMW01R, a larger-diameter boring
 8 could be advanced that can accommodate the installation of multiple casings with a minimum 2-inch
 9 annular space.

10 **3.3.5 Borehole Abandonment**

11 Borehole abandonment procedures are presented in the MWIWP (DON 2016b).

12 **3.3.6 Monitoring Well Development**

13 Monitoring well development procedures are presented in the MWIWP (DON 2016b).

14 **3.3.7 Dedicated Groundwater Pump System Installation**

15 Groundwater pump system installation procedures are presented in the MWIWP (DON 2016b).

16 **3.3.8 Potable Water Sampling**

17 Potable water sampling procedures are presented in the MWIWP (DON 2016b).

18 **3.3.9 Subsurface Unconsolidated Material Sampling**

19 The samples of subsurface unconsolidated material (i.e., soil or any material of small grain size,
 20 including coarse-grained sand or smaller grain size, such as clay, sands, and clinker zone sand) will
 21 be inspected for evidence of contamination (visual, olfactory, or elevated PID readings) in order to
 22 evaluate the potential migration of NAPL and associated constituents. The collection of subsurface
 23 material for laboratory analysis will be conducted in accordance with Procedure I-B-1 *Soil Sampling*,
 24 and samples will be handled in accordance with Procedure III-F, *Sample Handling, Storage, and*
 25 *Shipping* (DON 2015). If unconsolidated material is present at depths lower than the elevation of the
 26 tank bottoms, or if contaminated unconsolidated material is encountered at any depth in the
 27 subsurface, discrete samples will be collected for laboratory analysis of COPCs to provide additional
 28 data on the level of contamination present in the area. Should unconsolidated material be sampled,
 29 field quality control (QC) samples will also be collected in accordance with Table 3-2.

30 **Table 3-2: Field Quality Control Samples**

QC Sample	Analytical Group ^a	Frequency ^b	DQI	Measurement Performance Criteria
Field duplicate	All	10% of primary samples collected per matrix per analytical method	Precision	RPD ≤100% unconsolidated material (judgmental) ^c
Field blank	All	Once per source of decontamination water per sampling event	Adequacy of the decontamination water quality	≤1/2 of LOQ
Equipment rinsate	All	5% of primary samples collected per matrix per analytical method	Adequacy of the decontamination process	≤1/2 of LOQ

QC Sample	Analytical Group ^a	Frequency ^b	DQI	Measurement Performance Criteria
Trip blank	VOCs, TPH-g (soil/unconsolidated material)	One per cooler	Contamination during sample transport	≤2 of LOQ

1 % percent
2 DQI data quality indicator
3 LOQ limit of quantitation
4 RPD relative percent difference
5 TPH-g total petroleum hydrocarbons – gasoline range organics
6 VOC volatile organic compound

7 ^a Refer to Section 5.2 of the MWIWP for a list of all analytical groups.

8 ^b Per *Project Procedures Manual*, Procedure III-B, *Field QC Samples* (DON 2015).

9 ^c Per *Project Procedures Manual*, Procedure II-A, *Data Validation* (DON 2015).

10 Unconsolidated material will be collected from split-spoon samplers prior to encountering solid
11 basalt or from core barrels thereafter. Using the discrete sampling approach, approximately
12 100 grams of unconsolidated material for non-volatile-organic-compound (VOC) analyses will be
13 collected using disposable scoops or spoons and placed in appropriate containers for each subsurface
14 unconsolidated material sample as specified in Section 4. Material collected for VOC analysis will
15 be collected using 5-gram plugs using EnCore, Terra Core, or equivalent samplers. To minimize
16 VOC loss during the sampling effort, the VOC sample plugs will be collected as quickly as possible
17 and placed in laboratory-supplied water- and methanol-preserved containers.

18 All sample containers will be labeled with the sampling location, date and time of collection, and
19 unique sample identifier as discussed in Section 4.1, and recorded in the field logbook. Sample
20 containers will be placed in re-sealable plastic zip bags, kept in coolers containing wet ice, and
21 preserved in accordance with analytical method requirements and as specified in Section 4. Samples
22 will be shipped to the analytical laboratory via overnight airfreight.

23 3.4 SURVEYING

24 Groundwater flow conditions have been evaluated within and around the Facility; however, there
25 remains uncertainty in the magnitude and directions of hydraulic gradients. The uncertainties
26 primarily result from inconsistencies and potential errors with survey data and the potential for
27 measurement error if the monitoring wells are not truly vertical. All wells in the groundwater
28 monitoring network will be resurveyed and their vertical alignment will be checked to see if
29 corrections need to be made to account for any significant deviation.

30 Accurate surveyed top-of-casing (TOC) elevations tied into the same datum as surrounding wells
31 will be necessary to establish accurate groundwater elevations and estimate groundwater flow
32 directions. A first order survey will be conducted to determine northing and easting coordinates
33 referenced to the Hawai'i State Plane Zone 3, North American Datum (NAD) 83 (ft) coordinate
34 system, and ground surface and TOC elevations referenced in ft msl. The survey will be conducted
35 in coordination with the National Oceanic and Atmospheric Administration's National Geodetic
36 Survey to develop a plan that meets the accuracy requirements for this project. Detailed survey
37 methodology and procedures will be presented in the forthcoming project SAP (see DON 2016c).

38 3.5 EQUIPMENT DECONTAMINATION AND OTHER QUALITY CONTROL PROCEDURES

39 Equipment will be decontaminated in accordance with Procedure I-F, *Equipment Decontamination*
40 (DON 2015).

3.6 INVESTIGATION-DERIVED WASTE MANAGEMENT AND DISPOSAL

Unconsolidated material and liquid investigation-derived waste (IDW) generated during monitoring well installation and development activities will be collected at the end of each day. The IDW will be evaluated based on the corresponding unconsolidated material and groundwater sampling data and IDW samples (including liquid wastes generated during drilling operations, well development water, and decontamination liquids) to select appropriate disposal methods. IDW will be stored in U.S. Department of Transportation-approved 55-gallon steel drums, placed on pallets, covered with tarps, and temporarily stored at a secure, Navy-designated staging area. As an alternative and to facilitate drilling activities, drill cuttings may be placed in rolloff containers. Rolloff containers will be covered with a tarp to prevent them from filling up with precipitation.

The IDW will be handled, stored, and labeled in accordance with Procedure I-A-6, *Investigation-Derived Waste Management* (DON 2015). The drums will be segregated according to source and matrix, and at least one representative 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 to a Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP)-certified laboratory for analysis. Waste profile forms will be prepared and submitted to potential disposal facilities for approval. The IDW will be kept at the 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, 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.

4. Sample Details

Subsurface unconsolidated material, geotechnical, and potable water sample details are presented in Table 4-1, Table 4-2, and Table 4-3, respectively.

4.1 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 NAVFAC Pacific Environmental Restoration Program Procedure I-A-8, *Sample Naming* (DON 2015). All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). 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.

1 **Table 4-1: Subsurface Unconsolidated Material Sample Details**

				Analysis Group:	TPH-d/TPH-o	TPH-g	VOCs	PAHs
				Analytical Method:	SW-846 8015	SW-846 8015	SW-846 8260	SW-846 8270
				Container Type:	8-oz clear or amber borosilicate wide-mouth jar, with Teflon-lined lid	Pre-weighed 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	Pre-weighed 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	8-oz clear or amber borosilicate wide-mouth jar, with Teflon-lined lid
				Preservative:	≤6 °C	1 × 5mL methanol-preserved; ≤6 °C	2 × 10mL water-preserved; 1 × 5mL methanol-preserved; ≤6 C°	≤6 C°
				Holding Time (Preparation/Analysis):	14 days	14 days	7 days (water); 14 days (methanol)	14 days
Analytical laboratory: APPL, Inc.								
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval				
Red Hill	Unconsolidated Material ^{a,b}	RHMW01R	RHMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material ^{a,b}	OWDFMW01R	OWDFMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Field QC Samples								
Red Hill	Field Duplicate	TBD	Aaaaaa-BScC-Dee-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Matrix Spike/Matrix Spike Duplicate	TBD	Aaaaaa-BScC-See-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Equipment Blank	TBD	Aaaaaa-WQ-Eee-ffff	—	✓	✓	✓	✓
Red Hill	Trip Blank	TBD	Aaaaaa-WQ-Tee-ffff	—	—	✓	✓	—
Red Hill	Field Blank	TBD	Aaaaaa-WQ-Fee-ffff	—	✓	✓	✓	✓
Miscellaneous Samples								
Red Hill	IDW	RHMW01R	RHMW01R-IDW-01-ffff	—	—	—	✓	—
Red Hill	IDW	OWDFMW01R	OWDFMW01R-IDW-01-ffff	—	—	—	✓	—

- 2 ✓ analysis is applicable to sample
 - 3 — analysis is not applicable to sample
 - 4 °C degree Celsius
 - 5 Aaaaaa sampling point
 - 6 APPL Agriculture & Priority Pollutants Laboratories, Inc.
908 N Temperance Ave., Clovis, CA 93611
 - 7 cc consecutive sampling location number
 - 8 ee chronological sample number from a particular sampling location
 - 9 ff.f depth of sample in feet (ft) bgs (measured to the tenth of a foot)
 - 10 fff sample collection date (e.g., "0215" for February 15)
 - 11 mL milliliter
 - 12 oz ounce
 - PAH polynuclear aromatic hydrocarbon
 - TBD to be determined
 - TPH-d total petroleum hydrocarbons – diesel range organics
 - TPH-g total petroleum hydrocarbons – gasoline range organics
 - TPH-o total petroleum hydrocarbons – residual range organics (i.e., TPH-oil)
 - VOA volatile organic analyte
- ^a Unconsolidated material includes soil, coarse-grained sand, and smaller grain size material, such as clay, sands, and clinker zone sand.
^b Unconsolidated material will be sampled as described in Section 3.3.9.

1 **Table 4-2: Geotechnical Sample Details**

Analytical laboratory: APPL, Inc.					Analysis Group:	Atterberg Limits	Effective Porosity ^a	Permeability	Grain Size Distribution
					Analytical Method: ^b	ASTM D4318	ASTM D6836M	ASTM D5084	ASTM D422
					Container Type:	Core	Core	Core	Core
					Preservative:	N/A	N/A	N/A	N/A
					Holding Time (Preparation/Analysis):	N/A	N/A	N/A	N/A
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval					
Red Hill	Unconsolidated material ^{c,d}	RHMW01R	RHMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓	✓
Red Hill	Unconsolidated material ^{c,d}	OWDFMW01R	OWDFMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓	✓

(cont'd)					Analysis Group:	Cation Exchange Capacity	pH	Total Organic Carbon
					Analytical Method: ^b	EPA 9081	ASTM G51	Walkley Black
					Container Type:	Core	Core	Core
					Preservative:	N/A	N/A	N/A
					Holding Time (Preparation/Analysis):	N/A	N/A	N/A
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval				
Red Hill	Unconsolidated material ^{c,d}	RHMW01R	RHMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated material ^{c,d}	OWDFMW01R	OWDFMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓

2 ✓ analysis is applicable to sample
 3 ff.f depth of sample in feet (ft) bgs (measured to the tenth of a foot)
 4 N/A not applicable
 5 TBD to be determined
 6 ^a Effective porosity includes total porosity, moisture content, density, and specific gravity.
 7 ^b Sources: (ASTM 2007, 2010, 2012, 2016a,b)
 8 ^c Unconsolidated material includes soil, coarse-grained sand, and smaller grain size material, such as clay, sands, and clinker zone sand.
 9 ^d Unconsolidated material will be sampled as described in Section 3.3.9.

1 **Table 4-3: Potable Water Sample Details**

Analytical laboratory: APPL, Inc.					Analysis Group:	TPH-d/TPH-o	TPH-g	VOCs	PAHs
					Analytical Method:	SW-846 8015	SW-846 8015	SW-846 8260	SW-846 8270
					Container Type:	1-L amber borosilicate wide- or narrow-mouth bottle, with Teflon-lined lid	3 × 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	3 × 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	1-L amber borosilicate wide- or narrow-mouth bottle, with Teflon-lined lid
					Preservative:	≤6 °C	HCl-preserved; ≤6 C°	HCl-preserved; ≤6 C°	≤6 C°
					Holding Time (Preparation/Analysis):	7 days	14 days	14 days	7 days
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval					
Red Hill	Water	Potable Water ^a	Aaaaaa-PW01-S01-ffff	TBD	✓	✓	✓	✓	
Total Number of Samples to the Laboratory					1				

- 2 ✓ analysis is applicable to sample
- 3 Aaaaaa sampling point
- 4 ffff sample collection date (e.g., "0215" for February 15)
- 5 HCl hydrochloric acid
- 6 L liter
- 7 TBD to be determined
- 8 ^a Potable water will be sampled prior to potable water use during drilling activities (see Section 3.3.8).

4.1.1 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 Groundwater Long-Term Monitoring 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 groundwater monitoring event)

QC samples will be included in the chronological sequence.

4.1.2 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:

Aaaaaa-bbcc-dee-Dff.f

Where:

Aaaaaa = Site area (see Table 4-4)

bb = Sample type and matrix (see Table 4-5)

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

d = Field QC sample type (see Table 4-6)

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

D = The letter "D" denoting depth

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

Table 4-4: Area Identifiers

Identifier	Site Area
RHMW01R	Monitoring Well RHMW01R
OWDFMW01R	Monitoring Well OWDFMW01R

Table 4-5: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
BS	Subsurface Unconsolidated Material	Solid
WQ	Water Blanks	Water
PW	Potable Water	Water

1 **Table 4-6: Field QC Sample Type Identifiers**

Identifier	Field or QC Sample Type	Description
S	Primary Sample	All field samples, except QC samples
D	Duplicate	Co-located for unconsolidated material
E	Equipment Blank	Water
B	Field Blank	Water
T	Trip Blank	Water

2 For example, the sample number OWDFMW01R-BS01-S01-D20.0 would indicate that the sample is
3 the first sample collected from the first subsurface unconsolidated material location, encountered at
4 20 ft bgs, from the borehole advanced for monitoring well OWDFMW01R. The duplicate sample
5 would be designated as OWDFMW01R-BS01-D01-D20.0. These characters will establish a unique
6 descriptive identifier that will be used during data evaluation.

7 **5. References**

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**Appendix A:
RHMW01 and OWDFMW01
Boring and Monitoring Well Construction Logs
(DON 2000, 2002)**

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PROJECT: Red Hill Bulk Storage Facility
CLIENT: PACNAVFACENGCOM

Boring/Monitoring Well No. B-V1D
Project No. CTO 0229

LOCATION: V1D - Basal Aquifer **ELEVATION:** 102.56
DRILLER: Salisbury & Associates, Inc. **DATE DRILLED:** 2/13/01 **LOGGED BY:** Lance Williams
DRILL RIG: SAITECH EH5, Portable Core Drill **DEPTH TO WATER >** **FIRST:** 86.0 **COMPL.:** 86.1
BORING ANGLE: 90 **WELL DIAMETER (inch):** 1"

This information pertains only to this boring and should not be interpreted as being indicative of the site.

Corrected Elevation/ Boring Length (ft)	Core Run Number	PID Reading (ppm)	Sample Number	Core Recovery %	Graphic Log	SOIL DESCRIPTION	WELL CONSTRUCTION
102.56	1	NM		100		Concrete 0-2' over fine to coarse sand with fine gravel and silt 2-2.5; basalt 2.5'; no odor	
102.06	2	172		83		Small to large vesicles; no odor; 10YR 3/1	
98.56	3	NM		71		Small to medium vesicles; no odor; 10YR 3/1 to 2/1	
95.36	4	NM		0		Small vesicles; no odor; 5YR 3/2 to 10YR 2/2	
94.16	5	NM		33		Small to medium vesicles; no odor; 5YR 3/2 to 10YR 2/2	
93.66	6	NM		100		Small to medium vesicles; no odor; 5YR 3/2 to 10YR 2/2	
91.76	7	124		105		Small to large vesicles; no odor; 10YR 2/2	
	8			93		Small to large vesicles; no odor; 10YR 2/2 to 3/2	
86.06	9	NM		96		Primarily small to medium vesicles; no odor; 10YR 2/2	
81.66	10	NM		100		Small to primarily large vesicles; no odor; 10YR 2/2 to 5YR 3/2 to 10YR 3/1	
76.26	11	3.2		100		Small to large vesicles; no odor; 10YR 3/1 to 5YR 3/2	
71.26	12	10.8		100		Small to medium vesicles; no odor; 5YR 3/2 to 10YR 3/1	
66.16	13	NM		102		Small to large vesicles; no odor; 5YR 3/2 to 10YR 3/1	
60.96	14	NM		100		Small to large vesicles; no odor; 10YR 2/2 to 5YR 3/2	
57.26	15	NM		98		Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2	
56.91	16	NM		98		Void	
53.06	17			89		Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2	
48.06	18	1.0		100		Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2	
43.36	19	6.9		83		Small to large vesicles; no odor; 10YR 3/1 to 2/2 to 5YR 3/2	
38.36	20	1.8		92		Small to large vesicles; no odor; 10YR 2/5 to 5YR 3/2	
34.26	21	0.0		92		Small to medium vesicles; no odor; 10YR 2/1 to 2/2 to 5YR 3/2	
29.16		0.0	RH-BR-V1D-S01	102		Small vesicles; no odor; 10YR 2/1	


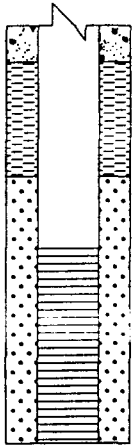


Corrected elevations are provided for angle borings.

PROJECT: Red Hill Bulk Storage Facility
CLIENT: PACNAVFACENGCOM

Boring/Monitoring Well No. B-V1D
Project No. CTO 0229

LOCATION: V1D - Basal Aquifer **ELEVATION:** 102.56
DRILLER: Salisbury & Associates, Inc. **DATE DRILLED:** 2/13/01 **LOGGED BY:** Lance Williams
DRILL RIG: SAITECH EH5, Portable Core Drill **DEPTH TO WATER:** **FIRST:** 86.0 **COMPL.:** 86.1
BORING ANGLE: 90 **WELL DIAMETER (inch):** 1"





This information pertains only to this boring and should not be interpreted as being indicative of the site.

Corrected Elevation/ Boring Length (ft)	Core Run Number	PID Reading (ppm)	Sample Number	Core Recovery %	Graphic Log	SOIL DESCRIPTION	WELL CONSTRUCTION
24.06	22	0	RH-BR-V1D-S02	100		Medium vesicles; no odor; 10YR 2/2	
18.86	23	0.0		106		Medium vesicles; no odor; 10YR 2/2	
15.66	24	0.0		96		Large vesicles; no odor; 10YR 2/1	
10.16	25	0.0	86		Small vesicles; no odor; 10YR 2/2		
9.56					Clinker zone 93-100'		
6.56	26	0.0	56		Medium vesicles; clinker zone; no odor; 10YR 2/1		
4.96	27	0.0	50		Medium vesicles; clinker zone; no odor; 10YR 2/2		
2.56					Clinker zone		
						B-V1D terminated at 100.0'	

Corrected elevations are provided for angle borings.

Borehole/Well Construction Log

Project Name: Red Hill Phase II RI/FS		Project Number: CTO-0034		Borehole Number: MW08	
Borehole Location: Near AST		Northing: 75254.41 Easting: 530845.19		Sheet 1 of 9	
Drilling Agency: Valley Well Drilling			Driller: Dean Mclure, David Brown		
Drilling Equipment: B59, Jaswell 3000			Date & Time Started: 4/7/98	Total Depth (feet): 142.8	
Drilling Method: Air Rotary, Hollow Stem Auger		Top of Casing Elevation (feet msl): 138.06	Date & Time Finished: 4/24/98	Depth to Water (feet): See remarks	
Size and Type of Bit: -		Borehole Diameter (in): 10	Sample Bulk: NA Drive: x Type: SS: 16 Grab: NA	Sample Length (ft): 1.5' or 5' Driving Weight: NA Drop Length: NA	
Drilling Fluid: Air		Drilling Angle (degrees): 90	Number of Samples: 16		
Completion Information: See remarks			Logged By: W. Wen		Checked By: B. Tsutsui

Depth (feet)	Samples				Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks
	Number	Type	Blow Count	Percent Recovery	Time	Gravel	Sand	Fines	Graphic			
1		◇	50/5'	40	1352	5	TR	95		CL	Topsoil	 <p>Ground surface elevation: 135.67 feet msl</p> <p>Steel casing (12 inch diameter)</p> <p>PVC Casing</p> <p>Grout</p>
2											LOW PLASTIC INORGANIC CLAY ; black, 5YR 2.5/1; dry; hard; CL; 95% low plastic inorganic clay; 5% fine, subangular gravel; trace amount of sand and roots.	
3												
4												
5		◇	50/5'	35	1359	TR	80	20		SC	CLAYEY SAND ; dark yellowish brown, 10YR 4/6; dry; dense; SC; 80% fine, medium, coarse, subrounded sand; 20% low plastic inorganic clay; trace amount of fine, subangular gravel.	
6												
7												
8												
9												
10		◇	50/6'	15	1410	-	-	-		IE	EXTRUSIVE ; basalt; gray, 10YR 6/1; vesicular basalt; fresh; hard; dry; IE.	
11												
12												
13												
14												
15												

Red Hill Phase II RI/FS/CTO-0034

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
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Borehole Location: Near AST	Sheet 2 of 9
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Depth (feet)	Samples				Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks	
	Number	Type	Blow Count	Percent Recovery	Time	Gravel	Sand	Fines	Graphic				USCS or Rock Type
16			NA	5	1420	-	-	-		IE	Same as above		
17													
18			50/3"	0		-	-	-			No Recovery		
19											Called off at 1435, 4/7/98		
20			NA	70	1300	-	-	-			No recovery		
21													
22						-	-	-			No Recovery		
23													
24													
25			NA	0	1442	40	-	60		CL	GRAVELLY CLAY ; strong brown and dark gray, 7.5YR 5/6, 4/1; dry; soft; CL; 60% high plastic inorganic clay; 40% fine, subrounded basalt gravel.		
26											No Recovery		
27											Called off at 1442, 4/13/98		
28													
29													
30													
31													
32			NA	80	1430	-	TR	100		CH	HIGH PLASTIC INORGANIC CLAY ; dark	Bottom of steel casing	

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
---------------------------------------	--------------------------	-----------------------

Borehole Location: Near AST	Sheet 3 of 9
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Depth (feet)	Samples				Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks
	Number	Type	Blow Count	Percent Recovery	Gravel	Sand	Fines	Graphic	USCS or Rock Type			
33										brown, 7.5YR 3/3; moist; soft; CH; 100% high plastic inorganic clay; trace amount of sand.		
34										Logged at 1439, 4/14/98.		
35												
36					30	TR	70		CL	GRAVELLY CLAY ; very dark gray and brown, 10YR 3/2; moist; stiff; CL; 30% subrounded gravel; 70% low plastic inorganic clay; trace amount of sand; extensive mottling.		
37		NA	60		-	-	-		IE	EXTRUSIVE ; basalt; light gray, 5YR 7/2; vesicular basalt; highly weathered; friable; dry; IE.		
38					-	-	-		IE	Same as above		
39					100	TR	-		GP	POORLY GRADED GRAVEL ; pale olive gray, 5YR 6/2; dry; GP; 100% coarse, subrounded gravel; trace amount of coarse sand.		
40					-	-	-		IE	EXTRUSIVE ; basalt; pale olive, 5YR 7/2; lightly weathered; massive; friable; dry; IE.		
41												
42		NA	70		80	10	10		GC	CLAYEY GRAVEL ; strong brown, 7.5YR 4/6; moist; GC; 80% fine, medium and coarse subrounded gravel; 10% coarse subrounded sand; 10% high plastic inorganic clay.		
43												
44					100	-	-		GW	WELL GRADED GRAVEL ; brown, 7.5YR 4/3; moist; GW; 100% medium coarse subrounded gravel.		
45					90	5	5		GP	EXTRUSIVE ; basalt; brown, 7.5YR 4/3; highly weathered; vesicular basalt; fractured; moist; IE. POORLY GRADED GRAVEL ; strong brown, 7.5YR 4/6; moist; GP; 90% fine, medium, coarse subrounded gravel; 5% coarse, subrounded sand; 5% high plastic inorganic clay.		
46									IE	EXTRUSIVE ; basalt; brown, 7.5YR 4/3; highly weathered; vesicular basalt; fractured; moist; IE.		
47		NA	80		-	-	-		IE	EXTRUSIVE ; basalt; brown, 7.5YR 4/3; highly weathered; vesicular basalt; fractured; moist; IE.		
48					-	-	100		CH	HIGH PLASTIC INORGANIC CLAY ; brown, 7.5YR 4/2; moist; firm; CH; 100% medium plasticity inorganic clay.		
49					-	-	-		IE	EXTRUSIVE ; basalt; olive gray, 5YR 5/2; fresh; vesicular; moist; IE.		
50												

Red Hill Phase II RI/FS/CTO-0034

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS Project Number: CTO-0034 Borehole Number: MW08



















Borehole Location: Near AST Sheet 4 of 9

Depth (feet)	Samples				Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks
	Number	Type	Blow Count	Percent Recovery	Time	Gravel	Sand	Fines	Graphic			
51												
52		NA	100	1700	-	-	-		IE	Same as above		
53												
54									IE	EXTRUSIVE ; basalt; gray, 10YR 5/1; most massive basalt with some vesicular fabric; fresh; hard; moist; IE.		
55												
56									IE	EXTRUSIVE ; basalt; olive gray, 5YR 5/2; fresh; vesicular; moist; IE.		
57		NA	80	0917	-	-	-		IE	No Recovery		
58									IE	Grading to faintly weathered; well developed fracture in basalt.		
59												
60												
61						70	10	20	GC	Color changes to brown (7.5YR 4/4); grading to highly weathered and soft. CLAYEY GRAVEL ; dark gray, 5YR 4/1; dry; dense; GC; 70% fine, subangular and subrounded gravel; 20% low plastic, inorganic clay; 10% fine, subangular sand.		
62		NA	85	0947	-	-	-		IE	EXTRUSIVE ; basalt; brown, 7.5YR 4/4; massive basalt; highly weathered; medium hard; moist; IE.		
63									IE	EXTRUSIVE ; volcanic breccia; gray, 5YR 5/1; 60% basalt clast; 20% matrix; 20% porosity; faintly weathered; hard; dry; IE.		
64												
65												
66												
67		NA	80	1040	-	-	-			No recovery		

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
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Borehole Location: Near AST	Sheet 5 of 9
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Depth (feet)	Samples				Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks	
	Number	Type	Blow Count	Percent Recovery	Time	Gravel	Sand	Fines	Graphic				USCS or Rock Type
68						-	-	-		IE	EXTRUSIVE ; volcanic breccia; gray, 7.5YR 5/1; 40% basalt clast; 40% matrix; 20% porosity; faintly weathered; hard; wet; IE.		
69						-	-	-		IE	EXTRUSIVE ; basalt; dark gray, 7.5YR 4/1; massive basalt; fresh; hard; wet; IE.		
70													
71													
72		NA	90	1130		-	-	-		IE	Same as above		
73													
74													
75													
76													
77						-	-	-		IE	Same as above		
78													
79													
80													
81													
82													
83													
84													
85													

Red Hill Phase II RI/FS/CTO-0034

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
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Borehole Location: Near AST	Sheet 7 of 9
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Depth (feet)	Samples					Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks
	Number	Type	Blow Count	Percent Recovery	Time	Gravel	Sand	Fines	Graphic	USCS or Rock Type			
103						-	-	-	L	IE	Same as above (basalt)		
104									L				
105									L				
106									L				
107									L				
108									L				
109									L				
110									L				
111									L				
112									L				
113									L				
114									L				
115									L				
116									L				
117									L				
118									L				
119									L				
120									L				

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS Project Number: CTO-0034 Borehole Number: MW08

Borehole Location: Near AST Sheet 8 of 9

Depth (feet)	Samples				Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks		
	Number	Type	Blow Count	Percent Recovery	Time	Gravel	Sand	Fines	Graphic				USCS or Rock Type	
121						-	-	-	↖ ↗ ↘ ↙ ↚ ↛ ↜ ↝ ↞ ↠ ↡ ↢ ↣ ↤ ↥ ↦ ↧ ↨ ↩ ↪ ↫ ↬ ↭ ↮ ↯ ↰ ↱ ↲ ↳ ↴ ↵ ↶ ↷ ↸ ↹ ↺ ↻ ↼ ↽ ↾ ↿ ↻ ↽ ↿ ↻ ↽ ↿ ↻ ↽ ↿	IE	Same as above (basalt)			
122														
123														
124														
125														
126														
127														
128														
129														
130														
131														
132														
133														
134														
135														
136														
137														

Approximate static basal groundwater level (122.2 feet bgs); top of filter pack

Top of screen

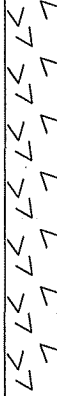
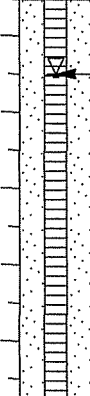
0.02 inch stainless steel screen

Red Hill Phase II RI/FS/CTO-0034

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
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Borehole Location: Near AST	Sheet 9 of 9
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Depth (feet)	Samples				Estimated %			Log		Lithologic Description	Well Construction Diagram	Remarks	
	Number	Type	Blow Count	Percent Recovery	Time	Gravel	Sand	Fines	Graphic				USCS or Rock Type
138 139 140 141 142						-	-	-		IE	Same as above (basalt)		First encountered depth of basal groundwater (138.5 feet bgs) Bottom of well
											Boring finished at 143 feet on 4/24/98.	Total depth of borehole	

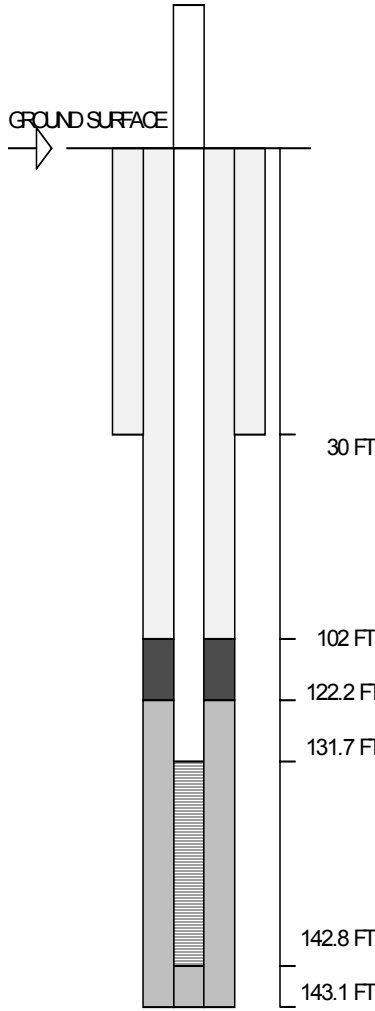
WELL COMPLETION RECORD

JOB NO.: CTO 0034 WELL NO. MW-08 HYDROGEOLOGIST: Bruce Tsutsui
 CLIENT: PACNAVFACENGCOM DRILLER: Valley Well Drilling
 WELL LOCATION: Near AST DATE/TIME: 4/24/98 10:50

DETAILS OF CONSTRUCTION

Date Completed 4/24/98
 Borehole Diameter (in.) 10
 Type and Size of Casing (in.) PVC; 4
 Type and Size of Screen (in.) Stainless Steel; 4
 Screen Perforation Diameter (in.) 0.02
 Screen Length (ft.) 11.1
 Centralizer Depths (ft.) N/A
 Completion Technique
 1. Type of Filter Pack and Placement Method
Lonestar #3
 2. Type of Bentonite and Placement Method
Pellets, chips
 3. Type of Grout Mixture and Placement Method
Portland; tremmie pipe
 Description of Potential Problems With Well:
Perched Water

Development Technique
Surge with block during construction; surge with bailer during development



Well Head Elevation 138.06 ft (MSL)
 Ground Surface Elev. 135.67 ft (MSL)
 Well Head Completion Method Manual crash hole
 Drilling Method/Rig Type B-59; Jaswell
 Surface Casing: Type PVC
 Diameter 4 in.
 Length 2.39 ft.

MATERIALS
 Cement (bags) NA
 Filter Pack Material (sand bags) 10
 Casing Material (ft.) 131.66
 Bentonite (buckets/bags) 1 (pellets) 7 (chips)

Top of Bentonite Seal 102 ft.
 Top of Filter Pack 122.2 ft.
 Top of Screen 131.66 ft.

Bottom of Screen 142.76 ft.
 Bottom of Hole 143.1 ft.

NOTE: ALL DEPTHS ARE REFERENCED TO GROUND SURFACE

