Groundwater Flow Model Progress Report 02, Red Hill Bulk Fuel Storage Facility

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

Administrative Order on Consent in the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket Number RCRA 7003-R9-2015-01 and DOH Docket Number 15-UST-EA-01, Attachment A, Statement of Work Section 6.2, Section 7.1.2, Section 7.2.2, and Section 7.3.2

August 4, 2017
Revision 00

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

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August 4, 2017
Revision 00

Prepared for:

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

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ACRONYMS AND ABBREVIATIONS

µS/cm	microsiemen per centimeter
AOC	Administrative Order on Consent
BWS	Board of Water Supply, City and County of Honolulu
CF&T	contaminant fate and transport
Cl^-	chloride ion
CSM	conceptual site model
CTD	conductivity, temperature, and depth
CWRM	Commission on Water Resource Management, State of Hawai‘i Department of Land and Natural Resources
DLA	Defense Logistics Agency
DLNR	Department of Land and Natural Resources, State of Hawai‘i
DOH	Department of Health, State of Hawai‘i
EPA	Environmental Protection Agency, United States
ft	foot/feet
GHB	general-head boundary
GIS	geographic information system
GWMWG	Groundwater Modeling Working Group
HGU	hydrogeologic unit
HIGP	Hawai‘i Institute of Geophysics and Planetology
mg/L	milligram per liter
mgd	million gallons per day
msl	mean sea level
OS	Ocean Sensors, Inc.
RBR	RBR Ltd.
SFB	specified-flux boundary
SHB	specified-head boundary
SME	subject matter expert
SOW	scope of work
SWAP	Source Water Assessment Program
TBD	to be determined
USGS	United States Geological Survey
WP	work plan

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1. Introduction

This *Groundwater Flow Model Progress Report 02* is the second in a series of modeling progress reports that describes the technical status of the groundwater flow modeling effort being conducted for the Investigation and Remediation of Petroleum Product Releases and Groundwater Protection and Evaluation project at the Red Hill Bulk Fuel Storage Facility ("Facility"), Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. The progress report is a component of the overall project reporting as specified in the project *Work Plan/Scope of Work* (WP/SOW) (DON 2017a). The WP/SOW presents the process, tasks, and deliverables that address the goals and requirements of Statement of Work Sections 6 and 7 of the *Administrative Order on Consent* (AOC) *In the Matter of Red Hill Bulk Fuel Storage Facility* (EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01) (EPA Region 9 and DOH 2015). Submittal of groundwater flow model progress reports at a minimum of every 4 months is stipulated in AOC Statement of Work Section 7.1.2.

Reporting Period 02 covered in this report represents progress for the second 4-month period following conditional approval of the project WP/SOW by the Regulatory Agencies, which was received by the Navy on December 5, 2016 (EPA Region 9 and DOH 2016). *Groundwater Flow Model Progress Report 01*was submitted on April 5, 2017.

2. Work Completed This Period

2.1 CURRENT STATUS

The groundwater modeling work completed during this reporting period included obtaining and evaluating hydrologic and geologic data to develop the conceptual site model (CSM) for groundwater flow and contaminant transport, and assessing the usefulness and limitations of the existing data for the planned groundwater modeling, which are described in the *Existing Data Summary and Evaluation Report for Groundwater Flow and Contaminant Fate and Transport Modeling* (DON 2017b). As discussed in the previous *Groundwater Flow Model Progress Report 01* (DON 2017c), some uncertainties with and limitations of the archived files for the 2007 groundwater model (DON 2007) were identified, as detailed in the *Data Gap Analysis Report* (DON 2017d). These issues are being and will continue to be addressed during updating of the 2007 model to incorporate new data being collected in the Red Hill area, refine the model setup, and calibrate the model for current conditions. The updated model will be changed substantially from that produced in 2007, but evaluating the details of the 2007 model has informed and facilitated the process of planning the upcoming modeling evaluation. The focus of the upcoming modeling is to improve understanding of groundwater flow direction and rates in the Facility area to provide a basis for evaluating potential contaminant migration.

2.1.1 Technical Progress

A Groundwater Modeling Working Group (GWMWG) composed of subject matter experts (SMEs) from the United States Geological Survey (USGS), State of Hawai'i Department of Health (DOH), State of Hawai'i Department of Land and Natural Resources (DLNR) Commission on Water Resource Management (CWRM), City and County of Honolulu Board of Water Supply (BWS), University of Hawai'i, and the Navy was formed to coordinate the development of accurate and reliable groundwater flow and contaminant fate and transport (CF&T) models. The GWMWG met twice during this reporting period (on June 1 and June 26, 2017) to discuss and decide upon the final model area, domain, boundary locations, and boundary types of the groundwater flow model.

The model boundaries agreed to during discussions so far are described below and illustrated on Figure 1:

- *Northeast:* Along the northeast side of the dike-free basalt area mapped by the USGS in Izuka et al. 2016 (same location as the 2007 model [DON 2007]). The boundary will be set as a specified-flux boundary (SFB) consistent with flux rates in the DOH regional Source Water Assessment Program (SWAP) model (Whittier et al. 2004) or the USGS regional saturated-unsaturated transport (SUTRA) model (Oki 2005).
- *Southeast:* Along the southeast ridge of Kalihi Valley (approximately 2.5 miles south of the Facility) before joining with the previous model boundary described in *Groundwater Flow Model Progress Report 01* (DON 2017c). The boundary will likely be set as a general-head boundary (GHB), but this is still under review.
- *Southwest:* Extends generally south from the Pearl City Peninsula, follows Iroquois Point, and then extends offshore along the sea floor out to an ocean depth of approximately 1,300 feet (ft). As suggested by SMEs for the BWS and the USGS during the Groundwater Modeling Group meeting on June 26, this boundary will be a specified-head boundary (SHB) set along the ocean-floor, with heads specified to be equivalent-freshwater heads representing the sea-water depth at points along the SHB. Extending the SHB out to the seawater depth of -1,300 ft has been estimated anticipating that the bottom of the model will be a horizontal no-flow boundary, set approximately 100 ft below the freshwater–saltwater interface in the area of interest. The location of this SHB on Figure 1 is approximate, and may actually be farther southwestward as defined based on bathymetry. Also the SHB location may change if the model bottom changes based on further discussion with the SMEs in the next groundwater modeling group meeting.
- *Northwest:* Along the northwest ridge of Waimalu Valley before joining with the Punanani Gulch branch of Waimalu Stream. The boundary then extends from north of Punanani Gulch (at the junction of two stream branches) to the easternmost point of Pearl City Peninsula, and follows the peninsula to its southwestern-most point. The boundary will be set as a GHB.

The GWMWG also discussed the number and thickness of model layers, which will be finalized following completion of the model's conceptual hydrogeologic framework. Although it was proposed by the GWMWG that the five model layers should be uniform, the Navy is considering use of newer models that allow modeling of layers of various thickness. The Navy will provide a recommendation that can be further discussed in the next meeting. Figure 2 and Figure 3 show the approximate model layers being planned. The upper two layers would be relatively thin (approximately 30–50 ft thick) to enable the MODFLOW model to provide more detailed results at depths near the water table, and would be consistent with the intake intervals of the major supply infiltration galleries and supply wells near the Facility. The valley fill thickness is not yet determined. Valley fill will be incorporated into the model, where geologic information exists to demonstrate its presence, by assigning hydraulic properties of the valley fill. Layers 3 and 4 would be thicker than the upper two layers. The thicknesses of the upper four layers would be specified to reflect the thickness of the hydrogeologic units (HGUs) and well screen intervals. The bottom layer would extend approximately 100 ft below the freshwater–saltwater interface, as estimated by the Ghyben-Herzberg Principle, resulting in a depth of approximately -800 ft msl in the area of interest. Exact model layer thicknesses are preliminary at this point, and will be refined as the hydrogeologic framework is compiled and updated.

It was agreed by the Parties to the AOC (i.e., the Navy/Defense Logistics Agency [DLA], United States Environmental Protection Agency [EPA], and DOH) that predictive model simulations will be calibrated for the same period as the available data, and that the predictive simulations will be run

into the future consistent with the current long-term water management plan. Additionally, flux values along the model boundaries will be set based on SUTRA model files from the most recent regional model reports (Oki 2005; Whittier et al. 2004).

Work performed to date has involved compiling well locations, construction details, and borehole geologic logs for wells within the model area. This information was gleaned from past site investigations, the DLNR, and the website *Water Wells in the State of Hawai'i*, which is hosted and maintained by the Hawai'i Institute of Geophysics and Planetology (HIGP).

Pumping rates for all water supply wells within the model area (Figure 4) were obtained from the DLNR CWRM and are currently being analyzed and incorporated into appropriate model files. Additionally, groundwater elevations and pumping values for wells monitored by the USGS during the May 2015 pumping test of Hālawa Shaft have been identified and compiled (Figure 5), and the data are currently being analyzed.

The Navy continued its development of the geologic characterization of the Facility and the surrounding area by creating cross sections of the geologic units in the subsurface based on the boring logs compiled from all sources currently available to the Navy, including the data presented in the *Existing Data Report* (DON 2017b). The cross sections will be updated as necessary as new geologic boring logs and data are obtained and analyzed, and along with additional 3D illustrations will be presented in a forthcoming groundwater modeling progress report or technical memorandum.

Additional data points for groundwater levels and hydraulic head are needed to further define the water table potentiometric surface, vertical hydraulic gradients, and vertically delineate potential contamination, if it exists, within the model area. To address this data need, the Navy is now proposing to install additional deep wells at select locations (Figure 6) with screens at different intervals, as described in the forthcoming *Monitoring Well Installation Work Plan Addendum 01*. These wells will be constructed with isolated screens to allow measurement of hydraulic heads and water sampling at depths below the water table. Outside the casing, packers will be set and sealed to prevent vertical groundwater movement in the borehole. Also, these new wells will be installed in open boreholes to allow geophysical logging and vertical profiling.

A high-accuracy survey (Second Order, Class I, vertical) was conducted in July 2017 to verify the top of casing measurements of the Red Hill monitoring well network wells. Additional out-of-network wells will be added to the survey. This resurvey is critical to establishing accurate groundwater elevations and determining groundwater flow direction.

Following the top of casing survey, a USGS synoptic water level survey of approximately 22 wells in the Hālawa – Red Hill area commenced in July 2017, and is currently scheduled to run for 3 months, ending in October 2017 (USGS 2017).

2.1.2 Technical Issues

The work performed so far has revealed several uncertainties and limitations in both the archived model files and the publically available well data, including:

- The HIGP water well website lacked detailed information required for the modeling effort (e.g., geologic logs) for the majority of wells within the model area. To remedy this data gap, a data gathering trip was conducted to review and obtain copies of well locations, construction details, and geologic logs from the DLNR headquarters.
- Detailed data request letters were sent to BWS on May 4 and June 6, 2017 requesting their assistance in acquiring data required for the modeling effort. No data requested have been

received, so a follow-up request was made at an in-person meeting of the AOC parties and SMEs on June 21, 2017.

- The Navy has obtained graphical representations of the freshwater–saltwater interface from two deep monitor wells within or near the model area (Figure 7 and Figure 8). However, data from these locations alone are equivocal in establishing the elevation of this interface, and there appear to be additional deep monitor wells in the model area that may be useful for this purpose. Accordingly, the Navy is currently seeking additional information from the DLNR and CWRM, including a map of the interface if it exists, to better establish the elevation of the interface beneath the model area.
- During the working group meeting, DOH indicated that GIS shapefiles of the caprock and basalt maps may be available from the DOH and DLNR Geographic Information System (GIS) website. In following up to retrieve the maps, the Navy did not find these maps on the DOH/DLNR website. The Navy also learned from the USGS that the structural contour map of the top of the basalt and isopach thickness map of the caprock deposits presented in USGS Scientific Investigations Report 2015-5164 (Izuka et al. 2016) were not released as geospatial datasets or GIS shapefiles. However, USGS provided the files to the Navy on July 21, 2017, noting that the files contain preliminary data and are subject to revision.
- The 2005 USGS regional groundwater model SUTRA electronic input and output files (from Oki 2005) obtained from the USGS are currently unusable as they lacked the critical .MBB file, which provides geo-referenced locations. The USGS informed the Navy that the geo-reference points are also located in a previous USGS modeling report (Oki 2005). The Navy found and used the geo-reference points in the Oki report, but the geospatial projections from those points required adjustment by the Navy GIS team. After successfully determining geospatial location in the SUTRA model files, the Navy is now proceeding to extract information from the SUTRA files, including the geometry of HGUs and well construction details that were included in the model. The Navy intends to use this information from the SUTRA model as a basis for discussions about the HGUs' extents and depths, MODFLOW layers, and calibration points during the next groundwater modeling working group meeting.
- The Navy requested a copy of the regional SWAP model developed by DOH (Whittier et al. 2004), but DOH informed the Navy that the model cannot be released yet due to the need to remove some privileged information and add new recharge information. Additionally, the Attorney General's signature is required to authorize the release of the SWAP model. The SWAP model files have not yet been received.
- The Navy requested shapefiles from the USGS for the recent maps of groundwater recharge rates on O'ahu (Engott et al. 2015 and/or Izuka et al. 2016). The USGS noted that these maps and geospatial data sets contain small errors and the maps are currently being revised. Due to the urgency to obtain data for the groundwater model, the Navy was able to obtain the current USGS geospatial data sets for the Basalt and Caprock HGUs from the USGS. However, the Navy has not yet obtained and still needs the shapefiles of geospatial data for O'ahu recharge rates (Engott et al. 2015).

2.1.3 RHMW10 Boring Log and Well Construction Diagram

The lithological boring log and well construction diagram for new monitoring well RHMW10, constructed between December 2016 and April 2017 at the location shown on Figure 6, are presented in Appendix A.

2.2 SUBMITTAL OF MODELING DELIVERABLES

2.2.1 Current Period

Relevant deliverables submitted during this reporting period include:

- *Data Gap Analysis Report for Groundwater Flow and Contaminant Fate and Transport Modeling* (April 2017)
- *Final First Quarter 2017 - Quarterly Groundwater Monitoring Report* (April 2017)
- *Final Second Quarter 2017 - Quarterly Groundwater Monitoring Report* (July 2017)

2.2.2 Next Period

Additional deliverables due for submittal during the next 4-month reporting period include:

- *Monitoring Well Installation Plan Addendum 01, Revision 01* (August 2017), for up to 12 additional monitoring wells (see Figure 6). Two of these wells were previously proposed for installation in alternate locations in the August 2016 *Monitoring Well Installation Work Plan* (DON 2016). Four are identified as high-priority wells: RHMW11 (north of Red Hill and RHMW07); RHMW12, -16, or -20 (in the vicinity of the Hawaiian Cement Quarry northwest of Hālawa Correctional Facility); RHMW15 (between RHMW05 and Red Hill Shaft); and RHMW17 (near BWS Hālawa Shaft).
- *CSM Development Plan* (September 2017)
- *Attenuation Evaluation Plan* (September 2017)
- *Groundwater Model Evaluation Plan* (September 2017)
- *Final Third Quarter 2017 - Quarterly Groundwater Monitoring Report, Red Hill Bulk Fuel Storage Facility* (October 2017)

3. Schedule Status

While the modeling effort is proceeding, the current schedule is undergoing modifications based on revised well installation schedule and additional attenuation studies.

4. Anticipated Work Next Reporting Period

Anticipated work for Reporting Period 03 (August 5 – December 3, 2017) includes:

- Evaluate new hydrogeologic information to develop the CSM and update the 2007 flow model, including:
  - Well locations, construction details, and borehole geologic logs (from new Navy wells, BWS, DLNR, CWRM)
  - Screen depth intervals in monitoring wells for model calibration
  - GIS shape files from USGS for maps of groundwater recharge rates, caprock thickness, and top of basalt
  - Map showing altitude of base of freshwater aquifer (from CWRM and/or USGS)
- Assist with coordination of stakeholder activities.
- Work with USGS to evaluate data collected during the synoptic monitoring study and high accuracy survey.

- Establish up to 12 new multi-level monitoring wells.
- Present plans to conduct geophysical techniques to determine valley fill depths in the North and South Hālawa valleys.
- Publish the deliverables indicated in Section 2.2.2.

5. References

Department of the Navy (DON). 2007. *Red Hill Bulk Fuel Storage Facility Final Technical Report, Pearl Harbor, Hawaii*. Prepared by TEC Inc., Honolulu, HI. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. August.

———. 2016. *Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; August 29, 2016*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017a. *Work Plan/Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oah'u, Hawai'i; January 4, 2017, Revision 02*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017b. *Existing Data Summary and Evaluation Report for Groundwater Flow and Contaminant Fate and Transport Modeling, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; March 5, 2017 [Revision 00]*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017c. *Groundwater Flow Model Progress Report 01, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; April 5, 2017, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017d. *Data Gap Analysis Report, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; April 25, 2017, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

Engott, J. A., A. G. Johnson, M. Bassiouni, and S. K. Izuka. 2015. *Spatially Distributed Groundwater Recharge for 2010 Land Cover Estimated Using a Water-Budget Model for the Island of O'ahu, Hawai'i*. Scientific Investigations Report 2015–5010. Prepared in cooperation with the State of Hawai'i Commission on Water Resource Management and the City and County of Honolulu Board of Water Supply. U.S. Geological Survey.

Environmental Protection Agency, United States, Region 9; and Department of Health, State of Hawaii (EPA Region 9 and DOH). 2015. *Administrative Order on Consent In the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01*. September.

———. 2016. "Conditional Approval of Red Hill AOC SOW Deliverable under Sections 6 & 7 - Work Plan/Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, November 5, 2016 Revision 01." Letter from Bob Pallarino, EPA Red Hill Project Coordinator, and Steven Chang, DOH Red Hill Project Coordinator, to: Captain Richard D. Hayes, Navy Region Hawaii. December 2, 2016.

Izuka, S. K., J. A. Engott, M. Bassiouni, A. G. Johnson, L. D. Miller, K. Rotzoll, and A. Mair. 2016. *Volcanic Aquifers of Hawai'i—Hydrogeology, Water Budgets, and Conceptual Models*. Scientific Investigations Report 2015–5164. Water Availability and Use Science Program. U.S. Geological Survey.

Oki, D. S. 2005. *Numerical Simulation of the Effects of Low-Permeability Valley-Fill Barriers and the Redistribution of Ground-Water Withdrawals in the Pearl Harbor Area, Oahu, Hawaii*. Scientific Investigations Report 2005-5253. U.S. Geological Survey.

United States Geological Survey (USGS). 2017. *DRAFT Synoptic Water Level Study Work Plan, Hālawa Area, O'ahu, Hawai'i*. May 5. Honolulu: Pacific Islands Water Science Center.

Whittier, R. B., K. Rotzoll, S. Dhal, A. I. El-Kadi, C. Ray, G. Chen, and D. Chang. 2004. *Hawaii Source Water Assessment Report*. Prepared for the Hawai'i Department of Health, Safe Drinking Water Branch. University of Hawai'i, Water Resources Research Center.

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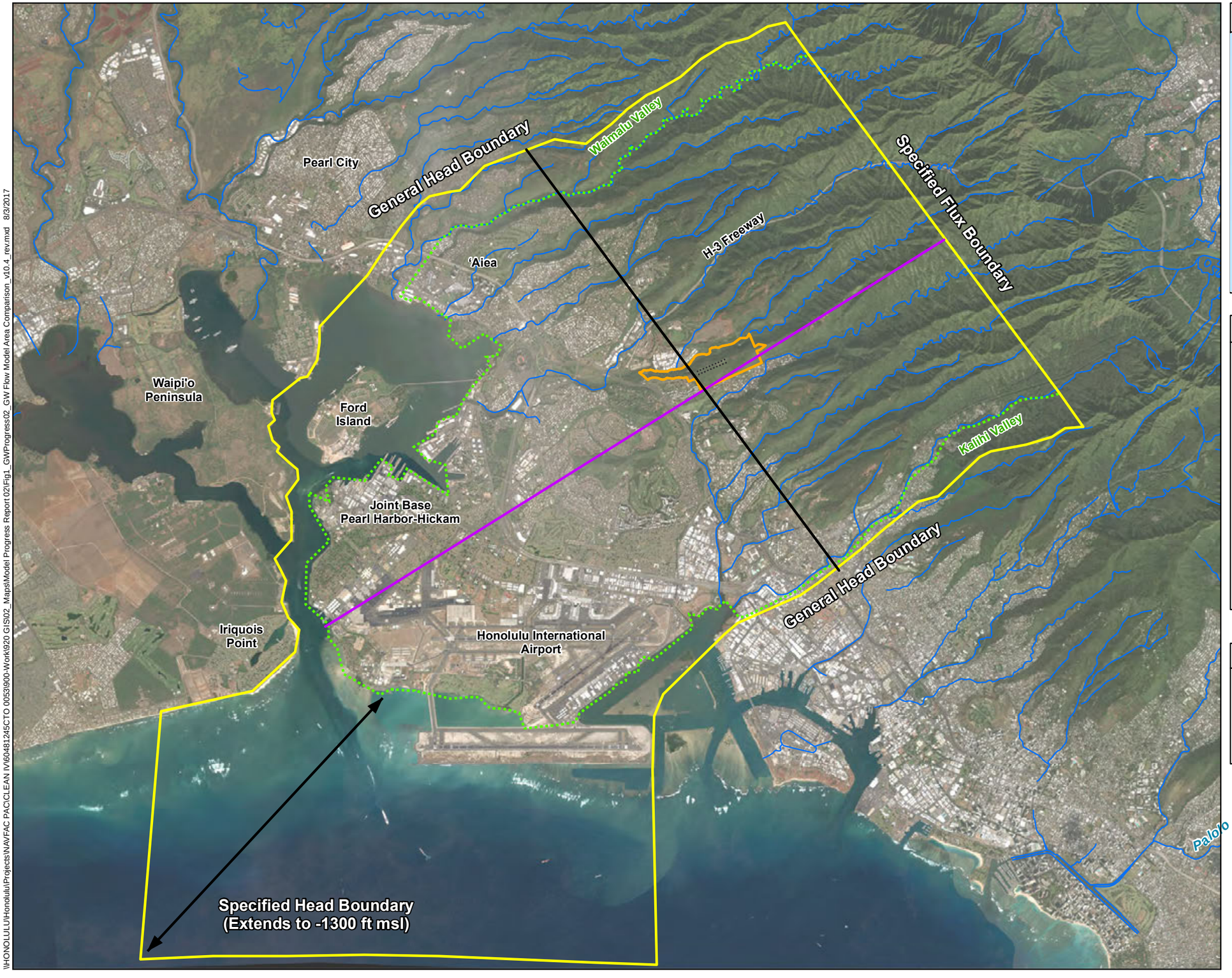
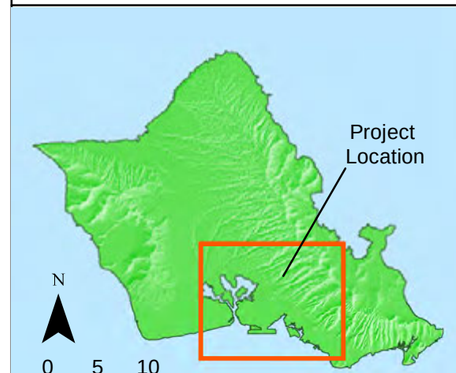


Location Map



Legend

- Planned Model
- 2007 Model
- Red Hill Bulk Fuel Storage Facility Boundary
- Red Hill Fuel Storage Tank
- Stream
- Southeast to Northwest Cross Section (Figure 2)
- Southwest to Northeast Cross Section (Figure 3)

Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015
3. Proposed model boundaries are under discussion.

N

0 4,000 8,000 Feet

Figure 1
Planned Model Area and
Proposed Boundary Conditions
Groundwater Flow Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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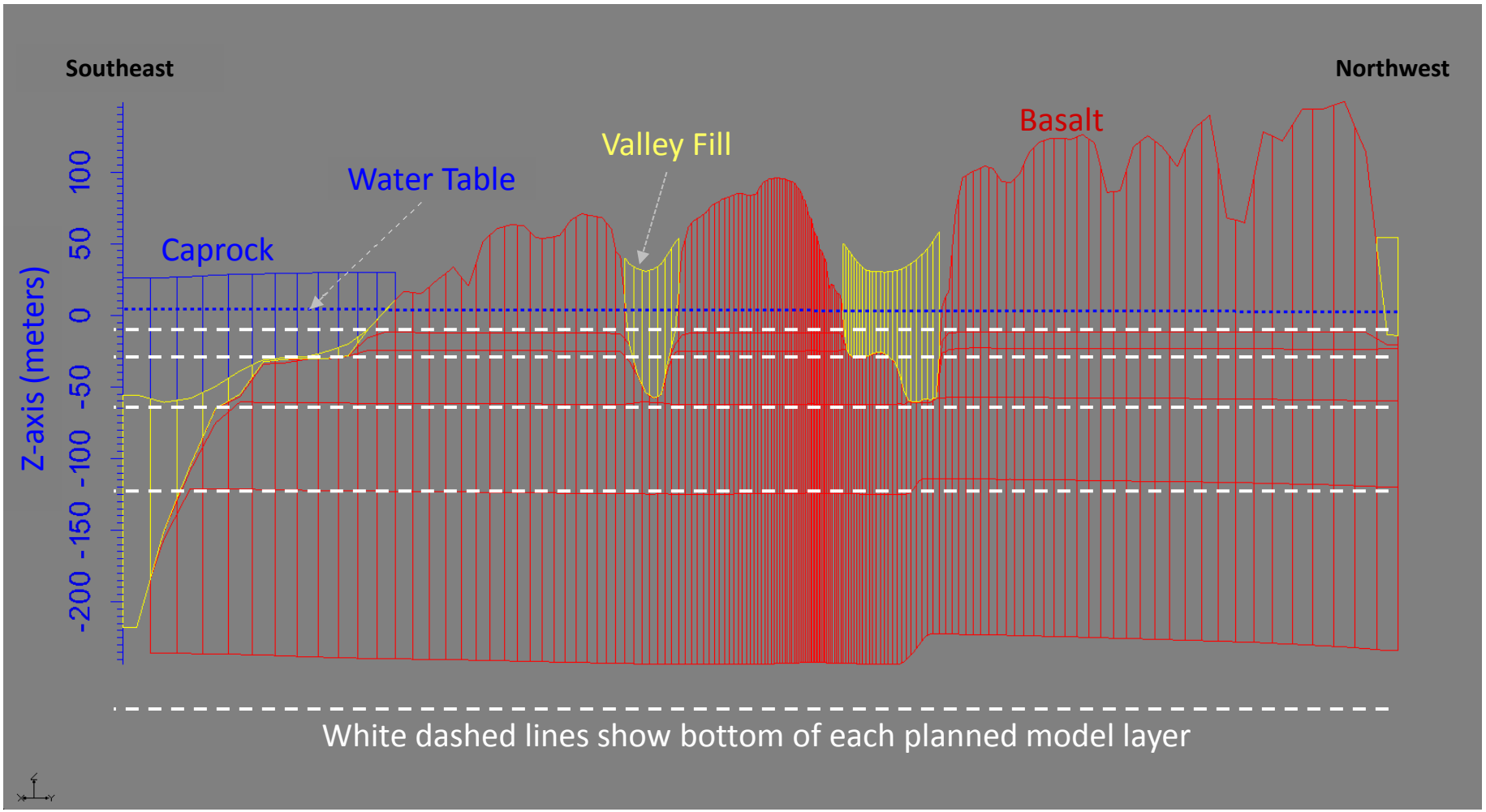

Notes:
Lower model bottom 100 feet below freshwater-saltwater interface
Valley fill depth will depend on field observations and collected data

Figure 2
Planned Model Layers Compared to 2007 Model Layers,
Southeast to Northwest Profile
Groundwater Flow Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

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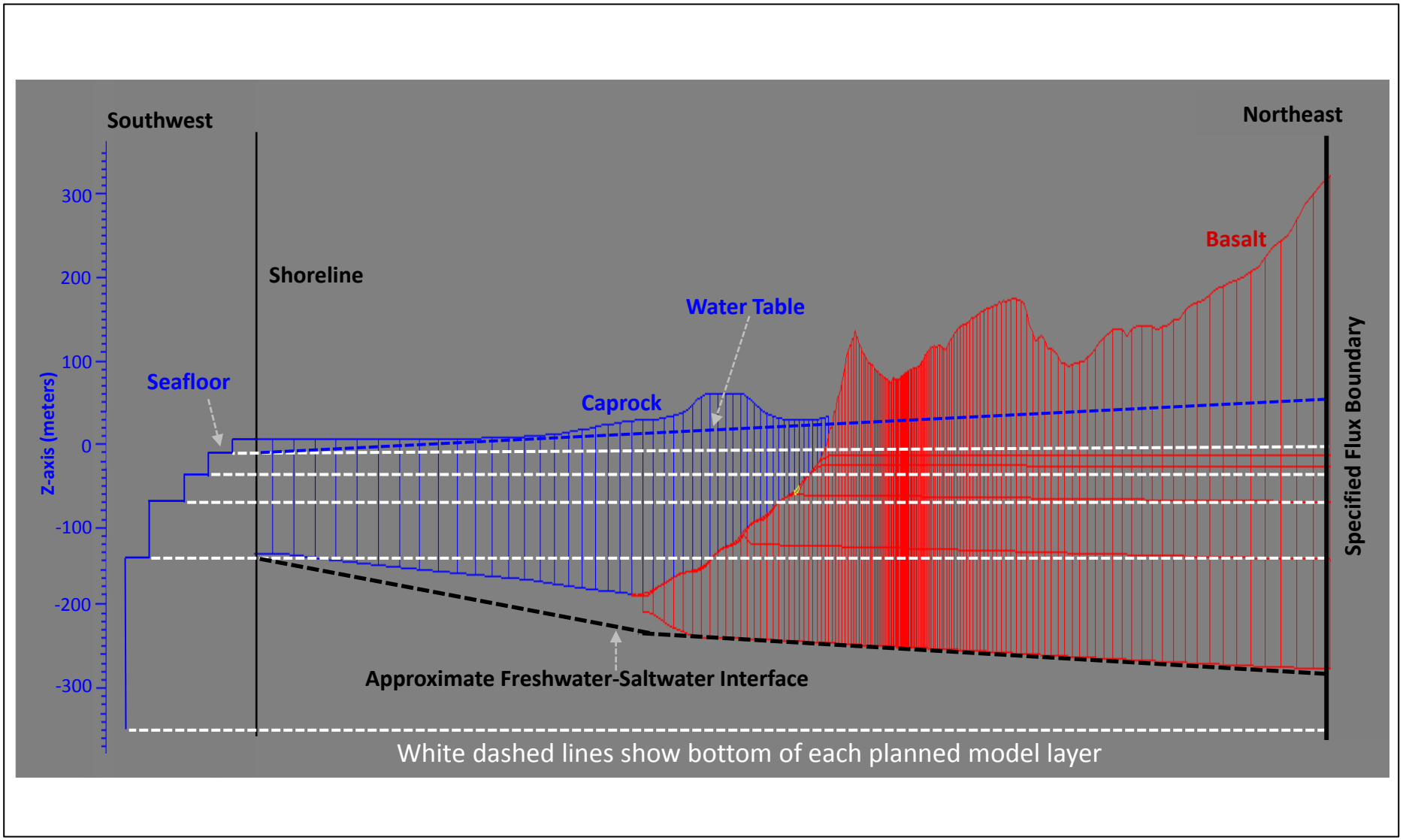

Figure 3
Planned Model Layers Compared to 2007 Model Layers,
Southwest to Northeast Profile
Groundwater Flow Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, Hawaiʻi

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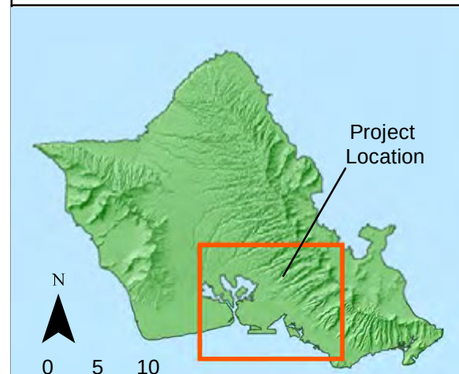
Location Map



Legend

- Pumping Well
- Model Area
- Red Hill Bulk Fuel Storage Facility Boundary
- Stream
- Red Hill Fuel Storage Tank

Notes

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

N

0 3,500 7,000 14,000 Feet

Figure 4
Pumping Wells Within the Model Area
Goundwater Flow Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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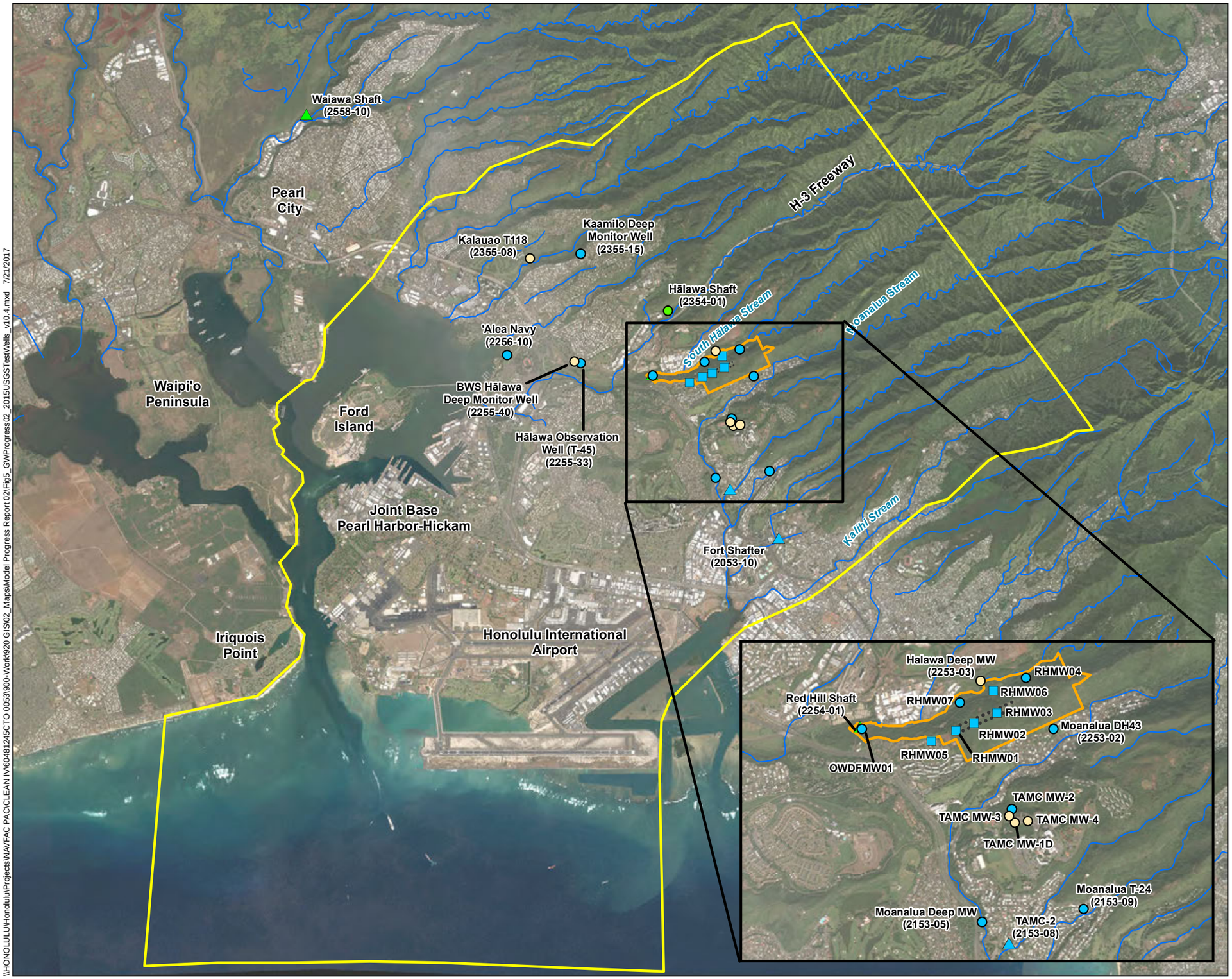
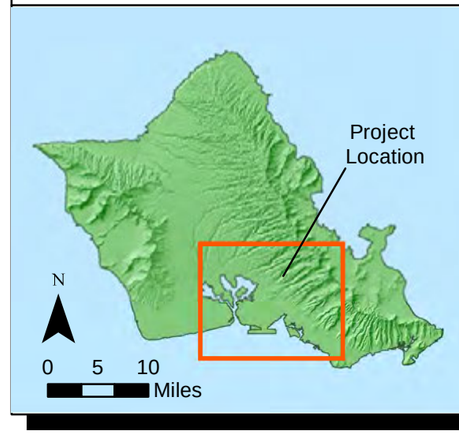


Location Map



Legend

- Planned Well for USGS Test- No Data Collected
- Planned Well for USGS Test- Groundwater Level Data Collected
- Planned Well for USGS Test- Groundwater Level and Pumping Rate Data Collected
- Potential Well for USGS Test- Groundwater Level Data Collected
- Well Not Originally Planned for USGS Test- Groundwater Level Data Collected
- Well Not Originally Planned for USGS Test- Groundwater Level and Pumping Rate Data Collected
- Model Area
- Red Hill Bulk Fuel Storage Facility Boundary
- Stream
- Red Hill Fuel Storage Tank

Notes

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

N

0 4,000 8,000 Feet

Figure 5
Planned, Potential, and Other Wells Involved in the 2015 USGS Aquifer Test
Groundwater Flow Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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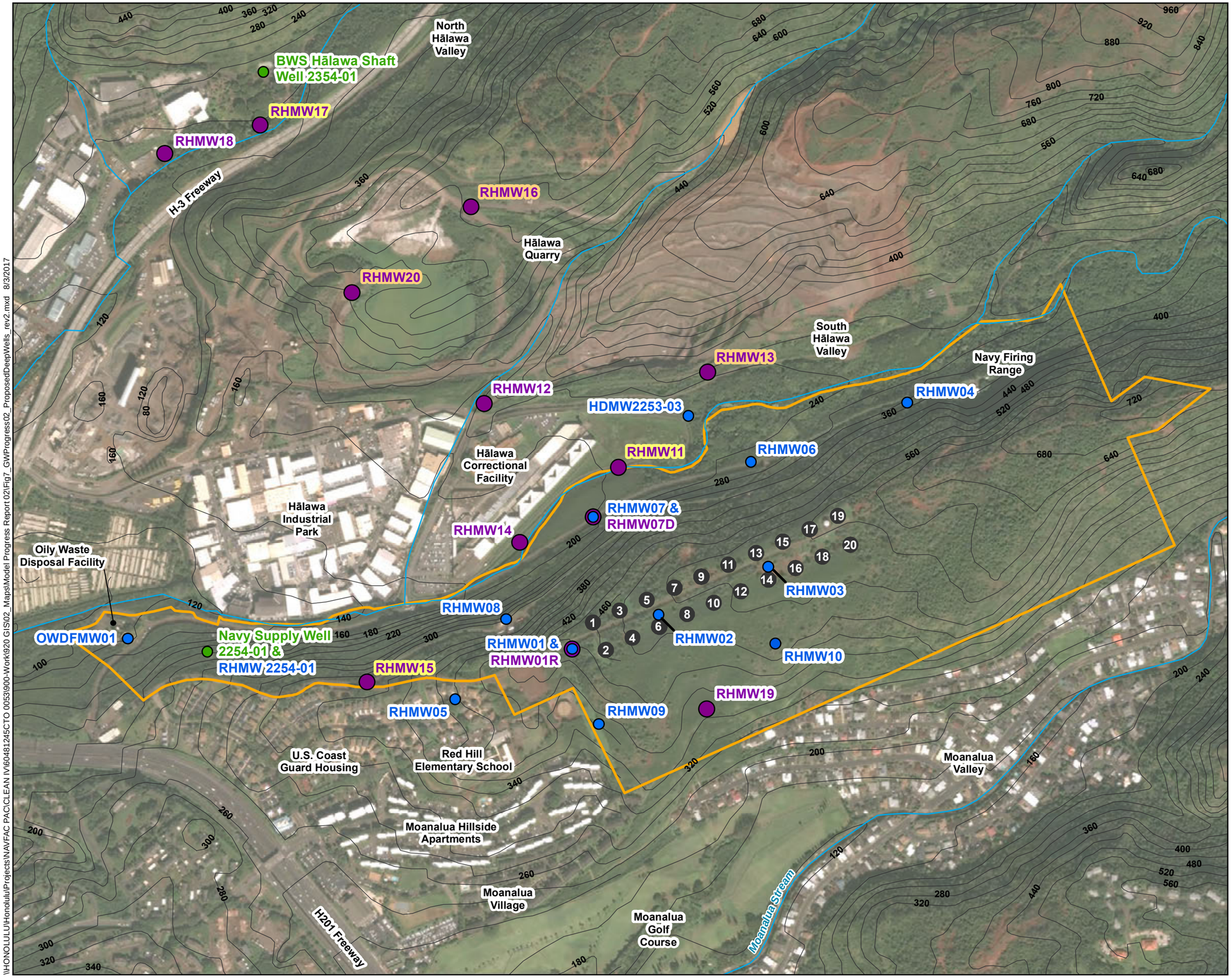
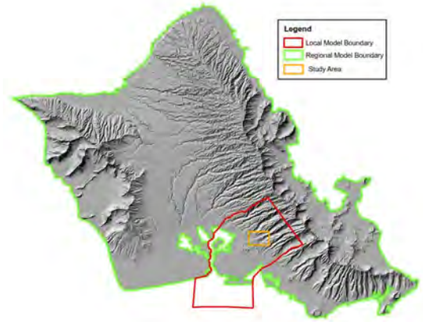


Groundwater Modeling Domain



Legend

- Proposed Monitoring Well Location
- Existing Monitoring Well Location
- Proposed and Existing Monitoring Well Adjacent Locations
- Existing Water Supply Well
- Red Hill Fuel Storage Tank
- Stream
- 400 — Topographic Contour (feet above mean sea level)
- Red Hill Installation Boundary

Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015
3. Coordinates: NAD 1983 UTM Zone 4N
4. RHMW-- indicates well identified for priority installation.
5. RHMW-- indicates three potential wells, one of which will be identified for priority installation.

N

0 500 1,000 2,000 Feet

Figure 6
Proposed Deep Monitor Wells
Near Red Hill Bulk Fuel Storage Facility
Groundwater Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

\\HONOLULU\Honolulu\Projects\NAVFAC PACIFIC\CLEAN IV\60481245\CTO 0053\900-Work\920 GIS\02_Maps\Model Progress Report 02\Fig7_GWProgress02_ProposedDeepWells_rev2.mxd 8/3/2017

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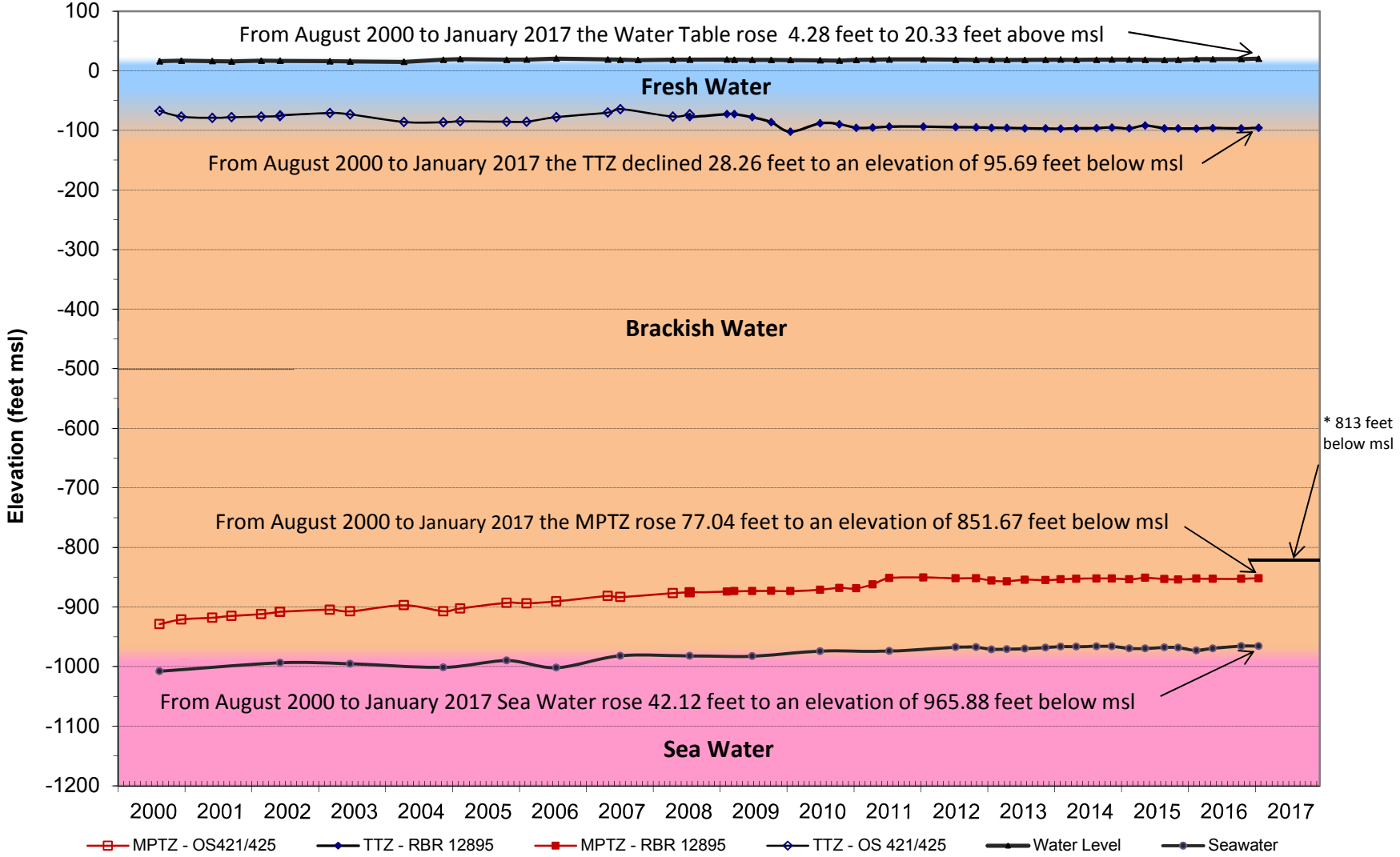
Halawa Deep Monitor Well, Oahu (3-2253-003)

Fluctuations in the Water Table, Top of Transition Zone (TTZ), and Midpoint of Transition Zone (MPTZ)

From August 2000 through January 2017



Notes: : (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl^-); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl^-) (2) Fresh Water < 220 mg/L Cl^-, Brackish Water 220 mg/L CL^- to 16,999 mg/L Cl^-, Sea Water >= 17,000 mg/L Cl^-; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level.

* Since the year 2000, the MPTZ has risen 77 feet, rising toward a calculated Ghyben-Herzberg equilibrium elevation of approximately 813 feet below msl (relative to the Water Table, measured at 20.33 feet above msl). Note the relatively thick mixing zone, resulting from upward borehole flow of an influx of brackish water.

S:\Projects\NAVFAC PAC\CLEAN IV\60481245CTO 0053\900-Work\921 Graphics\GW Model Progress Report 02\Fig8_FreshSalt Interface_Halawa 3-2-2017

last updated 3/2/2017

Figure 7
Freshwater-Saltwater Interface for Hālawa Deep Monitor Well
Groundwater Flow Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

Source: http://files.hawaii.gov/dlnr/cwrm/monitoringdata/dmw_halawa.pdf

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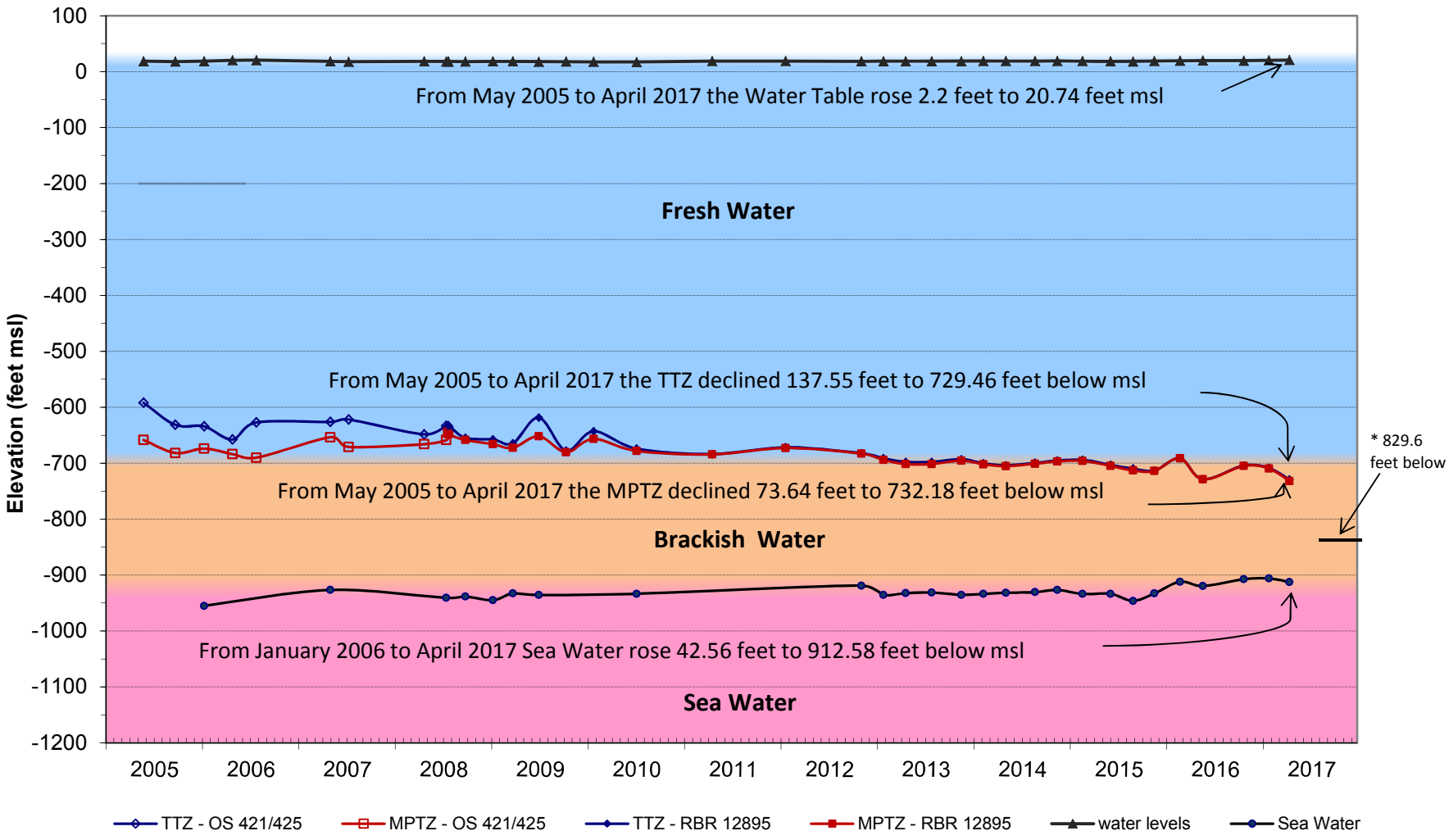
Waimalu Deep Monitor Well, Oahu (3-2456-005)

Fluctuations in the Water Table, Top of Transition Zone (TTZ), and Midpoint of Transition Zone (MPTZ) from May 2005 through April 2017



Notes: : (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl^-); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl^-) (2) Fresh Water < 220 mg/L Cl^-, Brackish Water 220 mg/L CL^- to 16,999 mg/L Cl^-, Sea Water >= 17,000 mg/L Cl^-; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level.

* Since the year 2005, the MPTZ has declined 73.64 feet toward a calculated Ghyben-Herzberg equilibrium elevation of approximately 829.6 feet below msl, relative to the Water Table measured at 20.74 feet above msl.

last updated 4/27/2017

Source: http://files.hawaii.gov/dlnr/cwrm/monitoringdata/dmw_waimalu.pdf

S:\Projects\NAVFAC PAC\CLEAN IV\60481245CTO 0053\900-Work\921 Graphics\GW Model Progress Report 02\Fig9_FreshSalt Interface_Waimalu 4-27-2017.pdf

Figure 8
Freshwater-Saltwater Interface for Waimalu Deep Monitor Well
Groundwater Flow Model Progress Report 02
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, Hawaiʻi

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Appendix A:
Boring Log and Well Construction Diagram, RHMW10
(on CD-ROM)

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Project: CTO53 - Red Hill Bulk Fuel Storage Facilty
Project Location: CTO53
Project Number: 60481245

Key to Log

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SOIL SAMPLES: Type	Number	Blows /12 in.	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation (in feet) referenced to mean sea level (MSL).

2 **Depth:** Distance (in feet) below the collar of the borehole.

3 **Run No.:** Number of the individual coring interval.

4 **Box No.:** Number of the core box which contains core from the corresponding run.

5 **Recovery:** Amount (in percent) of core recovered from the coring interval; calculated as length of core recovered divided by length of run.

6 **Fractures per Foot:** (Fracture Frequency) The number of naturally occurring fractures in each foot of core; does not include mechanical breaks (induced by drilling) or healed fractures. "NA" indicates not applicable due to lack of core recovery.

7 **R Q D:** (Rock Quality Designation) Amount (in percent) of intact core (pieces of sound core greater than 4 inches in length) in each coring interval; calculated as the sum of lengths of intact core divided by length of core run. RQD of highly weathered/altered rock does not meet soundness requirements, but provides some indication of rock quality with respect to the degree of fracturing.

8 **Fracture Drawing:** Sketch of the naturally occurring fractures and mechanical breaks, showing the angle of the fractures relative to the cross-sectional axis of the core. "NR" indicates no recovery.

9 **Fracture Number:** Location of each naturally occurring fracture (numbered) and mechanical break (labeled "M"). Naturally occurring fractures are described in Column 11 (keyed by number) using descriptive terms defined on Sheet 2 (Items a through g).

10 **Lithology:** A graphic log of material encountered using symbols to represent differing soil and types; graphic symbols are explained below.

11 **Description:** Lithologic description in this order: rock type, color (Munsel), texture, grain size, weathering, strength, and other features; descriptive terms are defined on Sheet 2. Also, abbreviated description of fractures numbered in Column 9 using terms defined on Sheet 2.

12 **Well Schematic:** Schematic of piezometer, inclinometer or well installation; graphic symbols are explained below.

13 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

14 **Sample Number:** Sample identification number.

15 **Blows /12 in.:** Number of blows required to advance sampler 12 inches beyond first 6 inch interval or distance noted, using a 140-lb hammer with a 30-inch drop (unless otherwise noted).

16 **Drill Time [Rate]:** Time (in 24-hour clock) marking start and finish of each run; drill rate (in feet per hour) is reported in brackets.

17 **Field Notes and Test Results:** Comments and observations regarding drilling or sampling made by driller or field personnel. Field and lab tests are indicated using abbreviations explained below.

TYPICAL MATERIAL GRAPHIC SYMBOLS


Silty SAND (SC)


Clayey SAND (SC)


Fat CLAY (CH)


BASALT Breccia


BASALT a'a Clinker


Basalt

TYPICAL SAMPLER GRAPHIC SYMBOLS


Grab sample


Standard Penetration (SPT) split spoon sampler


Modified California sampler with brass liners

TYPICAL WELL GRAPHIC SYMBOLS


Blank casing in cement grout


Blank casing in filter sand


Blank casing in cement-bentonite grout


Slotted casing in filter sand


Blank casing in bentonite pellets


Filter sand, native fill or slough

OTHER GRAPHIC SYMBOLS


First water encountered at time of drilling and sampling (ATD)


Water level measured at specified time after completion of drilling and sampling

Minor change in material properties within a stratum

Inferred or transitional contact

FIELD AND LABORATORY TEST ABBREVIATIONS

LL Liquid Limit (from Atterberg Limits)
PI Plasticity Index (from Atterberg Limits), NP=Non Plastic
PP PP Pocket penetrometer field consitency reading, tst
SA Sieve Analysis, %fines (<#200 sieve) and gravel (>#4 sieve)
WA Wash on #200 sieve, % fines (<#200 sieve)
UC Unconfined compressive strength (qu), psf

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

Project: CTO53 - Red Hill Bulk Fuel Storage Facilty Project Location: CTO53 Project Number: 60481245	**Key to Log** Sheet 2 of 2

KEY TO DESCRIPTIVE TERMS USED ON CORE LOGS

DISCONTINUITY DESCRIPTORS

a Dip of discontinuity, measured relative to a plane normal to the core axis.

b **Discontinuity Type:**

- F - Fault
- J - Joint
- Sh - Shear
- Fo - Foliation
- V - Vein
- B - Bedding

c **Aperture (inches):**

- W - Wide (0.5-2.0)
- MW - Moderately Wide (0.1-0.5)
- N - Narrow (0.05-0.1)
- VN - Very Narrow (<0.05)
- T - Tight (0)

d **Type of Infilling:**

- Bi - Biotite
- Cl - Clay
- Ca - Calcite
- Ch - Chlorite
- Ep - Epidote
- Fe - Iron Oxide
- H - Healed
- K^+ - Potassium
- My - Mylonite
- No - None
- Py - Pyrite
- Qz - Quartz
- Sd - Sand
- Si - Silt
- SiCl - Silty Clay
- Uk - Unknown

e **Amount of Infilling:**

- Su - Surface Stain
- Sp - Spotty
- Pa - Partially Filled
- Fi - Filled
- No - None

f **Surface Shape of Joint:**

- Pl - Planar
- Wa - Wavy
- St - Stepped
- Ir - Irregular

g **Roughness of Surface:**

- Slk - Slickensided [surface has smooth, glassy finish with visual evidence of striations]
- S - Smooth [surface appears smooth and feels so to the touch]
- SR - Slightly Rough [asperities on the discontinuity surfaces are distinguishable and can be felt]
- R - Rough [some ridges and side-angle steps are evident; asperities are clearly visible, and discontinuity surface feels very abrasive]
- VR - Very Rough [near-vertical steps and ridges occur on the discontinuity surface]

ROCK WEATHERING / ALTERATION

Description	Recognition
Residual Soil	Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand
Completely Weathered/Altered	Original minerals of rock have been almost entirely decomposed to secondary minerals, although original fabric may be intact; material can be granulated by hand
Highly Weathered/Altered	More than half of the rock is decomposed; rock is weakened so that a minimum 2-inch-diameter sample can be broken readily by hand across rock fabric
Moderately Weathered/Altered	Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 2-inch-diameter sample cannot be broken readily by hand across rock fabric
Slightly Weathered/Altered	Rock is slightly discolored, but not noticeably lower in strength than fresh rock
Fresh/Unweathered	Rock shows no discoloration, loss of strength, or other effect of weathering/alteration

ROCK STRENGTH

Description	Recognition	Approximate UCS Range
Extremely Weak Rock	Can be indented by thumbnail	35 to 150 psi
Very Weak Rock	Can be peeled by pocket knife	150 to 750 psi
Weak Rock	Can be peeled with difficulty by pocket knife	750 to 3,500 psi
Medium Strong Rock	Can be indented 5 mm with sharp end of pick	3,500 to 7,500 psi
Strong Rock	Requires one hammer blow to fracture	7,500 to 15,000 psi
Very Strong Rock	Requires many hammer blows to fracture	15,000 to 37,500 psi
Extremely Strong Rock	Can only be chipped with hammer blows	>37,5000 psi

Project: CT053 – Red Hill Bulk Fuel Storage Facility Project Location: CT053 Project Number: 60481245	Log of Boring RHMW10 Sheet 1 of 32

Date(s) Drilled	03/06/2017	Logged By	M. Higley, Q. Meehan, J. Kronen	Checked By (Date)	J. Kronen
Drilling Method	HQ core / air rotary	Drill Bit Size/Type	HQ diamond bit / 8" tricone bit	Total Depth of Borehole	501.0 feet
Drill Rig Type	Mobile B-59 / T3	Drilling Contractor	Valley Well Drilling	Approximate Surface Elevation	490.97
Groundwater Level	El. 18.2' (3/31/2017)	Location	22.3702166 , -157.962447	Inclination from Horizontal/Bearing	90°
Borehole Completion	4-inch diameter monitoring well. See RHMW10 well cross section for details.			Hammer Data	140 lbs/30-inch drop

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
490	0								ALLUVIUM Very soft, reddish-brown (10R 4/6), CLAY (CL)							Hand auger to 5 ft bgs
	1															
	2															
488	3															
	4															
486	5		1													Begin hollow stem auger
	6															
484	7															
	8															
482	9															
	10															
480	11								VOLCANIC SAPROLITE Variably weathered volcanic rock. Moderately yellowish brown (10YR 5/4) to pale brown (5YR 5/3), slightly to moderate weathered, CLAY (CL) with harder intervals of slightly weak basalt							Variable drilling with mostly soft and some hard intervals
	12															
478	13															

Report: CT053 RED HILL WITH WELL AND PID; File: CT053 RED HILL CORE LOGS.GPJ; 8/1/2017 RHMW10

Project: CT053 – Red Hill Bulk Fuel Storage Facilty
Project Location: CT053
Project Number: 60481245

Log of Boring RHMW10

Sheet 2 of 32

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
476	15															
474	17															
472	19		1													
		1		100	1	60	M M 1		**BASALT Massive a'a** Medium gray (N35), slightly weathered, very strong, 5% large vesicles					0	[19]	End of drilling 3/6/17; Begin 3/7/17 Drilling refusal with auger bit
470	21				0		M M 1									
					2		2		1. 90, J, T 2. 45, J, Vn, Fe+Mn, Su, St, SR 3. 0, J, T, Fe+Mn+Cl, Su, Ir, SR							
	22						3		4. 20, J, T, Fe+Mn, Su, Wa, SR 5. 0, J, T, Fe+Mn, Su, Pl, SR 6. 90, J, VN–N, Fe+Cl, Fi, Pl, SR							
		2		100	3	52	4 5		7. 20, J, VN–N, Fe+Cl, Fi, Wa, SR 8. 30, J, T, Fe+Mn, Su, Ir, Sr					0	[25]	
468	23								9. 5, J, VN, Cl, Pa, Wa, Sr							
					1		6									
	24						7 8 9									
					3											
466	25						M									
					0											
	26								**Saprolite** Moderately red (5R 5/6), completely weathered, extremely weak							
					0											
464	27								**BASALT Pahoehoe** Moderately reddish brown (10R 4/6), highly weathered, very weak, 35%– 40% small vesicles infilled with clay							
		3		100	0	38	1 2							0	[50]	
	28						IF		1. 60, J, Vn, Cl, Pa, Wa, SR 2. 20, J, N, Fe+Cl, Pa, Wa, SR 3. 90, J, Vn, Fe+Cl, Pa, Pl, S							
					2		3		4. 30, J, Vn, Fe+Mn, Fi, Pl, SR 5. 45, J, T, Fe+Mn, T,Su, Pl, SR							
462	29															

Report: CT053 RED HILL WITH WELL AND PID; File: CT053 RED HILL CORE LOGS.GPJ; 8/1/2017 RHMW10

Project: CT053 – Red Hill Bulk Fuel Storage Facility
Project Location: CT053
Project Number: 60481245

Log of Boring RHMW10

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	29				2		4 5		less weathered, grayish red (10R 4/2)							
	30				2		M 1 2									
460	31				3		3 4 5									
	32	4		100	2	53	6		1. 30, J, T, Fe, Su, St, R 2. 30, J, T, Fe, Su, St, R 3. 20, J, T, Fe, Su, St, R 4. 0, J, MW, Cl, Pa–Fi, St, R					0	[100]	
458	33		2				7		5. 0, J, MW, Cl, Pa–Fi, St, R 6. 30, J, VN, Fe+Cl, Pa, Wa, SR 7. 0, J, VN, Fe+Cl, Pa, Wa, SR							
	34				10+		F1		F1. J, T–VN, Fe+Cl, Pa, Wa, SR F2. J, T, Fe+Mn, Su, Wa, SR							
					10+		F2									
456	35								moderate gray (N5) to dark gray (N3), fresh to slightly weathered, strong							
					2		M 1									
	36				10+		M 2		1. 15, J, VN, Cl, Fi, Wa, R 2. 10, J, T, Fe+Mn, Su, Ir, R 3. 60, J, N, Cl, Fi, Pl, SR 4. 60, J, T–VN, Fe+Mn, Pa, Wa, R 5. 0, J, T, Fe+Mn, Su, Wa, SR 6. 60, J, T, Fe+Mn, Su, Pl, SR							
454	37						M E M									
		5		100	10+	65	M F2 F3							0	[30]	
	38				0											
452	39				3		M 4 5 6									
	40				3		1 2		grayish red (5R 5/4), slightly to moderately weathered, banded intervals of high vesicularity (20–30%) to less than 1% vesicles							
450	41				1		3		1. 30, J, VN, Cl, Fi, Pl, Sm 2. 30, J, T, Fe, Su, Wa, SR 3. 20, J, VN, Cl, Fi, Pl, Sm							
	42						M 4 5 6		4. 90, J, T, Fe, Su–Pa, Wa, SR 5. 45, J, T, Fe, Su, Pl, S 6. 45, J, T, Fe, Su, Wa, SR 7. 90, J, T, Fe, Su, Ir, SR							
		6		92	2	28								0	[27]	
448	43		3		1		7		BASALT a'a Welded Clinker BASALT Massive a'a							
	44				0				1. 90, J, N, Fe+Cl, Pa, Ir, R 2. 0, J, N, Fe+Cl, Pa, Wa, SR							
446	45															

Report: CT053 RED HILL WITH WELL AND PID; File: CT053 RED HILL CORE LOGS.GPJ; 8/1/2017 RHMW10

Project: CT053 – Red Hill Bulk Fuel Storage Facility
Project Location: CT053
Project Number: 60481245

Log of Boring RHMW10

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	45				1		1, 2, M									
	46				NA				**BASALT a'a Clinker** Moderately reddish brown (10R 4/6), completely weathered, extremely weak							
444	47	7		100	NA	13								0	[30]	
	48				NA				**BASALT Airfall Deposit** Dark reddish brown (10R 3/4), completely weathered, extremely weak, with 1" rounded spatter clasts in fine grained matrix							
442	49				NA											
	50				NA											
	51				NA											
440	52		4													
	53	8		100	1	33	1		**BASALT Massive a'a** Dark gray (N4), unweathered to slightly weathered, very strong, with <1% vesicles 1. 10, J, T, Fe+Mn, Su, Ir, SR 2. 70, J, T, Fe+Mn, Su, Pl, S 3. 30, J, T–VN, Fe+Cl, Pa, Wa, R 4. 20, J, T, Fe+Mn, Su, Wa,SR 5. 45, J, T, Fe, Su, Pl–Wa, S					0	[17]	
438	54				2		2, 3, 4									
	55				1		5									
436	56				0											
	57				0											
434	58	9		100	1	98	1		1. 20, J, T, Fe+Mn, Su, Wa, R 2. 20. J, T, Fe+Mn, Su, Wa, R					0	[15]	
	59				1											
432	60				0		2, M									
	61		5		1		M		healed vertical fractures							Driller experiencing core retrieval problems
430																

Project: CT053 – Red Hill Bulk Fuel Storage Facility
Project Location: CT053
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Log of Boring RHMW10

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type / Number / Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	61													
					2		1 M 2		1. 80, J, T, Fe+Mn, Su, Pl, SR 2. 0, J, T, Fe+Mn, Su, Pl, S 3. 45, J, VN, Fe+Cl, Pa, Wa, SR					
	62													
		10		100	0	83						0	[30]	
428	63													Total water used to 63 ft bgs ~3600 gal
					1		3							
	64													
					0				increase in vesicles up to 5–10%					
426	65													
					0									
	66						M		1. 20, J, T, Fe+Mn, Su, Pa, R 2. 5, J, T, Fe+Mn, Su, Wa, Sr 3. 0, J, T, Fe+Mn, Su, Wa, Sr 4. 0, J, T, Fe+Mn, Su, Wa, S 5. 70, T, Fe+Mn, Sp, Pl, VR					
					1		1							
424	67						2							Some Water return, water loss ~400 gal
		11		100	2	85	3					0	[21]	
	68													
					1									
422	69						4							
					1		5							
	70		6				1							
					1		M							
420	71								1. 0, J, T, Fe+Mn, Su, Wa, SR 2. 60, J, T, Fe+Mn, Su, Wa, SR 3. 0. J, T, Fe+Mn, Su, Wa, R 4. 60. J, VN, Cl, Fi, Pl, SR 5. 30. J, VN, Cl, Pa, Pl, SR					
					2		2							
	72						3							
		12		100	0	95						0	[75]	Some Water return, water loss ~500 gal
418	73						M							
					2		4 M							
	74						5							
					0									
416	75													End of drilling 3/7/17; Begin 3/8/17
					0		M							
	76						1F							
					10+									
414	77						1							

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Project: CT053 – Red Hill Bulk Fuel Storage Facility
Project Location: CT053
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Log of Boring RHMW10

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	77															
		13		100	1	26	2		**BASALT Pahoehoe** Dark reddish brown (10R 3/4), highly weathered, very weak					0	[30]	
	78						M		moderately weathered, moderately strong to weak							
					1		3		1. 70, J, T, Fe+Mn, Su, Pl, S 2. 80, J, T, Fe+Mn, Sp, Ir, R 3. 45, J, VN–N, Uk, Pa, Ir, R 4. 45, J, VN, Fe+Mn, Pa, Pl, R							Lose water return for the remainder of the boring, water loss ~500 gal
412	79															
					1											
	80		7				4		1. 60, J, VN, Fe+Cl, Fi, Pl, S–SR 2. 0, J, VN, Fe+Cl, Pa, Ir, R 3. 70, J, VN, Fe+Cl, Pa, Ir, R 4. 0, J, T, Fe+Mn, Su, St, SR							
					0											
410	81						1									
					3		2									
	82						3									
		14		94	NA	35			**BASALT Tuff** Pale reddish brown (10R 5/4), highly weathered, weak to very weak					0	[25]	
408	83															Water loss ~500 gal
					NA											
	84								**BASALT Pahoehoe** Reddish brown (10R 5/4), highly weathered, moderately weak, intensely fractured							
					10+		4									
406	85						IF									
					NA				**BASALT Tuff** Dark yellowish brown (10YR 4/2) mottled with brown (5YR 4/4), highly weathered, weak, with alternating fine grained deposits							
	86															
					NA				1. 10, J, T, Fe+Mn, Su, Ir, SR 2. 80, J, T, Fe+Mn, Su, Pl, SR							
404	87						1									Water loss ~400 gal
		15		80	NA	16								0	[19]	
							2									
	88								**BASALT Massive a'a** Dark yellowish brown (10YR 4/2), slightly to moderately weathered, moderately strong, fractured with clay infilling							
					10+		IF									
							IF									
402	89															
					10+		NR									
	90															
			8		10+		IF									
							IF									
400	91															
					10+											
	92								pervasively fractured, highly weathered, weak							
		16		100	NA	16			**BASALT a'a Clinker** Moderately reddish brown (10R 4/6) to dark reddish					0	[21]	
398	93															

Report: CT053 RED HILL WITH WELL AND PID; File: CT053 RED HILL CORE LOGS.GPJ; 8/1/2017 RHMW10

Project: CT053 – Red Hill Bulk Fuel Storage Facility
Project Location: CT053
Project Number: 60481245

Log of Boring RHMW10

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
396	95				NA		NR		brown (10R 3/4), moderately to highly weathered, weak, partially welded in intervals							Water loss ~600 gal
	96				NA											
394	97	17		100	NA	0								0	[16]	Water loss ~600 gal
	98				NA											
392	99				NA											
	100				NA				moderately weathered							Water level in core rods dropped from 36.05 to 49.06 ft bgs in 11 minutes
390	101				NA				dusky red (5R 3/4)							
	102	18	9	50	NA	0								0	[23]	
388	103				NA											Water loss ~600 gal, drill chatter and core jamming
	104				NA											
386	105				NA		1 M		welded, slightly to moderately weathered, strong to moderately strong							Core chatter and jamming, begin pumping water down annulus of borehole
	106				NA		M		1. 90. J, T, Fe+Mn, Su, Wa, SR 2. 30, J, T, Fe+Mn, Su, Wa, R							
384	107				NA		M									
	108	19		100	NA	88	2		highly weathered with mottled orange (10R 6/6) clay					0	[25]	Water loss ~500 gal
382	109				NA											

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	109				NA											
	110															
380	111				1				BASALT Massive a'a Dark gray (N3), fresh to slightly weathered, very strong, with <1% vesicles							
					2		1 2 3		1. Healed tight seam 2. 70, J, T, Fe+Mn, Su, Pl, SR–S 3. 70, J, VN, Fe+Cl, Pa, SR 4. 30, J, T, Fe+Mn, Su, Pl, SR 5. 10, J, T, Fe+Mn, Su, St, R–VR							
	112		10													
		20		100	1	100	4							0	[25]	
378	113															Water loss ~600 gal
					1		5		vesicular/scoriaceous, 7% vesicles, strong, slightly weathered, with scoriaceous, highly weathered, welded clinker inclusions							
	114															
					0											
376	115															
					0											
	116								non–scoriaceous, <1% vesicles							
					0				1. 20, J, T, Fe+Mn, Su, Wa, R 2. 70, J, VN, Fe+Cl, Pa, Pl, SR 3. 45, J, VN, Fe+Cl, Pa, St, R 4. 90, J, VN, Fe+Cl, Sp, Wa, R 5. 2, J, T, Fe+Mn, Su, Wa, R 6. 10, J, T, Fe+Mn, Su, Wa, R 7. 70, J, N, Fe+Cl, Sp, Wa, R							
374	117						1									Water loss ~500 gal
		21	11	100	1	68								0	[19]	
	118						2 3									
					2											
372	119						IF 4 5 IF 6		5% vesicles							
					4											
	120						7									
					1		1		1. 70, J, VN, Fe+Cl, Pa, Wa, R 2. 0–45, J, T, Fe+Mn, Su, St, R 3. 70, J T, Fe+Mn, Su, Wa, R 4. 45, J, T, Fe+Mn, Su, St, VR 5. 45, J, T, Fe+Mn, Su, St, SR 6. 45, J, T, Fe+Mn, Su, St, VR 7. 90, J, VN, Fe+Cl, Pa, Wa, R							
370	121						2									
					2											
	122						3 IF IF 5 6									Water loss ~500 gal
		22	12	85	10+	32								0	[20]	
368	123						7		moderate red (5R4/6), highly to completely weathered, weak to extremely weak, pervassively fractured							
					NA											
	124															
					NA											
366	125															

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	125				NA				less silt, more sand size particles (likely mechanical)							
	126				NA											
364	127	23		50	NA	12								0	[16]	Water loss ~500 gal
	128				NA											
362	129				NA											
	130				NA				BASALT Welded a'a Clinker Moderately reddish brown (10R 4/6) to dark reddish brown (10R 3/4), slightly to moderately weathered, strong to moderately strong, with 10% vesicles							
360	131				1		1		BASALT Massive a'g Dark gray (N4), slightly weathered, strong, with 5% vesicles 1. 45, J, T, Fe+Mn, Su, Wa, R 2. 5, J, T, Fe+Cl, Sp, Wa, R 3. 45, J, T, Fe+Mn, Su Wa, R							
	132	24	13	100	1	100	2							0	[27]	
358	133				1				10% vesicles							
	134				0		3									
356	135				2		1 2		olivine crystal in vesicle 1. 45, J, N, Fe+Cl, Fi, Wa, SR 2. 45, J, VN, Fe+CL, Pa, Wa, R 3. 45, J, T, Fe+Cl, Sp, Wa, R 4. 10, J, VN, Fe+Cl, Sp, Wa, R 5. 70, J, VN, Fe+Cl, Pa, Wa, R 6. 70, J, VN, Fe+Cl, Pa, Wa, R 7. 80, J, VN, Fe+Cl, Pa, Wa, R 8. 45, J, VN, Fe+Cl, Pa, Wa, R						
	136				0											
354	137	25		100	3	65	3 5 4							0	[30]	Water loss ~100 gal
	138				2		6 7									
352	139				1		8									
	140				1		1 IF 2		1. 60, J, VN, Fe+Cl, Pa, Wa, R 2. 5, J, VN, Fe+Cl, Pa, Wa, R 3. 45, J, VN, Fe+Cl, Pa, Wa, R							
350	141															

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	141				1											
	142															Water loss ~250 gal
		26		82	10+	36	M 3 IF							0	[33]	
348	143								void							Drill string drops ~0.5 ft
					10+		IF		dark reddish brown (10R 3/4), moderately weathered, moderately strong to weak, highly fractured/rubble							
	144															
					10+											
346	145															
					10+											
	146															
					10+		1 M		slightly weathered, moderately strong to strong, grades from dark reddish brown (10R 3/4) to medium dark gray (N4)							
344	147						IF		medium dark gray (N4), 10% vesicles							Water loss ~550 gal
		27		80	1	8	M M							0	[14]	
	148						2		1. 20, J, T, Fe+Mn, Su, Wa, VR 2. 45, J, VN, Fe+Cl, Sp, Wa, R							
					10+		M									
342	149															
					10+		NR									
	150		14						moderately to highly weathered, weak to moderately strong, intensely fractured (possibly mechanically)							End of drilling 3/8/17, no water encountered; Begin 3/9/17, water level recorded at 149.75 ft bgs
					NA		IF									
340	151															
					NA		NR									
	152															Per driller: soft drilling 150~153.8 ft bgs
		28		48	NA	8								0	[30]	
338	153															Water loss ~300 gal
					NA											
	154						MB		BASALT a'a Clinker Reddish brown (10YR 4/6) to medium dark gray (N4), slightly to moderatelyweathered, strong to moderately strong, with 10% vesicles							Per driller: better drilling at 153.8 ft bgs
					3		1 2 3									
336	155						1 2 3		1. 15, J, VN, Fe+Mn, Su, St, VR 2. 15, J, N, Fe+Mn, Su, IR, R 3. 35, J, N, Fe+Mn, Su, St, VR							
					4		4									
	156								BASALT Massive a'a Dark gray (N4), slightly weathered, strong to very strong, 10% vesicles, many stretched							
					2		5									
334	157															

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	157						6		1. 20, J, VN, Fe, Su, St, VR							Water loss ~250 gal
		29		100	2	48	7		2. 20, J, VN, Fe, Su, St, VR					0	[75]	
							8		3. 75, J, VN, Fe+Mn+Cl, Sp, Pl, SR							
							9		4. 0, J, VN, Fe, Su, Wa, R							
	158						10		5. 75, J, VN, Fe+Mn, Sp, Wa, R							
									6. 15, J, VN, Fe+Mn+Cl, Sp, Wa, R							
					2				7. 60, J, VN, Fe+Mn+Cl, Sp, Wa, R							
							11		8. 80, J, VN, Fe+Mn+Cl, Sp, Wa, R							
332	159								9. 45, J, VN, Fe+Mn+Cl, Sp, Wa, SR							
									10. 45, J, VN, Fe+Mn, Su, Wa, SR							
					0				11. 20, J, N, Fe+Mn, Su, St, R							
	160								15% vesicles, less stretched							
					2		1									
							M									
330	161						2		1. 45, J, VN, Fe+Mn, Su, Wa, SR							
							3		2. 20, J, VN, Fe+Mn, Su, Wa, SR							
					2		5 4		3. 0, J, VN, Fe+Mn, Su, Wa, SR							
							6		4. 90, J, VN, Fe+Mn, Su, St, R							
	162								5. 0, J, VN, Fe+Mn, Su, St, R							
									6. 10, J, VN, Fe+Mn+Cl, Su, Wa, SR							Water loss ~250 gal
		30	15	100	1	93	MB		7. 10, J, VN, Fe+Mn, Su, Wa, SR							
328	163								8. 45, J, VN, Fe+Mn, Su, Wa, SR					0	[25]	
					1											
	164						7									
					1		8									
326	165								Some stretched vesicles							
							M									
					3		3		1. 50, J, VN, Fe+Mn+Cl, Sp, Wa, SR							
									2. 50, J, VN, Fe+Mn+Cl, Sp, Wa, SR							
	166						4		3. 90, J, VN, Fe+Mn, Su, Wa, SR							
									4. 0. J, VN, Fe+Mn+Cl, Sp, Pl, SR							
					0				5. 5, J, VN, Fe+Mn, Sp, Pl, SR							
							M		6. 15. J, VN, Fe+Mn, Su, Wa, R							
324	167								7. 60, J, VN, Fe+Mn, Su, Wa, R							
							5		8. 0, J, VN, Fe+Mn, Su, Pl, SR							
									9. 10, J, VN, Fe+Mn, Su, St, SR							Water loss ~450 gal
		31		100	2	63	6		10. 60, j, VN, Fe+Mn+Cl, Su, St, SR					0	[27]	
	168						M									
					2		7									
							8									
322	169						9									
					2											
							10									
	170		16													
					1											
320	171						1									
					1				1. 5, J, VN, Fe+Mn, Su, Pl, SR							
							2		2. 75, J, Vn, Fe+Mn, Su, IR, R							
	172								3. 45, J, VN, Fe, Mn, Su, Pl, SR							
									4. 85, J, VN, Fe+Mn, Su, Wa, SR							
									5. 85, J, VN, Fe+Mn+Cl, Sp, Wa, SR							
									6. 5, J, VN, Fe+Mn, Su, Wa, SR							Water loss ~400 gal
		32		96	3	80			7. 90, J, T, H, No, IR, R							
318	173						5 4		8. 0, J, N, Fe+Mn+Cl, Sp, Wa, VR					0	[27]	
							3		9. 90, J, T, H, No, Pl, S							

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Elevation, feet	Depth, feet	Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	173				2		6, 7		10. 90, J, N, Fe+Mn+Cl, Sp, Wa, R							
	174				2		8, 9, 10									Per driller: softer drilling 174.5~175 ft bgs
-316	175						IF		**BASALT Pahoehoe** Dark reddish brown (10R 3/4), moderately to highly weathered, weak, with ~30% rounded vesicles, intensely fractured							
					10+		1									
	176						MB		slightly to moderately weathered, strong, larger vesicles, with trace clay infill from 176 ft to 176.3 ft bgs							
					1		2									
-314	177								1. 45, J, N, Fe+Mn+Cl, Sp, Pl, R 2. 45, J, VN, Fe+Mn+Cl, Sp, St, VR 3. 30, J, VN, Fe+Mn, S, Pl, SR 4. 60, J, N, Fe+Mn, Su, Wa, SR 5. 60, J, VN, Fe+Mn+Cl, Sp, Pl, SR							
		33		96	2	57	3							0	[50]	Water loss ~350 gal
	178						4		30–40% vesicles, vesicles smaller							
					1											
-312	179						5									
					10+		IF		intensely fractured							
	180						NR		no recovery							
					10+				**BASALT a'a Clinker** Dark reddish brown (10R 3/4) to dark gray (N4), moderately weathered, moderately strong to weak, intensely fractured, with clayey sand (possibly mechanical)							
-310	181				10+		1		1. 45, J, VN, Cl, Sp, Ir, VR							
	182						MB									
		34		42	10+	6	NR							0	[18]	Water loss ~1800 gal (included water to re-advance casing to 184 ft bgs)
-308	183				10+				no recovery							
	184		17		10+											Inner barrel stuck, pull casing; WL recorded in open hole to 184.2 ft bgs (bottom of hole)
-306	185				NA				moderately to highly weathered, weak to moderately strong, traces of clay on fracture and clinker fragment surfaces, intensely fractured							
	186						IF		1. 30, J, N, Fe+Cl, Sp, Ir, VR 2. 45, J, N, Fe+Mn, Su Ir, VR							
					NA		1									
-304	187						2									
		35		50	NA	80	IF							0	[27]	Water loss ~400 gal
	188						NR		no recovery							
					NA											
-302	189															

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	189				NA		NR		no recovery							
	190															
-300	191				NA		IF									
	192				NA		1									
		36		88	10+	22	2 3 IF		**BASALT Massive a'a** Gray (N4), slightly weathered, strong to very strong, with ~15% vesicles with trace clay on vesicle walls					0	[23]	Water loss ~800 gal
-298	193						4		← large vesicle with clay coating and dark reddish brown (10R 3/4) alteration on walls							
					10+		5 6		1. 60, J, N, Fe+Si, Sp, Pl, R 2. 75, J, VN, Fe+Mn+Si, Sp, Pl, SR 3. 10, J, N, Fe+Mn+Cl, Sp, Ir, VR 4. 0, J, VN, Fe+Mn, Su, Pl, SR 5. 45, J, VN, Fe+Mn, Su Wa, R 6. 60, J, VN, Fe+Mn, Su, Pl, S							
	194						IF									
					10+		NR									
-296	195															
					NA		IF		**BASALT a'a Clinker** Moderately brown (5YR 3/4) to dark reddish brown (10R 3/4), highly to moderately weathered, weak to moderately strong							
	196															
					NA				**BASALT Massive a'a** Medium dark gray (N4) to dark reddish brown (10R 3/4), moderately weathered to slightly weathered, strong, intensely fractured							
-294	197						IF									
		37		86	10+	35	1 2		← medium dark gray (N4), slightly weathered, strong to very strong, 15% vesicles					0	[25]	Water loss ~900 gal
	198						3		1. 20, J, VN, Fe+Mn, Su, Ir, VR 2. 90, J, VN, Fe+Mn+Cl, Sp, Wa, SR 3. 15, J, Vn Fe+Mn, Pa, Wa, R 4. 60, J, VN, Fe+Mn, Su, Pl, SR							
					1											
-292	199		18				4									
					10+		NR		no recovery							
	200						IF		← very dense, 5–10% vesicles							Water level in core rods dropped from 197.3 to 198.08 ft bgs in 36 minutes
					1											
	201						IF									
-290					3		3 2		1. 15, J, VN, Fe+Mn, Su, Pl, SR 2. 0, J, VN, Fe+Mn, Su, St, VR 3. 85, J, VN, Fe+Mn+Cl, Su, Pl, SR 4. 5, J, VN, Fe+Mn, Su, Pl, SR 5. 5, J, VN, Fe+Mn, Su, Wa, SR 6. 0, J, VN, Fe+Mn+Cl, Sp, Wa, SR 7. 80, J, VN, Fe+Mn, Su, Wa, SR							
	202						4									Water loss ~750 gal
		38		100	1	78	5							0	[30]	
-288	203						6									
					2											
	204															
					1				← dark reddish brown (10R 3/4) to medium dark gray (N4), ~35% vesicles, smaller vesicles							
-286	205						7									

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	205				NA				**BASALT a'a Clinker** Dark reddish brown (10R 3/4) to medium dark gray (N4), moderately to highly weathered, weak							
	206				NA		IF									
284	207	39		44	NA	0	NR		no recovery					0	[27]	Water loss ~400 gal
	208				NA											
282	209				NA											
	210		19				IF									End of drilling 3/9/17; Begin 3/10/17
	211				NA		MB		**BASALT Massive a'a** Medium dark gray (N4), slightly weathered, strong, with ~20% vesicles							
280					1		1		1. 60, J, VN, Fe+Mn, Su, Pl, S 2. 0, J, VN, Fe+Mn, Su, Pl, SR 3. 0, J, T, Fe+Mn, Su, Pl, R 4. 0, J, T, Fe+Mn, Su, Pl, R 5. 0, J, VN, Fe+Mn+Cl, Sp, Pl, SR 6. 0, J, VN, Fe+Mn+Cl, Sp, Pl, SR 7. 0, J, VN, Fe+Mn+Cl, Sp, Pl, R contains large vugs						
	212	40		94	0	45	MB							0	[25]	Water loss ~550 gal
	213						2									
278					3		3									
	214						4 MB 5 6									
					3		7									
276	215						NR		no recovery vesicles larger and more elongate							
					1		MB MB									
	216						1 2		1. 0, J, T, Fe+Mn, Su, Wa, SR 2. 0, J, T, Fe+Mn, Su, Wa, SR 3. 0, J, T, Fe+Mn, Su, Wa, SR 4. 90, J, VN, Fe+Mn+Cl, Sp, Wa, SR 5. 30, J, N, Fe+Mn+Cl, Sp, Ir, R 6. 90, J, N, Fe+Mn+Cl, Sp, Ir, R 7. 15, J, VN, Fe+Mn+Cl, Sp Wa, SR 8. 60, J, T, Fe+Mn, Su, Pl, SR						
					10+		IF									
274	217						3									
		41		100	4	47	4							0	[21]	Water loss ~450 gal
	218						5 6 7									
					NA											
272	219						8									
					NA		IF		**BASALT a'a Clinker** Dark reddish brown (10R 3/4) to medium dark gray (N4), moderately to highly weathered, weak							
	220															
					NA		IF									
270	221															

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Elevation, feet	Depth, feet	Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	221						IF									
					NA		NR									
	222															Water loss ~350 gal
		42	20	52	NA	0			no recovery					0	[25]	
268	223															
					NA											
	224						IF		BASALT Massive a'a Medium dark gray (N4) to dark reddish brown (10R 3/4), slightly weathered, moderately strong to very strong, intensely fractured, fracture surfaces with Fe/Mn staining, ~20% vesicles							
					10+											
266	225								medium dark gray (N4), slightly weathered, strong to very strong, highly to intensely fractured (some mechanical) 1. 45, J, VN, Fe+Mn, Su, Pl, SR 2. 5, J, VN, Fe+Mn, Su, Wa, R 3. 10, J, VN, Fe+Mn, Su, Wa, SR 4. 80, J, T, Fe+Mn, Su, Pl, SR							
					10+		IF									
	226						1									
					10+											
264	227						IF									
		43		100	10+	18			intensely fractured					0	[23]	Water loss ~350 gal
	228															
					10+		IF									
262	229						2									
					3											
							3									
	230						4									
					10+											
							IF		intensely fractured							
260	231															
					10+											
							2	1	BASALT Pahoehoe Medium dark gray (N4), slightly weathered, moderately strong to strong, ~40% vesicles with 2" moderate reddish brown (10R 4/6) weak, burn margin/alteration zone at 231.6' bgs							
	232							MB								
		44		100	1	40		MB						0	[25]	Water loss ~200 gal
									1. 45, B, N, Fe+Mn, Su, Wa, R 2. 60, J, VN, Fe+Mn, Su, Wa, SR 3. 5, J, VN, Fe+Mn, Su, Pl, SR							
258	233							3								
					0											
	234							MB	brownish black (N4), intensely fractured							
					10+		IF									
256	235		21				M		1. 60, J, VN, Fe+Mn+Cl, Sp, Wa, R 2. 70, J, VN, Fe+Mn+Cl, Sp, Wa, R 3. 60, J, VN, Fe+Mn+Cl, Sp, Wa, R 4. 45, J, VN, Fe+Mn+Cl, Sp, Wa, R 5. 80, J, VN, Fe+Mn+Cl, Sp, Wa, R 6. 45, J, VN, Fe+Mn+Cl, Sp, Wa, R 7. 0, J, N, Fe+Mn, Su, Wa, SR 8. 90, J, N, Fe+Mn, Su Wa, SR 9. 45, J, N, Fe+Mn, Su, Wa, SR							
					2		IF									
	236						1									
							2									
					2											
254	237						3									
								4								

Report: CT053 RED HILL WITH WELL AND PID; File: CT053 RED HILL CORE LOGS.GPJ; 7/28/2017 RHMW10

Project: CT053 – Red Hill Bulk Fuel Storage Facility
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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
252	237								10. 30, J, N, Fe+Mn, Su, Pl, SR 11. 90. J, Fe+Mn+Cl, Sp, Wa, R							Water loss ~125 gal
	238	45		100	10+	50								0	[60]	
	239				2				dark reddish brown (10R 3/4), smaller vesicles							
	240				3											
250	241				10+				medium dark gray (N4), larger vesicles							
	242				1				1. 90, J, N, Fe+Cl, Fi, Wa, SR 2. 45, J, N, Fe+Cl, Fi, Wa, SR 3. 0, J, VN, Cl, Sp, Wa, R 4. 30, J, VN, Cl, Pa, Wa, R 5. 20, J, T, Fe+Mn+Cl, Pa, St, SR–R 6. 20, J, T, Fe+Mn+Cl, Pa, St, R 7. 45, J, VN, Fe+Mn+Cl, Pa, Wa, VR						
248	243	46	22	100	1	18								0	[60]	Water loss ~150 gal
	244				3				smaller vesicles mottled medium dark gray (N4) and dark reddish brown (10R 3/4)							
	245				10+				intensely fractured with Fe+Mn+Cl on fractures							
246	246				10+				1. 2, J, VN, Fe+Mn+Cl, Pa, Wa, R 2. 10, J, MW, Fe+Mn+Cl, Pa, Wa VR 3. 0, J, N–MW, Fe+Mn+Cl, Pa, Wa, R 4. 20, J, VN, Fe+Mn+Cl, Pa, Wa, R 5. 10, J, N, Fe+Mn+Cl, Pa, Wa, R–VR 6. 70, J, VN, Fe+Mn+Cl, Pa, Wa, R 7. 90, J, VN, Fe+Mn+Cl, Pa, Wa, R						
	247	47		100	0	55			highly weathered, weak to very weak					0	[60]	Water loss ~150 gal
244	248				2											
	249				2											
242	250		23		2											
	251	48		100	1	20			1. 20, J, N, UK, Su, St, R 2. 90, J, MW, Fe+Mn+Cl, Sp, Wa, R (Uk = grayish olive (10Y 4/2) skin with white clay vein smaller vesicles 3. 60, J, VN, Fe+Mn+Uk, Su, Pl, SR–R (Uk = light olive gray (5Y 5/2) skin with white clay veins larger vesicles 4. 60, J, VN, Fe+Mn+Cl, Sp, Wa, R					0	[100]	Water loss ~150 gal
240	252				10+											
	253															

Report: CT053 RED HILL WITH WELL AND PID; File: CT053 RED HILL CORE LOGS.GPJ; 7/28/2017 RHMW10

Project: CT053 – Red Hill Bulk Fuel Storage Facilty
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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	253															
	254				10+		4		intensely fractured with Fe+Cl							
					10+		IF									
-236	255								40% vesicles, vesicles become larger (2–3mm)							
					3		M									
							1		1. 70–90, J, VN, Fe+Mn+Cl, Fi, Wa, R							
	256						2		2. 70, J, VN, Cl, Sp, Wa, R							
					1		3		3. 0, J, VN, Fe+Mn+Cl, Pa, Wa, R							
							4		4. 0, J, VN, Fe+Mn+Cl, Pa, Wa, R							
-234	257						M		5. 45, J, T, Cl, Sp, Wa, R							
		49		100	2	33	5		vesicles <1mm, with 1 inch band of gray, very strong, 10% vesicles					0	[50]	Water loss ~150 gal
	258						6									
					1											
							7		smaller vesicles							
-232	259						M		6. 5, J, VN, CL, Sp, Wa, VR							
									7. 10, J, T, Cl, Sp, Wa, R							
					10+		8		8. 90, J, VN, Fe+Mn+Cl, Pa, Wa, R							
							IF									
	260		24				MB		larger vesicles (1–2mm)							
							MB									End of drilling 3/10/17; Begin 3/13/17
					10+		IF									
-230	261						MB									
							MB									
					10+		IF									
							MB		highly to intensely fractured, mostly mechanical breaks, some surfaces contain traces of Fe+Mn+Cl							
	262						MB									
		50		78	10+	43	IF							0	[13]	Per driller: something grabbing bit. Pull casing (bit badly worn, replace)
-228	263															
					10+		NR		no recovery							
	264						1		1. 5, J, VN, Fe, Su, Wa, SR							Water loss ~300 gal
					1											
-226	265						1		1. 80, J, T, Fe+Mn, Su, Pl, SR							
					1				2. 45, J, VN, Fe+Mn+Cl, Sp, Pl, SR							
									vesicles 2–3mm in diameter							
	266						MB		3. 60, J, VN, Fe+Mn+Cl, Sp, Pl, SR							
					10+		2		4. 60, J, T, Fe+Mn, Su, Wa, R							
							IF									
-224	267															
		51		76	10+	38	IF		smaller vesicles, intensely fractured, moderately weathered, ~50% vesicles, vesicles contain trace clay infill					0	[60]	Water loss ~250 gal
	268															
							3		dark reddish brown (10R 3/4), slightly weathered, more dense, ~25% vesicles, vesicles 2–6mm							
					2		MB									
-222	269						4									

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Project: CT053 – Red Hill Bulk Fuel Storage Facility
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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	269				10+		NR		no recovery							Worn bit at 270 ft bgs. Pull casing and replace
	270								~30% vesicles ~1–2mm in diameter 1. 45, J, VN, Fe+Mn+Cl, Sp, Pl, SR 2. 0, J, VN, Fe+Mn+Cl, Sp, Ir, R 3. 90, J, T, Fe+Mn, Su, Wa, SR 4. 30, J, VN, Fe+Mn, Su, Wa, SR 5. 0, J, VN, Fe+Mn, Pa, Wa, R 6. 0, J, VN, Fe+Mn+Cl, Sp, Wa, SR 7. 0, B, N, Fe+Mn+Cl, Pa, Wa, SR						
220	271				2											rough drilling and drill chatter
	272				10+				moderately to highly weathered, weak to moderately strong, highly to intensely fractured with clay coating on fracture surfaces							
		52	25	96	10+	20			dark reddish brown (10R 3/4), pale yellow-orange (10YR 8/6), and black (N1), very weak to weak, ~50% vesicles, clayey completely weathered layer					0	[9]	
218	273								272.6'–272.8' bgs 8. 60, J, VN, Fe+Mn+Cl, Sp, Pl, SR 9. 50, J, VN, Cl, Sp, Ir, SR 1/4" black (N1), glassy deposit 10. 5, J, VN, Cl, Sp, Wa, R							
	274				10+				dark reddish brown (10R 3/4), moderately weathered, weak, highly to intensely fractured, 40–50% vesicles(many filled with grayish brown (5Y 8/4) clay) 11. 80, J, VN, Fe+Mn+Cl, Sp, Pl, SR 12. 15, J, VN, Fe+Mn+Cl, Sp, Wa, SR							Driler says bit badly worn. End drilling 3/13/17, Water level in core rods fell 3.71 ft in 11 minutes; Begin 3/15/17, pull casing and replace bit with Christensen surface set bit
216	275								alternates with bands of brownish black (5YR 2/1), possible flow boundaries							
	276				1				1. 90, J, T, H, Wa, SR 2. 45, J, VN, Mn+Cl, Sp, Wa, SR 3. 85, J, VN, Mn+Cl, Sp, Wa, SR 4. 45, J, VN, Fe+Mn, Sp, Pl, S 5. 45, B, VN, Fe+Mn, Sp, Ir, VR (possible baked paleosol)							
		53		100	2	43								0	[17]	
214	277															Water loss ~400 gal between 274 ft bgs and 280 ft bgs
	278				0											
					10+				BASALT Massive a'a Medium dark gray (N4), slightly weathered, strong, intensely fractured, with ~15% vesicles (some stretched) ~1–5mm in diameter, few vugs up to 40mm							
212	279															
					10+											
	280								1. 75, J, T, Fe+Mn, Su, Pl, SR 2. 85, J, VN, Fe+Mn, Su, Ir, R 3. 45, J, VN, Fe+Mn, Su, Wa, SR 4. 30, J, T, Fe+Mn, Su, Wa, VR 5. 30, J, VN, Fe+Mn, Su, Pl, R 6. 20, J, VN, Fe+Mn, Su, Pl, R 7. 5, J, N, Fe+Mn+Uk, Pa, Ir, R 8. 50, J, Fe+Mn, Su, Pl, SR 9. 10, J, VN, Fe+Mn, Su, Pl, SR 10. 5, B, VN, Uk, Ir, VR 11. 30, J, VN, Uk, Sp, Wa, R 12. 15, J, VN, Uk, Sp, Wa, R Uk = white (N9) waxy clay (halloysite?)							
210	281				10+											
					2											
	282															Water loss ~300 gal
		54	26	100	3	37								0	[12]	
208	283															
					3											
	284															
					3				BASALT Welded a'a Clinker Medium dark gray (N4) mottled with moderate brown (5YR 3/4), moderately weathered, weak							
206	285															

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Elevation, feet	Depth, feet	Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	285						M		BASALT Pahoehoe Dark gray (N3), slightly weathered, strong, ~30% vesicles (vesicles 1"–3" in diameter)							
					2		1		dark reddish brown (10R 3/4), ~50% vesicles							
	286					3	2		brownish black (5YR 2/1)							
					2	4	M		1. 30, J, VN, Fe+Mn, SP, Pl, SR 2. 10, B, VN, Cl, Pa, Wa, R 3. 60, J, T, H, Fi, Pl, SR							
							5									
-204	287						IF									
							M		intensely fractured with Uk coating (halloysite?)							Water loss ~300 gal
							IF									
		55		100	10+	75	7		dark gray (N3), larger vesicles ~1–5mm					0	[43]	
	288						M		4. 45, J, T, Fe+Mn, Su, Pl, SR 5. 80, J, T, Fe+Mn, Su, Pl, SR 6. 0, J, VN, Cl, Pa, Pl, SR							
					0											
-202	289						M									
					0											
	290		27						vesicles ~1–3mm							
					0		M									
							M									
-200	291						M		1. 50, J, T, Fe+Mn, Su, Pl, SR 2. 50, J, T, Fe+Mn, Su, Pl, SR							
					0											
	292															
		56		95	0	87	M							0	[43]	Water loss ~200 gal
							M									
-198	293						M									
					1											
	294						M									
							2									
					1		M									
-196	295						M									
					1				1. 0, J, T, Fe, Su, Ir, R 2. 90, J, T, Fe, Su, Wa, SR 3. 30, J, T, Fe, Su, Pl, SR 4. 60, J, T, Fe, Su, Pl, SR 5. 5, J, VN, Fe, Sp, Wa, SR							
	296						1									
							2									
					3	3										
							4									
-194	297						5									
							IF		intensely fractured							Water loss ~200 gal
		57		100	10+	68	6		dark reddish brown (10R 3/4), vesicles filled with clay					0	[21]	
	298						M									
			28		0				medium dark gray (N4), vesicles 3–10mm							
									6. J, VN, Cl, Sp, Wa, R 7. 80, J, VN, Fe+Mn, Su, Pl, SR 8. 0, J, VN, Fe+Mn, Su, Wa, SR							
-192	299															
					2		M									
							7									
							8		vesicles 1–3mm							
	300						IF									
									fine to coarse grained basalt sand (mechanically pulverized)							End of drilling 3/15/17; Begin 3/16/17
					10+				dark gray (N3), 40% vesicles							
-190	301						M									

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	301								vesicles 2–5mm vesicles 1–3mm							
	302	58		100	0 2	58	M 1 M 2 IF 3		1. 45, J, T, UK, No, Wa, R 2. 60, J, T, Uk, No, Wa, R 3. 45, J, VN, Cl, Sp, Wa, R 4. 70, J, VN, Fe+Mn+Cl, Su–Sp, Wa, R					0	[33]	Water loss ~400 gal
188	303				1		4									
	304				NA		IF									
186	305								BASALT a'a Clinker Dark gray (N3) to dark reddish brown (10R 3/4), moderately weathered, moderately strong to weak							
	306	59	29	68	NA NA	22	NR							0	[14]	Water loss ~300 gal
184	307				NA		IF 1		BASALT Massive a'a Dark gray (N3), slightly weathered, strong, with 5%–7% elongated vesicles 1. 45, J, MW, Fe+Mn, Su, St, SR 2. 60, J, T, Fe+Mn, Su, Wa, SR							
	308				3		2 3		3. 70, J, T, Fe+Mn, Su, Wa, SR 4. 30, J, T, Fe+Mn, Su, Wa, SR 5. 30, J, VN, Fe+Mn+Cl, Sp, Wa, SR							
182	309				4		4 5		moderately weathered with 50mm elongated void, weak to very weak 6. 90, J, T, Fe+Mn+Cl, Su, Pl, S							
	310						6 7 8		slightly weathered, strong 7. 5, J, VN, Fe+Mn+Cl, Su–Sp, St, R 8. 10, J, MW, Fe+Mn, Su, Wa, SR							Water level in core rods dropped from 305.98 to 307.5 ft bgs in 25 minutes
180	311	60		100	2	82	1		1. 40, J, VN, Fe+Mn+Cl, Sp, Wa, R 2. 45, J, T, Fe+Mn, Su, Wa, R					0	[17]	
	312				1		2 3		3. 0, J, T, Fe+Mn, Su, Wa, R 4. 5, J, T, Fe+Mn, Su, Wa, SR 5. 90, J, VN, Fe+Mn+Uk, Sp, Wa, SR 6. 0, J, VN, Fe+Mn+Uk, Sp, Wa, SR							Water loss ~800 gal
178	313				1		4 9 5 IF		7. 5, J, VN, Fe+Mn+Uk, Sp, Wa, R 8. 5, J, T, Fe+Mn, Su, Wa, R 9. 0, J, Vn, Fe+Mn+Uk, Pa, Wa, R							
	314				2		6 7									
176	315						8									
	316				10+		1 2 IF 6 3		1. 0, J, VN, Fe+Mn+Cl, Sp, Wa, R 2. 80, J, VN, Fe+Mn+Cl, Su, Wa, R 3. 0. J, T, Fe+Mn+Cl, Su, Wa, R 4. 80. J, VN, Fe+Mn+Cl, Su, Wa, R 5. 10, J, VN, Fe+Mn+Cl, Su, Wa, R							
174	317				2		4 5		6. 70, J, VN, Fe+Mn, Su, Pl, SR 7. 5, J, T, Fe+Mn+Cl, Sp, Wa, R							

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
317																
		61	30	74	NA	22	IF		BASALT a'a Clinker Dark gray (N3) and dark reddish brown (10R 3/4), highly to moderately weathered, weak, with clay along fracture surfaces					0	[17]	Water loss ~300 gal
318																
					NA				vesicles filled with moderate reddish brown (10R 4/6) clay							
172	319								BASALT Pahoehoe Dark reddish brown (10R 3/4), moderately weathered, moderately strong, 40% vesicles							
					1		7		1. 0, J, VN, Fe+Mn, Su, Wa, R							
320									2. 60, J, VN, Fe+Mn, Su, Wa, R							
							1		3. 70, J, N, Fe+Mn+Cl, Fi, Wa, SR							
							2		4. 60, J, T, Fe+Mn+Cl, Sp, Wa, R							
					3		3		5. 60, J, T, Fe+Mn+Cl, Sp, Wa, R							
170	321						IF		20% vesicles, 2–5mm diameter							
									6. 50, B, VN, Fe+Mn+Cl, Fi, Wa, R (flow contact)							
					10+		4		7. 60, B, N, Fe+Mn+Cl, Fi, Wa, SR (flow contact)							
322							5		dark gray (N3) with occasional light brown (5YR 5/6) halo along fractures							
		62		100	1	50	6		40% vesicles, 1mm diameter					0	[50]	Water loss ~300 gal
									8. 90, J, T, Fe+Mn, Su, Wa, R							
168	323								9. 0, J, T, Fe+Mn, Su, Wa, R							
							7									
					4		8		dark gray (N3), slightly weathered, strong, 10% vesicles 2–10mm diameter							
							9		10. 5, J, N, Fe+Mn+Cl, Pa, Wa, R							
	324						10		11. 90, J, VN, Fe+Mn+Cl, Pa, Wa, R							
									12. 20, J, N, Fe+Mn+Cl, Pa, Wa, R							
					3		11									
							12									
166							13									
	325						IF									
					0				1. 20, J, T, Fe+Mn, Su, Wa, SR							
									2. 30, J, T, Fe+Mn, Su, Wa, SR							
	326						1		3. 30, J, VN, Fe+Mn+Cl, Sp, Wa, R							
					1											
164	327															
		63	31	100	1	64			30–40% vesicles 0.5–3mm diameter					0	[43]	Water loss ~250 gal
							2									
	328															
					10+		IF		intensely fractured, highly weathered, very weak, dark reddish brown mottling							
162	329															
					10+		M		dark gray (N3), moderately weathered, moderately strong							
	330															
					1		3									
							M		15% vesicles 2–20mm diameter							
160	331								1. 45, J, T, Fe+Mn, Su, Wa, SR							
									2. 30, J, N, Fe, Su, Wa, R							
							1		3. 20, J, T, Fe+Mn+Cl, Fi, Pl, SR							
					0		M									
	332								40% vesicles 0.5–1mm diameter							
							M									
									4. 60, J, T, Fe+Mn, Su, Wa, R							
		64		100	3	56			5. 30, J, T, Fe+Mn, Su, Wa, R					0	[75]	
							2		6. 70, J, T, Fe+Mn, Su, Pl, SR							
158	333						3		7. 70, J, VN, Fe+Mn+Cl, Sp, Wa, R							
							4									

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Elevation, feet	Depth, feet	Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	333								8. 30, J, VN, Fe+Mn+Cl, Sp, Wa, R							
					2											
	334				10+				intensely fractured with moderate reddish brown (10R 4/6) mottling							
156	335		32						vesicles 1–3mm diameter							
					2											
	336				2				1. 45, J, VN, Fe+Mn+Cl, Sp, Wa, R 2. 60, J, T, Fe+Mn, Su, Wa, R 3. 45, J, T, Fe+Mn+Cl, Sp, Wa, R 4. 70, J, T, Fe+Mn+Cl, Sp, Wa, R							
154	337								5. 90, J, VN, Fe+Mn+Cl, Pa, Wa, R							Water loss ~150 gal
		65		100	1	62								0	[100]	
	338				10+											
152	339				0											
	340								1. 5, J, VN, Fe+Mn, Su, St, R 2. 30, J, T, Uk, No, Wa, R 3. 20, J, T, Fe+Mn, Su, St, S–SR 4. 10, J, T, Uk, Su, Pl, SR with medium dark gray (N6) alteration zone							
					0											
150	341				10+				5mm medium dark gray (N4) alteration zone at 341.5' bgs							
	342															Water loss ~250 gal
		66		100	2	60			dark reddish brown (10R 3/4) mottling					0	[43]	
148	343															
					2				larger vesicles 2–5mm diameter, ~10% red olivine/iddingsite within vesicles 5. 0, J, VN, Cl, SP, R 6. 0, J, VN, Cl, Sp, R Uk=greenish gray (5G 6/1) skin							
	344				1											
146	345								25% vesicles 5–10mm diameter, 10% olivine in vesicles							
					0											
	346								1. 70, J, VN, Fe+Mn+Cl, Sp, Wa, SR 2. 20, J, VN, Fe+Mn+Cl, Sp, Wa, SR 40% vesicles, 0.5–2mm diameter							
					10+		1									
144	347								moderately weathered, moderately strong, with dark reddish brown (10R 3/4) mottling							Water loss ~150 gal
		67	33	100	1	43			30% vesicles 1–3mm diameter					0	[75]	
	348								3. 30, J, T, Cl, Sp, St, R							
					10+											
142	349															

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	349				10+		IF		intensely fractured, moderately weathered, moderately strong with dark reddish brown (10R 3/4) mottling							
	350						IF									
					10+		M									
140	351						M		grades to larger vesicles (up to 10mm at at 352.8' bgs)							
					0		M									
	352						M									Water loss ~150 gal
		68		100	0	100								0	[100]	
	353						M		grades to smaller vesicles. 20–25% olivine in vesicles							
138					1		1									
	354						M		1. 60, J, VN–N, Uk, Su, Wa, R							
					1											
136	355						1		~10% olivine, some olivine in rock matrix							
							M									End of drilling 3/16/17; Begin 3/17/17
					0		M									
	356						M		1. 60, J, VN, Fe+Mn, Su, Wa, SR							
					0											
134	357						M									Water loss ~200 gal
		69		64	10+	38	M		intensely fractured, some fracture surfaces have Fe+Mn staining					0	[75]	
	358						NR									
					10+				no recovery							
132	359															
					10+		M									
	360		34				M		vesicles 1–5mm diameter							
					0											
130	361						M									
					0		M									
	362						M		vesicles 2–5mm diameter, ~20% olivine							Water loss ~200 gal
		70		100	0	100	M							0	[100]	
128	363															
					0											
	364								vesicles 1mm diameter							
					10+		M									
126	365						IF		intensely fractured							
							M									

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	365								1. 5, B, VN, Fe, Su, Wa, SR 2. 10, J, VN, Fe+Mn, Su, Wa, SR 3. 5, J, VN, Fe+Mn, Su, Wa, SR 4. 30, J, VN, Fe+Mn, Su, Wa, SR							
	366				10+				dark reddish brown 10R 3/4, slightly to moderately weathered, intensely fractured, without olivine							
124	367	71		100	2 0	76			dusky brown (5YR 2/2), slightly weathered, strong dark gray (N3), ~25% vesicles 2–10mm diameter, trace olivine, ~5% plagioclase					0	[150]	Water loss ~300 gal
	368				0				~50% vesicles 1–2mm diameter							
122	369				1											
	370		35						1. 50, J, VN, Cl, Sp, Wa, SR							
	371				1 0				~25% vesicles 2–10mm diameter 2. 40, J, VN, Fe+Mn, Su, Ir, VR 3. 90, J, VN, Fe+Mn, Su, Wa, VR 4. 45, J, T, Fe+Mn, Su, Pl, SR							
120	372	72		100	0	0			35% vesicles 1–2mm diameter					0	[75]	Water loss ~300 gal
118	373				3				vesicles and fractures have have Fe+Mn staining							
	374				0				vesicles 2–5mm diameter, olivine ~5%							
116	375															
	376				0 10+				1. 10, B, VN, Fe+Mn, Su, Pl, SR 2. 0, J, T, Fe+Mn, Su, Pl, SR 3. 0, J, T, Fe+Mn, Su, Pl, SR 4. 85, J, VN, Fe+Mn, Su, Wa, SR 5. 35, J, T, Fe+Mn, Su, Pl, SR							
114	377	73	36	100	10+	70			intensely fractured with Fe surface coating and ropey pahoehoe texture on fracture surfaces					0	[50]	Water loss ~300 gal
	378				10+				intensely fractured							
112	379				0											
	380								1. 45, B, VN, Fe+Mn, Sp, Wa, SR							
110	381				1				brownish black (5YR 2/1), moderately strong, ~40 vesicles, trace olivine							

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	381								2. 70, J, T, Fe+Mn, Su, Pl, SR							
					1		M M									
	382						3									Water loss ~350 gal
		74		85	10+	18	IF		intensely fractured					0	[50]	
108	383						4		3. 90, J, VN, Fe+Mn, Su, Wa, SR							
					10+		M		4. 60, J, VN, Fe+Mn, Su, Wa, R							
							IF		5. 60, J, T, Fe+Mn, Su, Pl, SR							
	384						5 6		6. 45, J, VN, Fe+Mn, Su, Wa, SR							
					10+		NR		no recovery							
106	385		37													
					0		M		dark gray (N3), without olivine and plagioclase phenocrysts							
							M M									
	386						M M									
							1 M									
					10+		2									
							IF		intensely fractured with oxidized staining on surfaces							
104	387						M									Water loss ~350 gal
		75		88	10+	60	M							0	[50]	
							IF		intensely fractured with oxidized staining on surfaces							
	388						M M									
					0		M		1. 90, J, VN, Fe+Mn, Su, Wa, SR							Core sample diameter becoming norrower. Per driller: soft rock vibrating in core barrel wearing down the core
							M		2. 0. J, VN, Fe+Mn, Su, Wa, SR							
102	389						M M									
					10+		NR		no recovery							
	390						M									
					0											
100	391								1. 45, J, VN, Mn+Fe, Su, Wa, SR							Water loss ~200 gal
					1											
	392						1 M		medium dark gray (N4), strong, ~25% vesicles 1–2mm diameter, ~25% plagioclase, 5–10% olivine							
		76		100	0	100								0	[38]	
98	393															Core returns to full diameter
					0											
	394															
					0											
96	395		38				M M									
					0											
	396						M M		~5–10% vesicles 1mm diameter							
									~35% vesicles 1–5mm diameter							difficult drilling with drill chatter
					0		M		~10% vesicles 1mm diameter							
94	397						M M M									

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	397						M		~40% vesicles 1–3mm diameter							Water loss ~400 gal
		77		74	0	74	M							0	[50]	
	398						M									
					0		M		core mis-shapen due to re-drilling from 397.6' - 398.7' bgs, no visible phenocrysts							dropped core (recovered 2.6'). Send inner barrel back down and retrieve another 1ft of core
-92	399						NR									
					10+				no recovery							
	400						M		~50% vesicles							
					0		M		1. 45, J, VN, Fe+Mn, Su, Wa, SR 2. 0, J, VN, Fe+Mn, Su, Wa, SR							
-90	401						M									
					10+		IF		intensely fractured (mechanically)							
	402						1 2		~25–30% vesicles 2–10mm diameter, 5% olivine, 5% plagioclase							Water loss ~350 gal
		78		100	0	85	M							0	[50]	
-88	403						M									
					10+		IF		intensely fractured with Fe+Mn stains							Per driller: inner barrel may be full. Pull inner barrel (cored 41" and recovered 41"). resume coring
	404						M									
					0		M									
-86	405						M		60% vesicles, no visivble phenocrysts							End of drilling 3/17/17; Begin 3/20/17; difficulty retrieving inner barrel, pull casing; 1.6' of core recovered from inside casing.
					0											
	406															
					0											
-84	407						NR									Water loss ~300 gal
		79	39	40	10+	40								0	[100]	
	408															
					10+				dropped core and no recovery							
-82	409															Re-advance casing but cannot get inner barrel to latch
					10+											
	410						IF		very dusky red (10R 2/2) to dark gray (N3), slightly to moderately weathered, ~50% vesicles							End of drilling 3/20/17; Begin 3/21/17
					10+		M									
-80	411						M		1. 45, J, VN, Fe+Mn, Su, Wa, SR							
					10+		M									
	412						IF		intensely fractured with traces of Fe+Mn staining							
							M									Water loss ~200 gal
		80		60	10+	52								0	[150]	
-78	413						IF									

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	413				10+		NR									
	414				10+				no recovery							
76	415						IF*		traces of white clay in vesicles							inner barrel will not latch. Pull casing to clear bit then re-advance.
					10+		1 M M M M		1. 90, J, T, Cl, Sp, Wa, SR							
	416															
					10+		IF*		intensely fractured, some oxidized fracture surfaces, most fractures are mechanical							
74	417						NR									Water loss ~100 gal
		81		40	10+	13								0	[150]	
	418															
					10+				no recovery							
72	419															
					10+											
	420		40				IF M									
					10+		1 M		1. 60, J, VN, Cl, Fe, Mn, Sp, Wa, R 2. 65, J, VN, Fe+Mn, Su, Wa, SR							
70	421						2 M		3. 0, J, VN, Fe+Mn, Su, Pl, S 4. 90, J, VN, Fe+Mn, Su, Wa, SR							Water loss ~400 gal
					2		M		5. 90, J, VN, Fe+Mn, Su, Wa, SR							
	422						4 3 M M									
		82		60	1	36	M		medium dark gray (N4), slightly weathered, strong to very strong, ~30% vesicles 1-3mm					0	[60]	
68	423						5 NR									
					10+											
	424								no recovery							no recovery inside inner barrel. pull casing and recover 3 ft of core inside casing
					10+											
66	425						M		alternating bands of small (1-3mm diameter) vesicles and larger (2-5mm diameter) vesicles 1. 0, B, VN, Fe, Su, Wa, R							
					1		M 1									
	426						NR									
					10+											
64	427															Water loss ~450 gal
		83		22	10+	0			no recovery					0	[50]	
	428															
					10+											
62	429															

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	429				10+		NR							No recovery inside core barrel. pull casing and recover 1.1 ft of core from inside casing install Boart Longyear diamond impregnated bit
	430				10+									
60	431				10+		IF		dark reddish brown (10R 3/4), slightly to moderately weathered, strong, intensely fractured (mechanical), ~50% vesicles					
	432						NR							Water loss ~450 gal
		84	41	70	10+	25			no recovery			0	[33]	
58	433				10+		1		medium dark gray (N4), slightly weathered 1. 45, J, VN, Fe+Mn, Su, Pl, VR					
	434				10+		M M 2 M M		strong to very strong, ~25% vesicles 2–10mm diameter 2. 0, J, VN, Fe+Mn, Su, Wa, VR					
56	435						M		1. 45, J, T, Fe+Mn, Su, Pl, SR					
					2		1 M 2		40% vesicles 1–3mm diameter					
	436						M M M		2. 45, J, T, Fe+Mn, Su, Pl, SR 3. 0, B, VN, Fe, Su, Wa, SR					
					1		M 3 M		dark reddish brown (10R 3/4), moderately weathered					
54	437						4 M		4. 30, J, T, Fe+Mn, Su, Wa, SR 5. 0, B, VN, Fe+Mn, Su, Ir, R					Water loss ~250 gal
		85		100	3	74			6. 15, B, VN, Fe, Su, Wa, R			0	[75]	
	438						5 6 7		dark redish brown (10R 3/4), moderately weathered, moderately strong					
					0		M		7. 90, J, VN, Fe+Mn, Su, Wa, SR					
52	439						M 8		8. 5, J, VN, Fe+Mn, Su, Wa, SR 9. 75, J, VN, Cl, Sp, Wa, SR					
					3		9 10		10. 10, J, T, Fe+Mn, Su, Pl, S					
	440						M M		25% vesicles 2–8mm diameter					End of drilling 3/21/17; Begin 3/22/17
					0		M		grades from 25% vesicles 2–8mm diameter at 440.6' bgs to 40% vesicles 0.5–1mm diameter at 442'bgs					
50	441						M M M M							Water loss ~200 gal
					1		M M 1							
	442						IF		10mm zone of grayish red (5R 4/2), possible flow boundary or alteration zone					
		86		–	10+	–	IF		1. 15, J, VN, Fe+Mn, Su, Ir, R 2. 15, J, T, Fe, Su, Pl, SR			0	[75]	
48	443				10+		2 NR							1 foot of core dropped, pull casing to recover core
	444				10+				no recovery					
					10+									
46	445													

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	445						IF		40–50% vesicles 1–3mm diameter							
					10+		M		1. 60, J, T, Fe+Mn, Su, Wa, R							
	446						M		2. 30, J, T, Fe+Mn, Su, Wa, R							
							M		3. 70, J, VN, Fe+Mn+Cl, Sp, Wa, R							Water loss ~400 gal + 3/4 bag of bentonite
					1	M	M									
-44	447						1									
							M									
		87	42	72	3	52	M							0	[27]	
	448						2		grayish red (5R 4/2) mottled, moderately to highly weathered, weak							
							IF									
					10+		IF									Core warm to the touch, pull casing to replace bit
							3		BASALT a'a Clinker							
-42	449						NR		Moderately red (5R 5/4), highly to completely weathered, weathered to clay							
					NA											
									no recovery							
	450						NR									End of drilling 3/22/17; Begin 3/23/17, water level recorded – no water encountered; install Christensen surface set bit
					NA											
							2									
-40	451								BASALT Massive a'a							
					10+		M		Dark gray (N3), slightly weathered, strong to very strong, with ~5% small vesicles and 10% olivine phenocrysts up to 5mm in diameter							
							1									
	452						2									
							M		20% vesicles 3–10mm diameter, some vesicles stretched							
		88		72	2	34	3							0	[30]	Water loss ~1000 gal + 1/2 bag bentonite
							4									
							M		1. 0, J, VN, Cl, Su, Ir, R							
-38	453						M		2. 45, J, VN, Fe+Mn, Su, Wa, SR							
							M		3. 50, J, VN, Fe+Mn, Su, Wa, SR							
					1		M		4. 50, J, VN, Fe+Mn, Su, Wa, SR							
							5		5. 45, J, VN, Fe+Mn, Su, Wa, SR							
	454						M									
							IF									
							MB									
					10+		NR									
									no recovery							
-36	455						IF		intensely fractured, moste fracture surfaces contain Fe+Mn stains and trace white waxy clay infill (halloysite?)							
					10+											
	456															
					10+											
-34	457								more stretched vesicles							Water loss ~1000 gal + 1/2 bag bentonite
		89		80	10+	0								0	[17]	
	458															
									fewer stretched vesicles							
					10+											
-32	459						NR									
					10+				no recovery							
	460															
							1		~10% vesicles 1–2mm diameter							
					3		M									
							2		dark gray (N3) to dusky brown (5YR 2/2)							
							M		1. 80, J, VN, Fe+Mn, Su, Wa, SR							
-30	461						3		2. 5, J, VN, Fe, SU, Ir, R							

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	461				NA				3. 90, J, VN, Fe+Mn, Su, Wa, SR BASALT a'a Clinker Dusky brown (5YR 2/2) to dark reddish brown (10R 3/4), moderately to highly weathered, moderately strong to weak, intensely fractured, oxidized							Water loss ~400 gal + 1/2 bag bentonite
	462	90		36	NA	13	NR							0	[60]	
28	463				NA				no recovery							Per driller: softer drilling 462~465 ft bgs
	464				NA											
26	465		43		NA				medium drak gray (N4) to dark reddish brown (10R 3/4)							
	466				NA											Water loss ~400 gal + 1/2 bag bentonite
24	467	91		70	NA	12			highly to completely weathered, weathers to sandy clay					0	[60]	
	468				NA		NR									
22	469				NA				no recovery							
	470				1		M		BASALT Massive a'a Medium dark gray (N4), slightly weathered, strong to very strong, with 15% (2–5mm diameter) ~20% vesicles 1–10mm diameter, few larger vesicles up to 30mm diameter							End of drilling 3/23/17; Begin 3/24/17
20	471				0		M									
	472	92		76	1	76 M	M		1. 0, J, T, Fe+Mn, Su, Wa, SR 2. 30, J, VN, Fe+Mn, Su, Wa, SR					0	[18]	Water loss ~750 gal + 1/2 bag bentonite
18	473				0		M									
	474				10+		NR		no recovery							Water level in core rods dropped from 466.1 to 466.96 ft bgs in 50 minutes. continues to drop steadily
16	475				0		M		15% vesicles, more stretched							
	476				2		M		1. 0, J, T, Fe+Mn, Su, Wa, SR 2. 3, J, T, Fe+Mn, Su, Wa, SR 3. 0, J, T, Fe+Mn, Su, Wa, SR 4. 70, J, T, Fe+Mn, Su, Wa, SR 5. 0, J, T, Fe+Mn, Su, Wa, SR 6. 3, VN, Fe+Mn+Ca, Sp, Wa, St							Water loss ~800 gal + 1/2 bag bentonite
14	477															

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	477								7. 0, J, T, Fe+Mn, Su, Wa, SR 8. 0, J, T, Fe+Mn, Su, Wa, SR 9. 4, J, VN, Fe+Mn, Su, Wa, SR 10. 0, J, VN, Fe+Mn, Su, Wa, R							
		93		100	3	78								0	[13]	
	478				2											
12	479				2				brownish black (5YR 2/1), 25% vesicles							Water in level core rods dropped from 465.1 to 466.45 ft bgs in 40 minutes. continues to drop steadily
	480		44						flow textures							
					NA				BASALT a'a Clinker Dusky brown (5YR 2/2) to moderately reddish brown (10R 4/6), highly weathered, very weak to weak							
10	481				NA											
	482															
		94		34	NA	0			no recovery					0	[33]	Water loss ~450 gal + 1/2 bag bentonite
8	483				NA											
	484															
					NA											Water level in core rods dropped from 472.52 to 472.8 ft bgs in 40 minutes. WL stabilizes at 472.8 ft bgs
6	485								BASALT Massive a'a Medium dark gray (N4), slightly weathered, strong to very strong, with 20% vesicles (1–10mm diameter with few vugs up to 60mm)							Slow drilling 485 – 488.5 ft bgs
					0											
	486								1. 0, J, VN, Fe+Mn, Su, Wa, R 2. 20, J, VN, Fe+Mn, Su, Wa, SR 3. 5, J, VN, Fe+Mn, Su, Wa, SR 4. 0. J, VN, Fe+Mn, Su, Wa, R 5. 90, J, VN, Fe+Mn, Su, Pl, SR 6. 0, B, N, Cl, Sp, Pl, S 7. 80, J, VN, Fe+Mn, Su, Ir, R							Water loss ~650 gal + 1/2 bag bentonite
					00											
4	487															
		95	45	80	3	54								0	[15]	last 18 inches of core run faster penetration, Per driller: last few inches felt like good rock
	488															
					2											
2	489								no recovery							
					10+											Water level in core rods dropped from 472.7 to 472.75 ft bgs in 20 minutes. WL stabilizes at 472.75 ft bgs
	490								BASALT Pahoehoe Grayish brown (5YR 3/2) to medium dark gray (N4), slightly weathered, strong, 40–50% vesicles (1–3mm diameter)							
					2											
0	491								1. 88, J, VN, Fe+Mn, Su, Wa, R 2. 0, J, VN, Fe+Mn, Su, Wa, SR 3. 2, B, VN, Cl, Sp, Wa, R							Water loss ~650 gal + 1/2 bag bentonite
					10+											
	492															
		96		52	10+	50			no recovery, possible void					0	[43]	drill string dropped from 492 to 493 ft bgs
−2	493															

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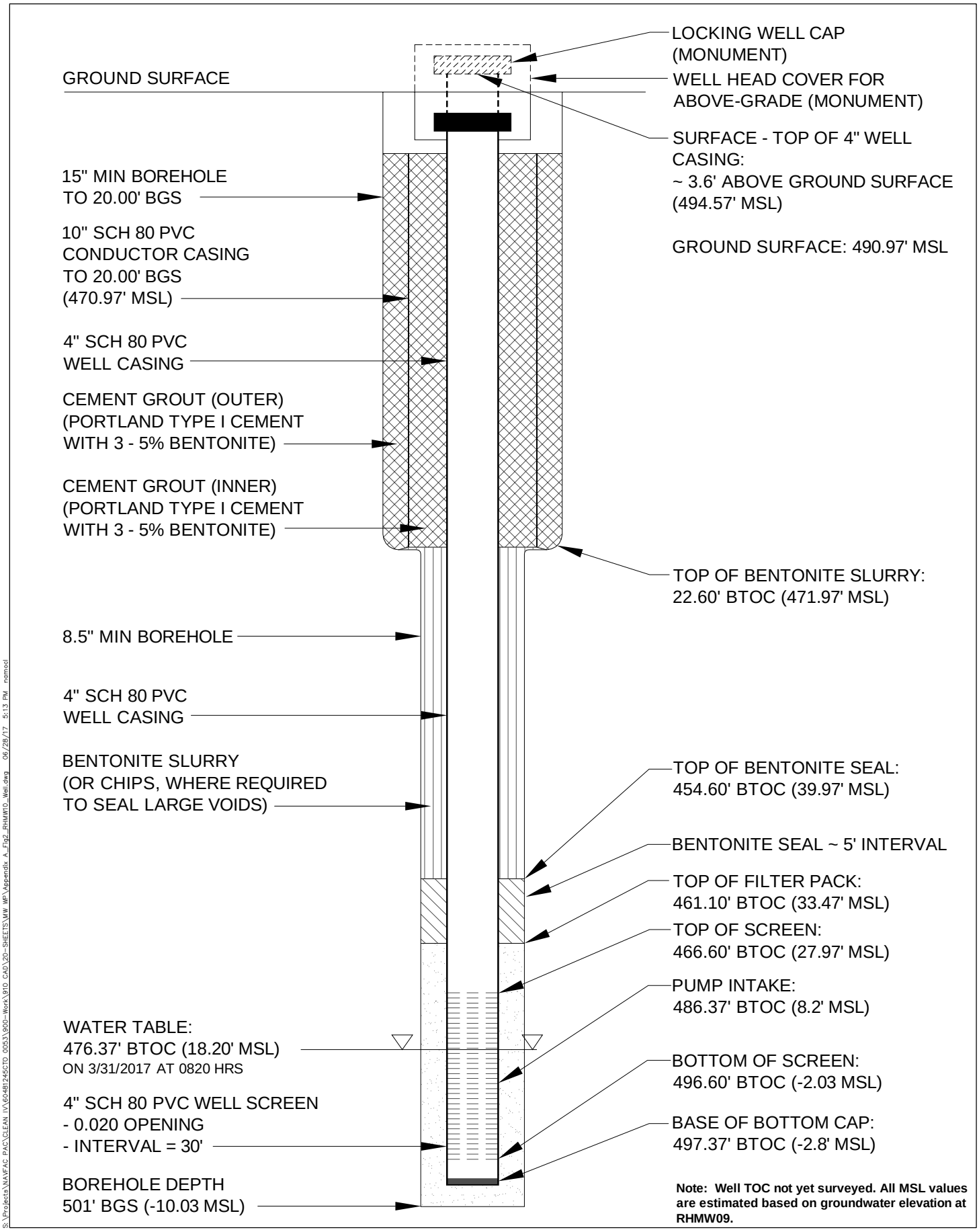
Log of Boring RHMW10

Sheet 32 of 32

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	493						M M M									
	494				0				35% vesicles ~1mm diameter							
					10+		NR		no recovery							
-4	495		46													Water level recorded – 472.8 ft bgs
					10+		M		50% vesicles 1–3mm diameter, intensely fractured (most mechanical, some oxidized surfaces)							
	496						M									
					10+		IF									
-6	497						M M									
		97		72	10+	72								0	[75]	Water loss ~350 gal + 1/2 bag bentonite
	498						IF									
					0		M M									
-8	499						NR									
					10+				no recovery							Water level recorded – 472.8 ft bgs
	500								Bottom of Boring; TD = 500 ft bgs							Complete drilling 3/24/17
-10	501															
	502								Used a total of approximately 30,025 gallons of circulation water and 5–3/4 50–lb bags of Maxgel bentonite powder during coring.							
-12	503															
	504															
-14	505															
	506															
-16	507															
	508															
-18	509															

Report: CT053 RED HILL WITH WELL AND PID; File: CT053 RED HILL CORE LOGS.GPJ; 7/28/2017 RHMW10



S:\Projects\NAVFAC PAC\CLEAN IV\6048\245CTO 0053\900--Work\910 CAD\2D--SHEETS\MW WP\Appendix A_Fig2_RHMW10 Well.dwg 06/28/17 5:13 PM namool

Appendix A Figure 1
Cross Section of RHMW10 Monitoring Well
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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