

# **Groundwater Model Progress Report 09, 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**

**December 5, 2019  
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**Comprehensive Long-Term Environmental Action Navy  
Contract Number N62742-17-D-1800, CTO18F0126**

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1 **Groundwater Model Progress**  
2 **Report 09, Red Hill Bulk Fuel**  
3 **Storage Facility**

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## ACRONYMS AND ABBREVIATIONS

1		
2	3D	three-dimensional
3	AOC	Administrative Order on Consent
4	bgs	below ground surface
5	BWS	Board of Water Supply, City and County of Honolulu
6	CSM	conceptual site model
7	CTD	conductivity, temperature, and depth
8	CWRM	Commission on Water Resource Management
9	DLA	Defense Logistics Agency
10	DLNR	Department of Land and Natural Resources, State of Hawai‘i
11	DOH	Department of Health, State of Hawai‘i
12	DON; Navy	Department of the Navy, United States
13	EPA	Environmental Protection Agency, United States
14	ft	foot/feet
15	GMS	Groundwater Modeling System
16	GWFM	groundwater flow model
17	GWMWG	Groundwater Modeling Working Group
18	IRR	Investigation and Remediation of Releases
19	LNAPL	light non-aqueous-phase liquid
20	msl	mean sea level
21	PEST	Parameter Estimation software
22	SME	subject matter expert
23	SOW	scope of work
24	TWG	Technical Working Group
25	U.S.	United States
26	USGS	United States Geological Survey
27	UH	University of Hawai‘i
28	WP	work plan

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## 1. Introduction

This *Groundwater Model Progress Report 09* is the ninth in a series of model progress reports that describe the technical status of the groundwater 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 (WP) / scope of work (SOW) (DON 2017b). 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 Model Progress Reports at a minimum of every 4 months is stipulated in AOC Statement of Work Section 7.1.2.

The objectives of AOC Statement of Work Sections 6 and 7 are to take steps to ensure that the drinking water resources in the vicinity of the Facility are protected and to ensure that operation of the Facility remains protective of human health and the environment. Work to support Section 6 is being conducted in response to the January 2014 release from Tank 5 and to evaluate potential remediation methods for the January 2014 Tank 5 release as well as any potential future releases. Work to support Section 7 is being conducted to monitor and characterize the flow of groundwater in the vicinity of the Facility and includes groundwater modeling. The work conducted under Section 7 will be used to inform changes to the current Red Hill *Groundwater Protection Plan* (DON 2014).

Reporting Period 09 covered in this report represents progress for the ninth approximately 4-month period (July 16 – November 15, 2019) following the Regulatory Agencies’ conditional approval of the project WP/SOW, which the United States (U.S.) Department of the Navy (DON; Navy) received on December 5, 2016 (EPA Region 9 and DOH 2016). *Groundwater Model Progress Reports 01 – 08* were submitted previously (DON 2017c; 2017d; 2017f; 2018a; 2018b; 2018d; 2019a; 2019d).

## 2. Work Completed this Reporting Period

### 2.1 CURRENT STATUS

**Groundwater Modeling Working Group (GMMWG).** The GMMWG is composed of representatives from the Navy, Defense Logistics Agency (DLA), U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), 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), and the University of Hawai’i (UH). The working group was formed to coordinate the Navy’s development of accurate and reliable groundwater flow and contaminant fate and transport models, and to solicit technical feedback from stakeholders during the model development process. Each meeting includes a review of the modeling objectives and responses to previous meeting action items.

One GMMWG meeting was held during the current reporting period and included discussion of the following items:

- *GMMWG Meeting #15, August 1, 2019:*
  - *Conceptual Site Model (CSM)* report update
  - Groundwater model update
  - Thermal profiling, Bemidji site

1           – Groundwater model development

2 **AOC Parties and Subject Matter Experts (SMEs) Meetings.** The AOC Parties Technical Working  
3 Group (TWG) met four times during this reporting period, on July 26, July 30, July 31, and October 21,  
4 2019. The main topics covered at each meeting are described below:

- 5           • *TWG Meeting #20, July 26, 2019*
  - 6           – Navy's multiple "stacked" impact factors analysis
- 7           • *TWG Meeting #21, July 30, 2019*
  - 8           – *Investigation and Remediation of Releases (IRR) Report and Groundwater Flow Model*
  - 9           – *(GWFM) Report* update
  - 10          – Holding capacity/capture zone/light nonaqueous-phase liquid (LNAPL) modeling
  - 11          – Natural source-zone depletion calculated rates
  - 12          – CSM changes in GWFM setup
  - 13          – Regulator overview of comments on CSM report
  - 14          – Regulator discussion of GWFM
- 15          • *TWG Meeting #22, July 31, 2019*
  - 16          – IRR Report
  - 17          – Related AOC deliverables and supporting work
  - 18          – Additional non-invasive data collection
  - 19          – Regulator discussion of GWFM
- 20          • *TWG Meeting #23, October 29, 2019*
  - 21          – Preliminary groundwater models to be delivered to AOC Parties in November 2019

## 22 **2.1.1 Technical Progress**

### 23 *2.1.1.1 GROUNDWATER SAMPLING*

24 During this reporting period, the Navy performed the Third Quarter and Fourth Quarter 2019 Red Hill  
25 groundwater monitoring events. The following monitoring locations were sampled during these  
26 events: RHMW2254-01; RHMW01 through RHMW10; RHMW11 Zones 5 and 7; RHMW14 Zones  
27 3, 4, 5, and 7 (Third Quarter 2019) and Zones 1, 2, 3, 4, 5, and 7 (Fourth Quarter 2019); RHMW15  
28 Zones 1, 2, 3, 4, and 5 (Fourth Quarter 2019 only); HDMW2254-01; and OWDFMW01. Analytical  
29 data are presented in the associated quarterly groundwater monitoring reports.

### 30 *2.1.1.2 FIELD ACTIVITIES*

31 The Navy conducted the following field work during this reporting period (see Figure 1 for well and  
32 test boring locations).

#### 33 **RHMW11:**

- 34           • Purged water from Westbay Zone 7.
- 35           • Downloaded transducer data.

1 RHMW11 planned future activities:

- 2 • Continue downloading transducer data.

3 **RHMW12:**

- 4 • Met with USGS to install LT 500H vented transducer in open borehole on August 27, 2019.  
5 • Met with DOH SME and DLNR/CWRM at RHMW12 on October 9, 2019. DOH ran a  
6 conductivity, temperature, and depth (CTD) tool and video camera in the borehole (open  
7 borehole from 200 to 215 feet [ft] below ground surface [bgs]). DOH was unable to collect  
8 depth-discrete sampling as planned due to failure of their equipment.

9 RHMW12 planned future activities:

- 10 • Continue with USGS monitoring of water levels.  
11 • Perform well development.  
12 • Complete installation of RHMW12 above the regional basal aquifer piezometric surface.  
13 • Drill and complete a companion well in proximity to RHMW12, with Westbay zones  
14 completed below the regional basal aquifer piezometric surface.

15 **RHMW13:**

- 16 • Commenced drilling operations at RHMW13 on August 21, 2019.  
17 • Hand cleared from 0 to 3 ft bgs.  
18 • Advanced hollow-stem augers from 3 ft bgs (through gravel fill) to 22 ft bgs (refusal).  
19 • Completed HQ coring from 22 to 175 ft bgs:  
20 – Conducted detailed geologic logging while coring.  
21 – Bailed and monitored water levels inside open borehole between core runs.  
22 • Reamed hole with 24-inch core bucket bit to 40 ft bgs.  
23 • Installed 18-inch steel surface casing and grouted to 40 ft bgs.  
24 • Reamed hole with 17-inch bit to 175 ft bgs.  
25 • Completed elevation survey of ground surface at RHMW13.  
26 • Installed 10-inch steel conductor casing to 172 ft bgs.  
27 • Completed HQ coring from 175 ft bgs to 220 ft bgs:  
28 – Conducted detailed geologic logging while coring.  
29 – Bailed and monitored water levels inside open borehole between core runs.  
30 – Conducted video logging after losing circulation of drilling fluids at approximately 219 ft  
31 bgs. Identified void in basalt in borehole wall between 219 and 220 ft bgs.  
32 • Reamed borehole with 9<sup>7</sup>/<sub>8</sub>-inch bit to 220 ft bgs.  
33 • Installed 5-inch steel conductor casing to 219 ft bgs.  
34 • Completed PQ coring from 220 to 530 ft bgs (total depth). Lost circulation during drilling at  
35 approximately 236 ft bgs.

- 1 • Conducted plumbness and alignment survey and geophysical logging (3-arm caliper and
- 2 acoustic televiewer).
- 3 • Conducted well development.
- 4 • Conducted video logging after reaching total depth.
- 5 • Installed packer at approximately 234–236 ft bgs (above circulation loss). Installed LT 700
- 6 vented transducer to monitor water levels in open borehole.
- 7 • Met with DLNR/CWRM and DOH SME for RHMW13 core review and preliminary well
- 8 design on October 24, 2019.
- 9 • Met with DLNR/CWRM and DOH SMEs to review and finalize well design on October 28,
- 10 2019.
- 11 • Currently installing Westbay well.
- 12 **RHMW13 planned future activities:**
- 13 • Install Westbay MOSDAX pressure transducers in completed Westbay zones.
- 14 • Depending on hydrogeologic conditions observed in RHMW13, potentially drill and complete
- 15 a companion well in proximity to RHMW13, with Westbay zones completed above regional
- 16 basal aquifer piezometric surface.

17 **RHMW14:**

- 18 • Purged water from Westbay Zones 4, 5, and 7.
- 19 • Downloaded transducer data.

20 **RHMW14 planned future activities:**

- 21 • Continue downloading transducer data.

22 **RHMW15:**

- 23 • Met with DLNR/CWRM and DOH SME for RHMW15 core review and preliminary well
- 24 design on July 18, 2019.
- 25 • Met with DLNR/CWRM and DOH SMEs to review and finalize well design on July 25, 2019.
- 26 • Developed well.
- 27 • Installed Westbay multilevel well.
- 28 • Downloaded transducer data.

29 **RHMW15 planned future activities:**

- 30 • Continue downloading transducer data.

31 **RHTB01:**

- 32 • Downloaded transducer data.

33 **RHTB01 planned future activities:**

- 34 • Continue downloading transducer data.

1     2.1.1.3     RECENTLY COLLECTED HYDROGEOLOGIC DATA

2     **RHMW11.** A discussion on RHMW11 multilevel well construction is presented in the CSM  
3     Revision 01 report (DON 2019b). Monitoring in RHMW11 used non-vented MOSDAX pressure  
4     transducers in Zones 5, 6, 7, and 8 during this reporting period. The pressure transducers were removed  
5     to facilitate purging and sampling of select zones for the two quarterly groundwater monitoring events.  
6     As discussed in *Groundwater Model Progress Report 08* (DON 2019d), groundwater levels in all  
7     zones appear to either have equilibrated or are asymptotically approaching equilibration within the  
8     formations the zones are completed in. Hydrographs for RHMW11 for this reporting period are  
9     presented in Appendix A. Data from monitoring well UMW-1, located at the Hālawā Correctional  
10    Facility, have been added to these hydrographs for comparison. Heads in Zones 6, 7, and 8 remained  
11    well above the regional basal aquifer piezometric elevation. Heads in UMW-1 remained more than  
12    40 ft above Zone 8.

13    **RHMW12.** An LT 500H vented pressure transducer was installed by the USGS in the open borehole  
14    (approximately 22.6–37.6 ft mean sea level [msl]) of RHMW12. Head data from this well will be  
15    presented in future *Groundwater Model Progress Reports*.

16    **RHMW13.** Drilling and coring of RHMW13 was completed at a total depth of 530 ft bgs. The boring  
17    log of RHMW13 will be included in the next *Groundwater Model Progress Report*. Low-permeability  
18    saprofite, which consists of clay-rich materials and weathered basalt, extends from approximately 22  
19    to 44 ft bgs (204–226 ft msl). Partial water loss occurred at a depth of approximately 219 ft bgs (29 ft  
20    msl). Subsequent video logging confirmed the presence of a void between 219 and 220 ft bgs. This  
21    void was grouted during installation of the 5-inch steel casing set to 219 ft bgs, and coring was  
22    completed through the grout seal. Complete drilling fluid loss occurred at a depth of approximately  
23    236 ft bgs (12 ft msl), indicating hydraulic communication with the regional basal aquifer at this depth  
24    and below. Bailing and water level monitoring was conducted between select core runs to evaluate the  
25    presence of shallow groundwater in intervals above the elevation of the potentiometric surface in the  
26    regional basal aquifer.

27    Prior to installing the Westbay well, a packer was installed at approximately 234–236 ft bgs (14–12 ft  
28    msl) immediately above where complete circulation loss occurred during drilling. A LT 700 vented  
29    transducer was installed to monitor water levels in the open borehole. Data from the MOSDAX  
30    transducers will be presented in future *Groundwater Model Progress Reports*.

31    The Westbay well is currently being constructed in accordance with the *Red Hill Monitoring Well*  
32    *Installation Work Plan* and addenda (DON 2016; 2017a; 2017e; 2018c). The well completion log and  
33    Westbay zone summary report will be provided in the next *Groundwater Model Progress Report*.

34    **RHMW14.** A discussion on RHMW14 Westbay construction is presented in *Groundwater Model*  
35    *Progress Report 08* (DON 2019d). Monitoring in RHMW14 used non-vented MOSDAX pressure  
36    transducers in Zones 1 through 7 during this reporting period. The pressure transducers were removed  
37    to facilitate purging and sampling of select zones for the Fourth Quarter 2019 groundwater monitoring  
38    event. Hydrographs for RHMW14 during this reporting period are presented in Appendix A. During  
39    this reporting period, heads in Zones 1, 2, and 3 are consistent with the regional basal aquifer. Heads  
40    in Zones 4, 5, 6, 7, and 8 vary from approximately 21 ft (Zone 4) to more than 40 ft (Zones 7–8) above  
41    the regional basal aquifer.

42    **RHMW15.** The geology encountered at RHMW15 is described in *Groundwater Model Progress*  
43    *Report 08* (DON 2019d). The boring log of RHMW15 is included in Appendix B. RHMW15 was  
44    completed with five discrete zones that are independently sealed and isolated using a series of Westbay

1 System packers (as illustrated on the well completion log in Appendix B). The well is constructed with  
2 Zone 1 as the deepest zone and with each subsequent zone completed at a shallower depth, with Zone  
3 5 as the shallowest.

4 Non-vented MOSDAX transducers were deployed in Zones 1 through 5 from October 7, 2019 through  
5 October 20, 2019. The transducers were removed from select RHMW15 zones to facilitate purging  
6 and sampling of select zones for the Fourth Quarter 2019 groundwater monitoring event. The two  
7 deepest zones (Zones 1 and 2) were completed in unweathered basalt, and Zones 3 through 5 (the  
8 shallowest zones) were completed in highly to moderately weathered basalt. Information on Westbay  
9 zone completion at RHMW15 is presented in Table 1, and the Westbay summary completion log is  
10 presented in Appendix C.

11 **Table 1: RHMW15 Westbay Zone Completion Summary**

Zone Identifier	Zone Top (ft bgs)	Zone Bottom (ft bgs)	Zone Top (elevation ft msl)	Zone Bottom (elevation ft msl)	Generalized Geology
Zone 5	276.3	321.6	33.7	-11.6	Weathered basalt
Zone 4	324.6	343.8	-14.6	-33.8	Weathered basalt
Zone 3	396.8	455.1	-86.8	-145.1	Weathered basalt
Zone 2	458.1	473.3	-148.1	-163.3	Basalt
Zone 1	559.3	583.2	-249.3	-273.3	Basalt

12 Notes: Approximate ground surface elevation = 310 ft msl.

13 Hydrographs for RHMW15 for this reporting period are presented in Appendix A. All zones have  
14 relatively similar piezometric head measurements of approximately 19–20 ft msl, consistent with the  
15 expected piezometric surface of the regional basal aquifer.

16 **RHTB01.** A discussion of test boring RHTB01's four grouted-in-place vibrating wire piezometers is  
17 presented in *Groundwater Model Progress Report 08* (DON 2019d). Hydrographs for RHTB01 for  
18 this reporting period are presented in Appendix A. Heads in all four monitoring zones declined slightly  
19 during this reporting period, but heads in Zone 2, 3, and 4 remained more than 50 ft above the expected  
20 regional basal aquifer piezometric head.

21 **2.1.1.4 GROUNDWATER MODELING**

22 The Navy conducted the following groundwater modeling activities this reporting period:

- 23 • Held weekly groundwater modeling team progress meetings to establish short-term milestones  
24 and resolve technical issues as they arose.
- 25 • Revised and performed additional transfer function-noise analysis to improve representation  
26 of field results. Updates included improving representation of water-level responses within  
27 Red Hill Shaft and BWS Hālawā Shaft.
- 28 • Identified apparent errors in model inputs and, through the process of debugging, determined  
29 that the errors were not present in the input files and had likely been erroneously introduced  
30 by the Groundwater Modeling System (GMS; a graphical user interface for MODFLOW)  
31 vendor as part of their proprietary modifications to MODFLOW. Communication with the  
32 vendor confirmed that GMS was erroneously modifying the model inputs. The project team  
33 discussed the delays and difficulties associated with the non-standard version of MODFLOW  
34 used by GMS, and concluded that the workarounds necessary to continue using GMS were

- 1 causing significant and unacceptable project delays. GMS does not produce text-only  
2 MODFLOW input files for use with PEST (Parameter Estimation software), which would  
3 permit the modeling team to use the USGS (standard) version of MODFLOW. GMS'  
4 unreported modifications to input files were determined to be an unacceptable bug that the  
5 software developer would not commit to fixing, rendering GMS unfit for further use for this  
6 project.
- 7 • Identified Groundwater Vistas as the groundwater modeling platform to complete the flow  
8 modeling effort. Most of the modeling team have a decade of experience or more with  
9 Groundwater Vistas, resulting in limited disruption. Converted the model from GMS to  
10 Groundwater Vistas and proceeded with modeling.
  - 11 • Updated head-difference-target and flow-target processing utilities developed by the team to  
12 work with Groundwater Vistas output.
  - 13 • Procured and deployed additional computing resources to improve calibration speed (four  
14 8-core PCs and one 128-core server).
  - 15 • Completed transient model calibration runs with PEST for two alternative saprolite  
16 interpretations (Models #51 and #52). Each PEST run consists of several hundred  
17 MODFLOW runs. Performed capture zone analysis simulations and delivered model files to  
18 EPA and DOH.
  - 19 • Developed a model using a heterogeneous basalt hydraulic conductivity distribution (Model  
20 #53). Several dozen pilot points (with greater density at the site) are used to define the  
21 hydraulic conductivity field through the autocalibration process. The heterogeneous basalt  
22 calibration is currently in progress.

### 23 **2.1.2 Technical Issues**

24 **Extension Request.** On September 23, 2019, the Navy requested an extension for the submittal date  
25 of the IRR and GWFM Reports, to March 25, 2020 (DON 2019e). The request was made after the  
26 Navy modeling team discovered unexpected errors that were determined to be fatal flaws in an update  
27 of the GMS software platform being used to develop the GWFM, and the vendor was unable to provide  
28 a timeframe for fixing the software. In the letter, the Navy indicated its intention to switch to the  
29 Groundwater Vistas software platform, which can provide better transparency as well as more  
30 seamless integration with the subsequent contaminant fate and transport modeling effort. A Regulatory  
31 Agency response to the requested extension is pending.

32 No other technical issues were identified during this reporting period.

### 33 **2.2 SUBMITTAL OF MODELING DELIVERABLES**

34 Relevant deliverables submitted during this reporting period include:

- 35 • *Final Second Quarter 2019 - Quarterly Groundwater Monitoring Report* (DON 2019c)
- 36 • *Final Third Quarter 2019 - Quarterly Groundwater Monitoring Report* (DON 2019f)
- 37 • Model files:
  - 38 – Model 51a, 51b, and 51c: November 8, 2019
  - 39 – Model 52: November 15, 2019
  - 40 – Model 51d: November 20, 2019

- 1           – Revised Model 51a, 51b, 51c, and 51d: November 22, 2019
- 2           – Models 53 and 59: December 3, 2019

### 3. Anticipated Work for Next Reporting Period

4 Anticipated work for upcoming Reporting Period 10 (November 16, 2019 – March 15, 2020) includes:

- 5           • Continue to download transducer data from RHMW11, RHMW12, RHMW14, RHMW15,  
6           and RHTB01.
- 7           • Complete RHMW12 and proximal companion well.
- 8           • Complete construction of RHMW13.
- 9           • Continue drilling and monitoring well installation efforts.
- 10          • Conduct First Quarter 2020 quarterly groundwater monitoring event.
- 11          • Continue groundwater flow modeling and present additional model files to AOC Party SMEs.
- 12          • Continue preparation of March 25, 2020 GWFM Report.
- 13          • Continue preparation of March 25, 2020 IRR Report.

14 Anticipated deliverables due during upcoming Reporting Period 10 (November 16, 2019 – March 15,  
15 2020) include:

- 16           • *Draft and Final Fourth Quarter 2019 - Quarterly Groundwater Monitoring Report*
- 17           • *Draft First Quarter 2020 - Quarterly Groundwater Monitoring Report*

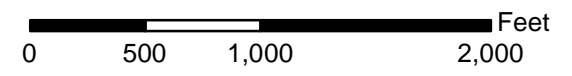
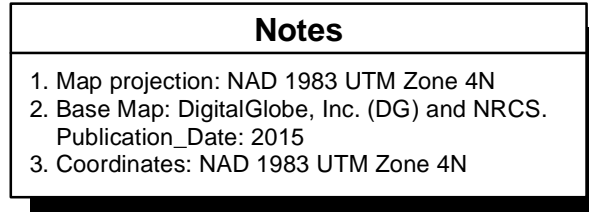
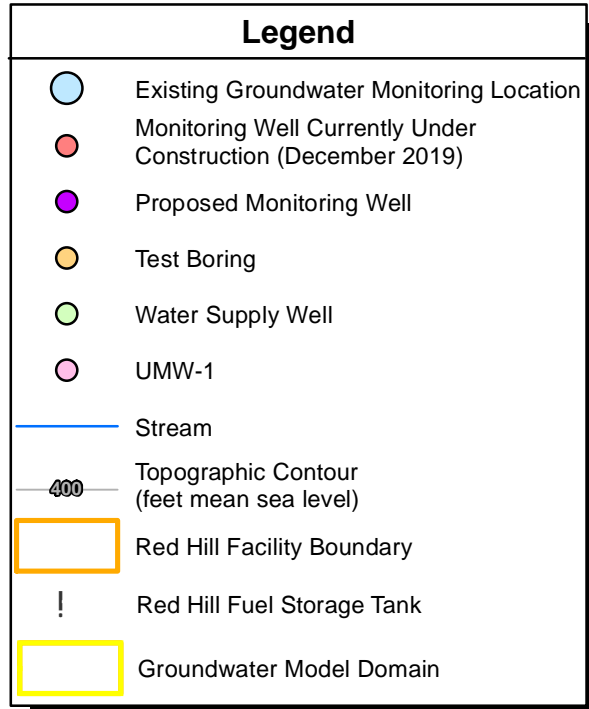
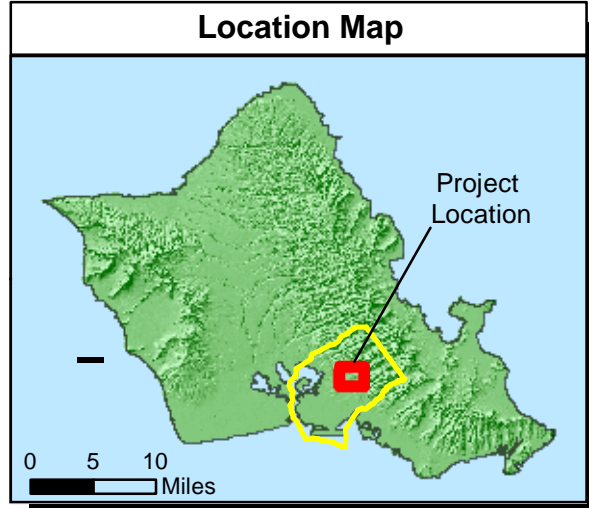
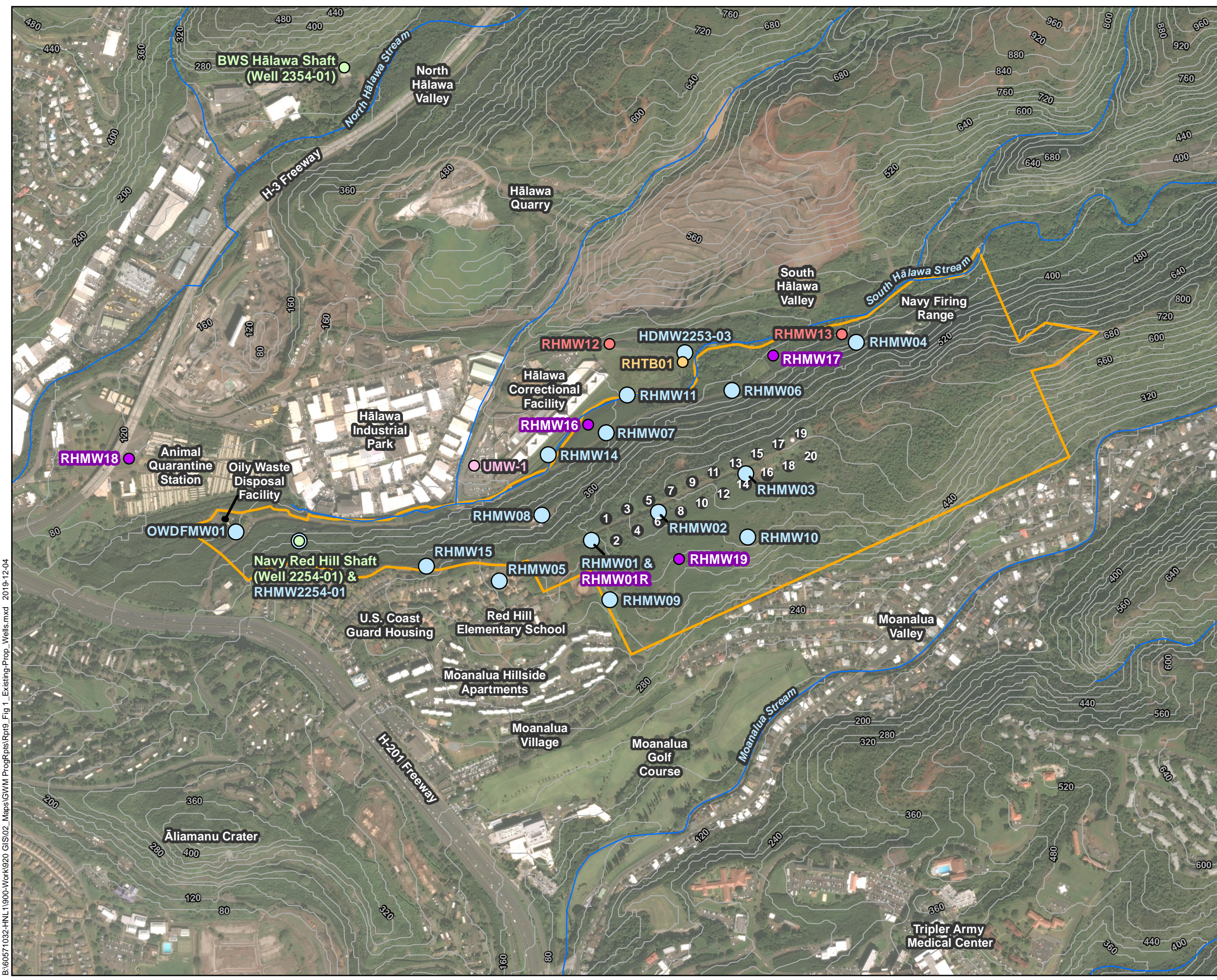
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12 AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy,  
13 Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.
- 14 ———. 2017f. *Groundwater Flow Model Progress Report 03, Red Hill Bulk Fuel Storage Facility,*  
15 *Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; December 3, 2017, Revision 00.* Prepared by  
16 AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy,  
17 Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.
- 18 ———. 2018a. *Groundwater Flow Model Progress Report 04, Red Hill Bulk Fuel Storage Facility,*  
19 *Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; April 5, 2018, Revision 00.* Prepared by  
20 AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy,  
21 Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.
- 22 ———. 2018b. *Groundwater Flow Model Progress Report 05, Red Hill Bulk Fuel Storage Facility,*  
23 *Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; August 3, 2018, Revision 00.* Prepared by  
24 AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy,  
25 Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.
- 26 ———. 2018c. *Monitoring Well Installation Work Plan Addendum 03, Investigation and Remediation*  
27 *of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility,*  
28 *Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; November 1, 2018, Revision 00.* Internal  
29 Review Draft. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense  
30 Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command,  
31 Hawaii, JBPHH HI.
- 32 ———. 2018d. *Groundwater Flow Model Progress Report 06, Red Hill Bulk Fuel Storage Facility,*  
33 *Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; December 4, 2018, Revision 00.* Prepared by  
34 AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy,  
35 Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.
- 36 ———. 2019a. *Groundwater Model Progress Report 07, Red Hill Bulk Fuel Storage Facility, Joint*  
37 *Base Pearl Harbor-Hickam, O'ahu, Hawai'i; April 3, 2019, Revision 00.* Prepared by AECOM  
38 Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort  
39 Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.
- 40 ———. 2019b. *Conceptual Site Model, Investigation and Remediation of Releases and Groundwater*  
41 *Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam,*

- 1        *O'ahu, Hawai'i; June 30, 2019, Revision 01*. Prepared by AECOM Technical Services, Inc.,  
2        Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval  
3        Facilities Engineering Command, Hawaii, JBPHH HI.
- 4        ———. 2019c. *Final Second Quarter 2019 - Quarterly Groundwater Monitoring Report, Red Hill*  
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6        AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Command, Hawaii.  
7        August.
- 8        ———. 2019d. *Groundwater Model Progress Report 08, Red Hill Bulk Fuel Storage Facility, Joint*  
9        *Base Pearl Harbor-Hickam, O'ahu, Hawai'i; August 5, 2019, Revision 00*. Prepared by AECOM  
10        Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort  
11        Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.
- 12        ———. 2019e. *Subject: Request for Extension of Administrative Order on Consent ("AOC")*  
13        *Statement of Work ("SOW") Section 6.3 Deliverable, Investigation and Remediation of Releases*  
14        *Report, and Section 7.1.3 Deliverable, Groundwater Flow Model Report, Red Hill Bulk Fuel*  
15        *Storage Facility ("Facility"), Joint Base Pearl Harbor-Hickam, Oahu, Hawaii*. Letter from: Capt.  
16        Mark Delao, Navy Region Hawaii, to: Omer Shalev, U.S. Environmental Protection Agency  
17        Region 9, and Roxanne Kwan, Hawaii Department of Health, Solid and Hazardous Waste Branch.  
18        5750, Ser N4/0654. September 23.
- 19        ———. 2019f. *Final Third Quarter 2019 - Quarterly Groundwater Monitoring Report, Red Hill Bulk*  
20        *Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i*. Prepared by AECOM  
21        Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Command, Hawaii. November.
- 22        Environmental Protection Agency, United States, Region 9; and Department of Health, State of Hawaii  
23        (EPA Region 9 and DOH). 2015. *Administrative Order on Consent In the Matter of Red Hill Bulk*  
24        *Fuel Storage Facility, EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-*  
25        *01*. September.
- 26        ———. 2016. *Conditional Approval of Red Hill AOC SOW Deliverable under Sections 6 & 7 - Work*  
27        *Plan/Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and*  
28        *Evaluation, Red Hill Bulk Fuel Storage Facility, November 5, 2016 Revision 01*. Letter from: Bob  
29        Pallarino, EPA Red Hill Project Coordinator, and Steven Chang, Hawaii DOH Red Hill Project  
30        Coordinator, to: Capt. Richard D. Hayes, Navy Region Hawaii. December 2.



**Figure 1**  
**Existing, Under-Construction, and Proposed Groundwater Monitoring Well and Boring Locations**  
**Groundwater Model Progress Report 09**  
**Red Hill Bulk Fuel Storage Facility**  
**JBPHH, O'ahu, Hawai'i**

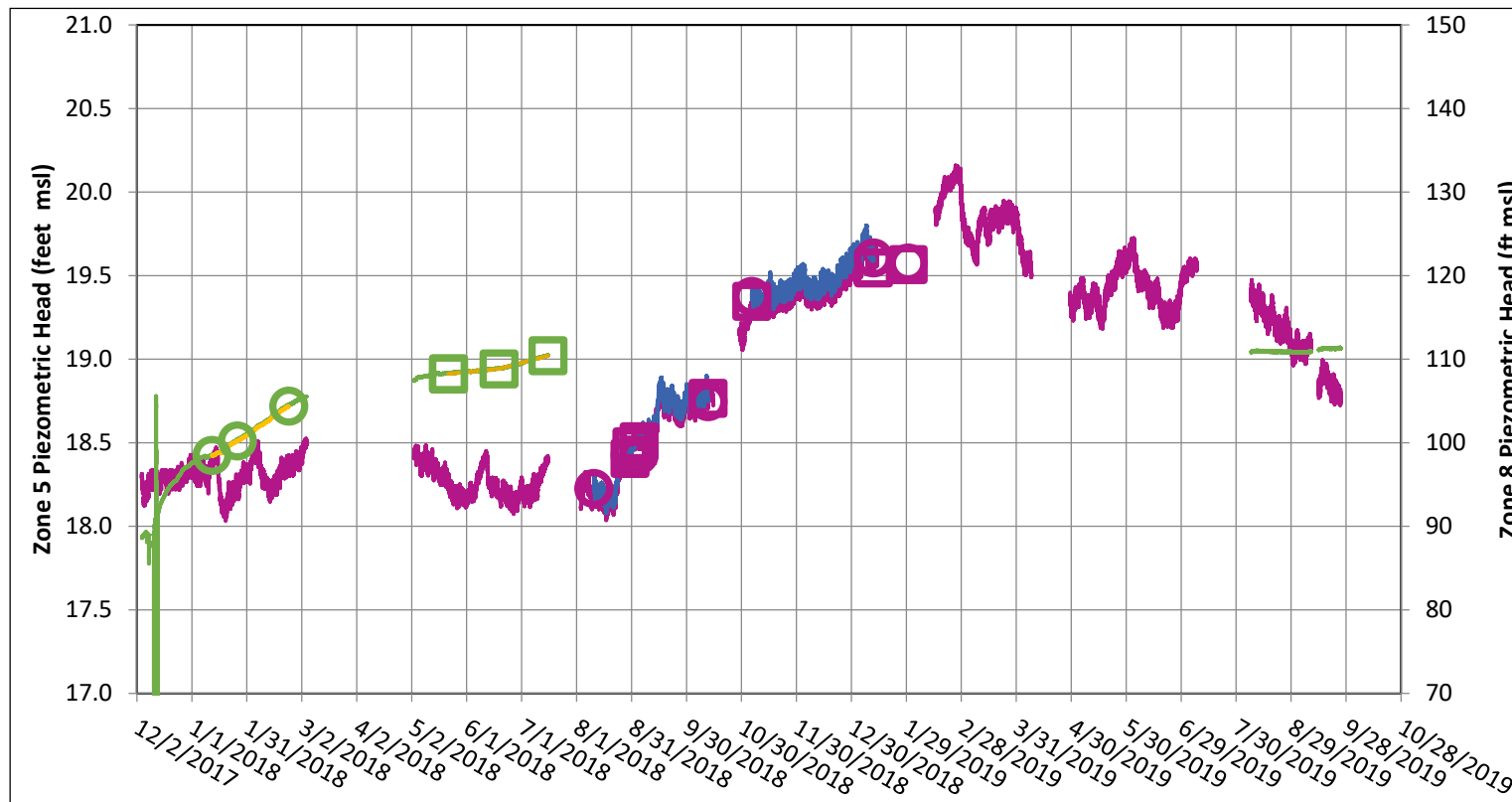
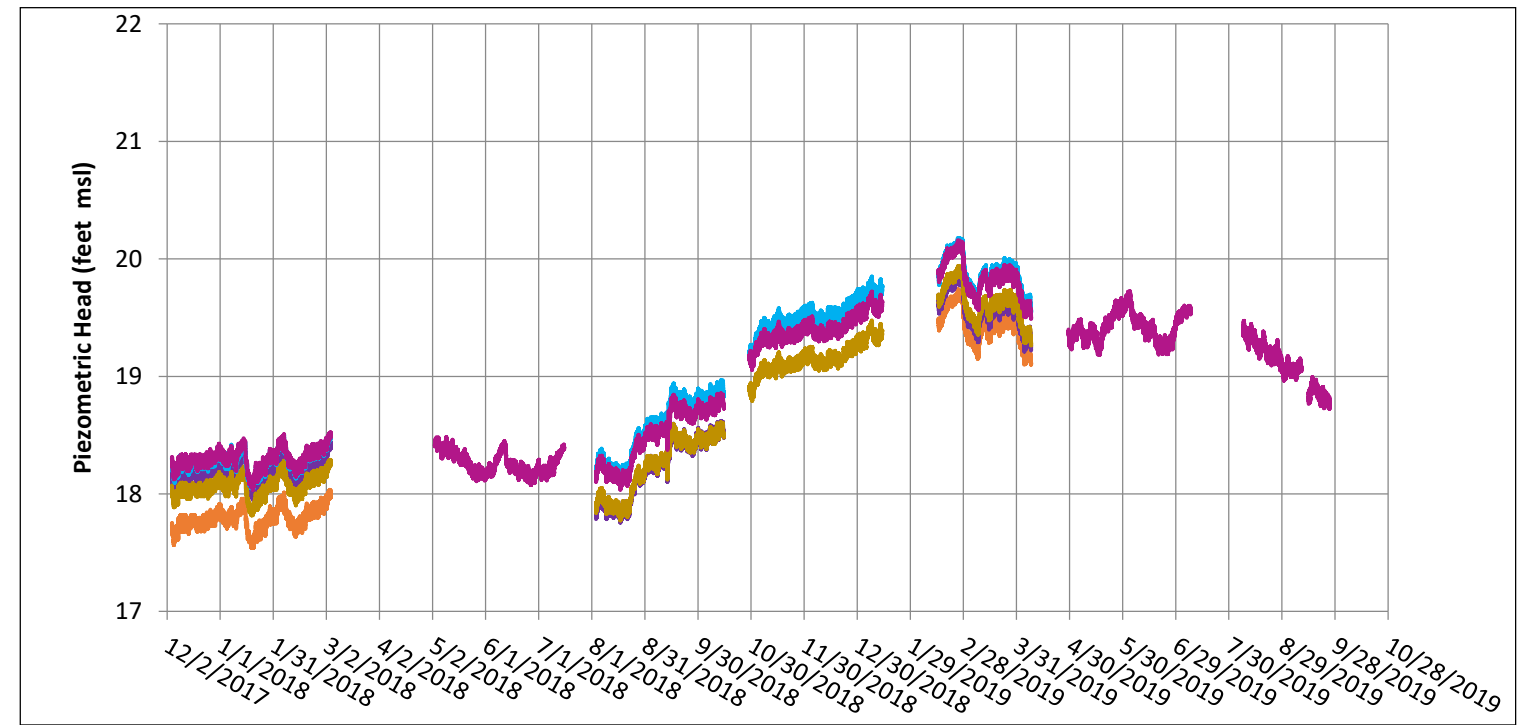
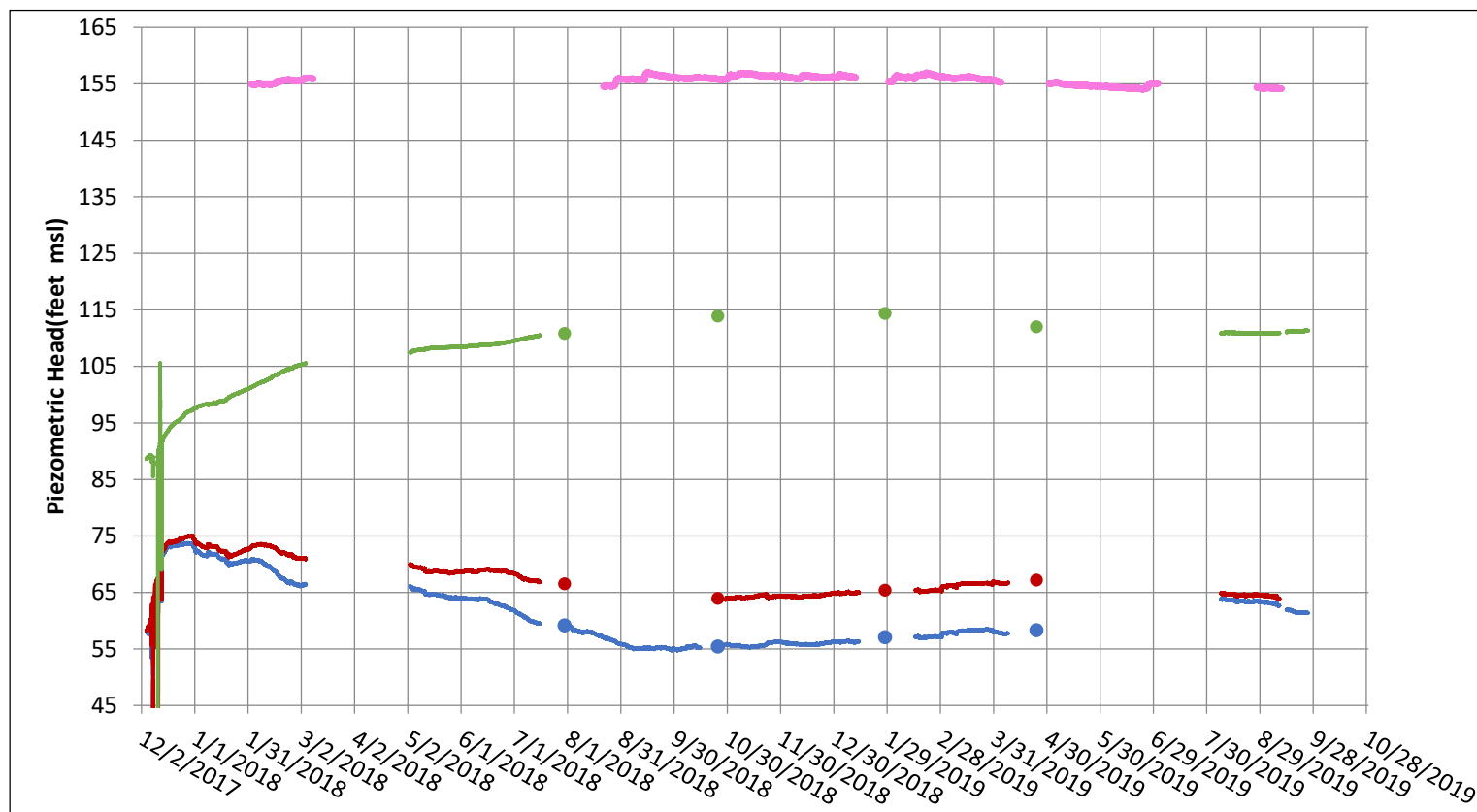
B:\60571032-HNL-1900-Work\920 GIS02\_Maps\GWM ProgRpt\9 Fig 1\_Existing-Prop\_Wells.mxd 2019-12-04

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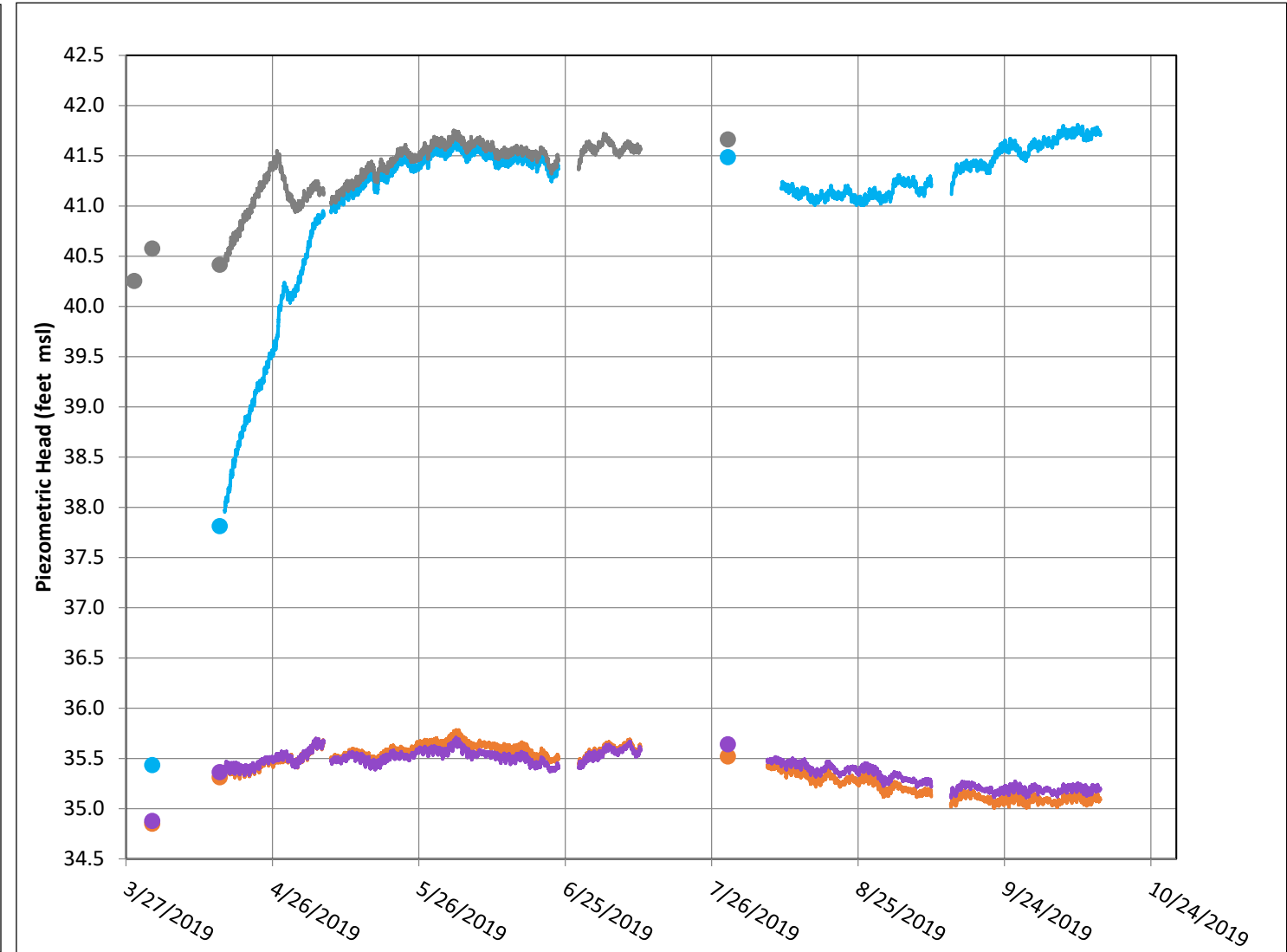
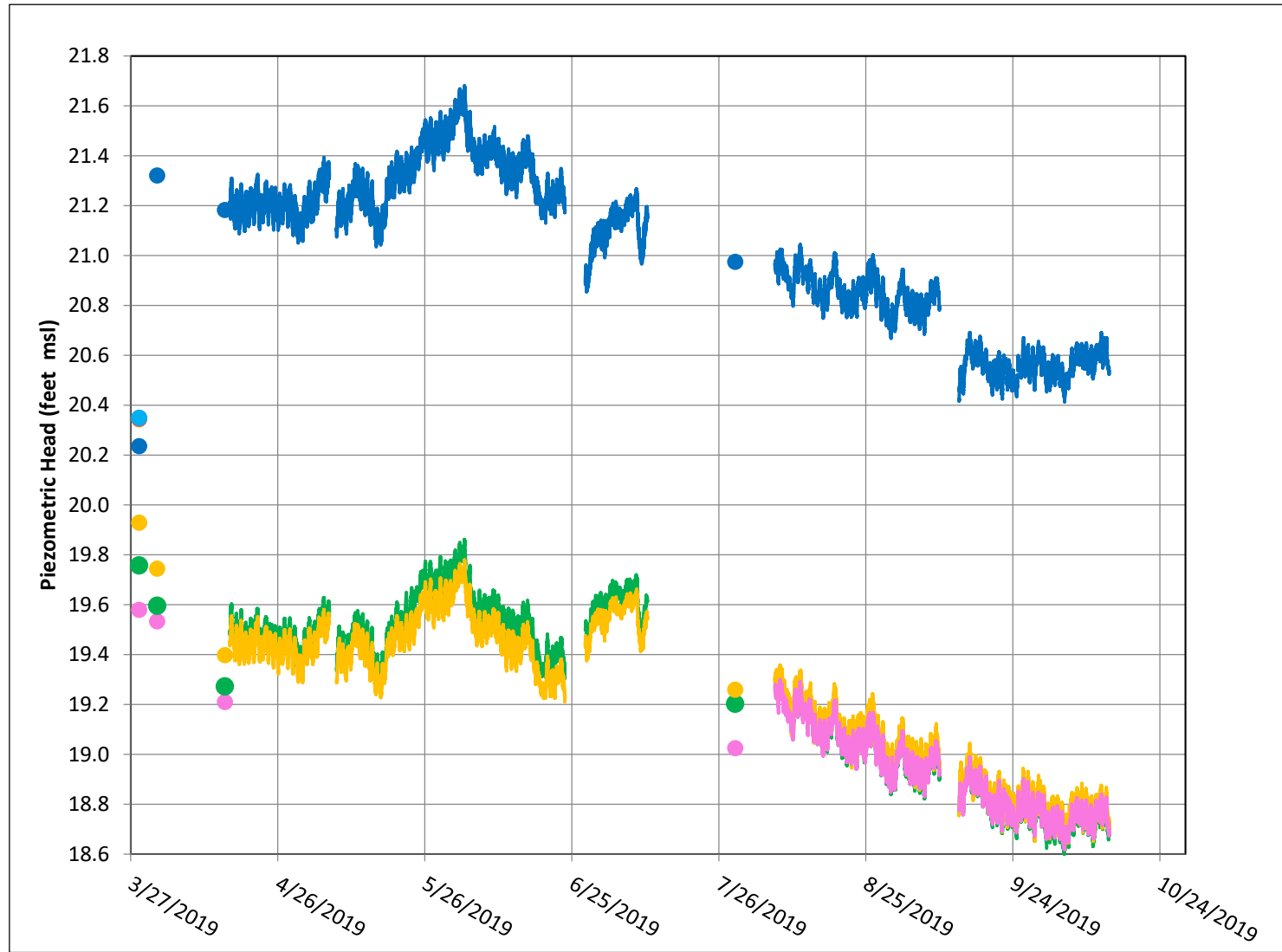
## **Appendix A: Hydrographs**

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LEGEND		Generalized Geology	Zone Top (ft msl)	Zone Bottom (ft msl)
—	Zone 8 – MOSDAX Transducer	Saprolite	51.06	5.86
—	Zone 7 – MOSDAX Transducer	Saprolite	0.56	-29.44
—	Zone 6 – MOSDAX Transducer	Saprolite	34.64	-45.14
—	Zone 5 – MOSDAX Transducer	Basalt	-66.94	-19.94
—	Zone 4 – MOSDAX Transducer	Basalt	-120.14	-132.44
—	Zone 3 – MOSDAX Transducer	Basalt	-137.44	-156.64
—	Zone 2 – MOSDAX Transducer	Basalt	-183.64	-209.94
—	Zone 1 – MOSDAX Transducer	Basalt	-239.91	-259.15
—	UMW-1 – 700H Vented Transducer			
●	Zone 8 – Pressure Profile			
●	Zone 7 – Pressure Profile			
●	Zone 6 – Pressure Profile			
—	Zone 8 – 700H Vented Transducer			
—	Zone 5 – 700H Vented Transducer			
○	Zone 8 USGS Hand Measurements			
○	Zone 5 USGS Hand Measurements			
□	Zone 8 Navy Hand Measurements			
□	Zone 5 Navy Hand Measurements			

Appendix A.1  
 RHMW11 and UMW-1 – Long-Term Piezometric Heads  
 Groundwater Flow Model Progress Report 09  
 Red Hill Bulk Fuel Storage Facility  
 JBPHH, O'ahu, Hawai'i

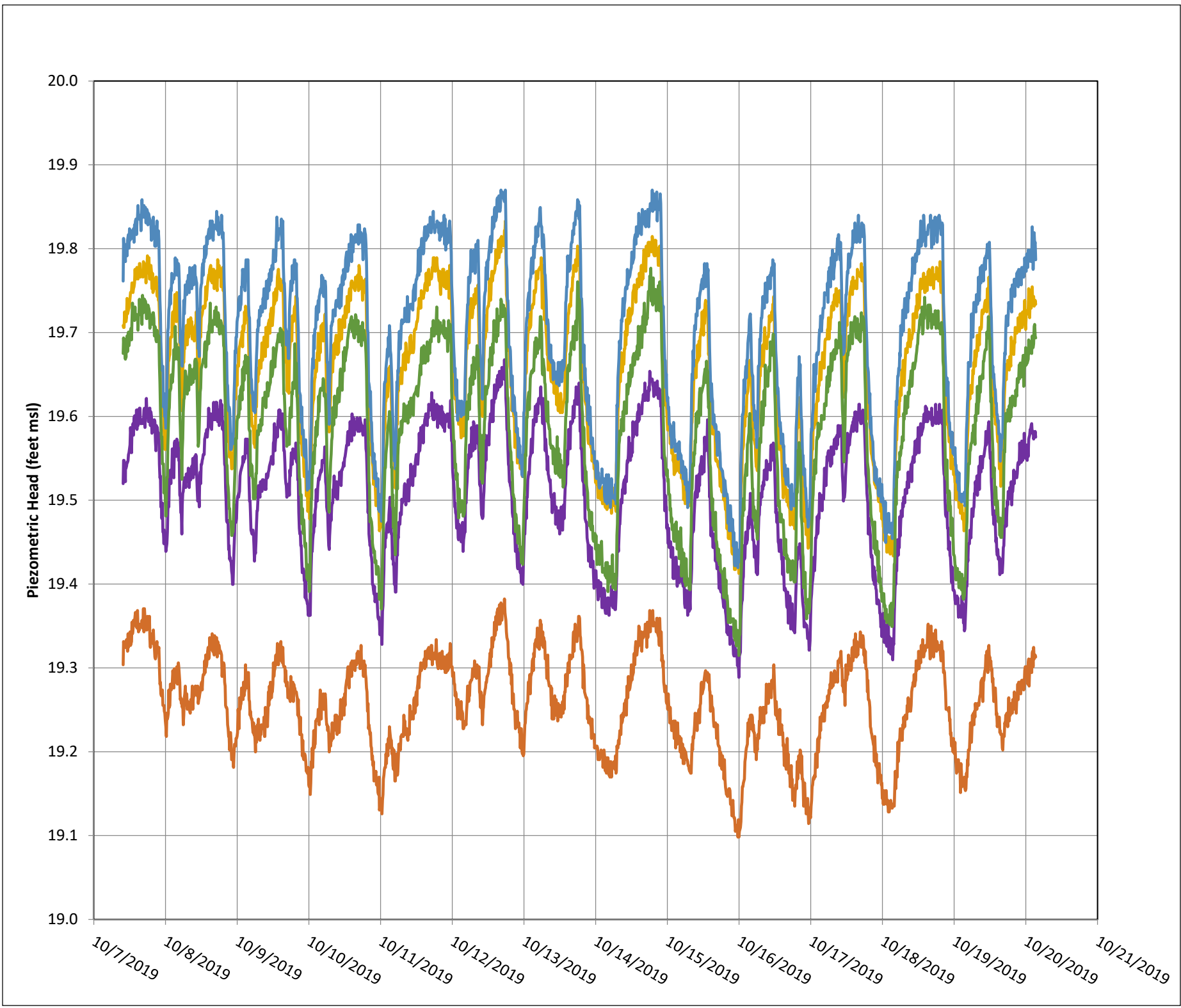


LEGEND		Generalized Geology	Zone Top (ft msl)	Zone Bottom (ft msl)
—	Zone 8 – MOSDAX Transducer	Weathered Basalt	49.8	30.8
—	Zone 7 – MOSDAX Transducer	Weathered Basalt	25.8	10.8
—	Zone 6 – MOSDAX Transducer	Weathered Basalt	32.8	-19.2
—	Zone 5 – MOSDAX Transducer	Basalt	-24.2	-36.2
—	Zone 4 – MOSDAX Transducer	Basalt	-65.2	-85.4
—	Zone 3 – MOSDAX Transducer	Basalt	-140.4	-157.3
—	Zone 2 – MOSDAX Transducer	Basalt	-230.6	-243.2
—	Zone 1 – MOSDAX Transducer	Basalt	-273.8	-285.0

LEGEND		Generalized Geology	Zone Top (ft msl)	Zone Bottom (ft msl)
●	Zone 8 – Pressure Profile	Weathered Basalt	49.8	30.8
●	Zone 7 – Pressure Profile	Weathered Basalt	25.8	10.8
●	Zone 6 – Pressure Profile	Weathered Basalt	32.8	-19.2
●	Zone 5 – Pressure Profile	Basalt	-24.2	-36.2
●	Zone 4 – Pressure Profile	Basalt	-65.2	-85.4
●	Zone 3 – Pressure Profile	Basalt	-140.4	-157.3
●	Zone 2 – Pressure Profile	Basalt	-230.6	-243.2
●	Zone 1 – Pressure Profile	Basalt	-273.8	-285.0

**Appendix A.2**  
**RHMW14 – Long-Term Piezometric Heads**  
**Groundwater Flow Model Progress 09**  
**Red Hill Bulk Fuel Storage Facility**  
**JBPHH, O’ahu, Hawai’i**

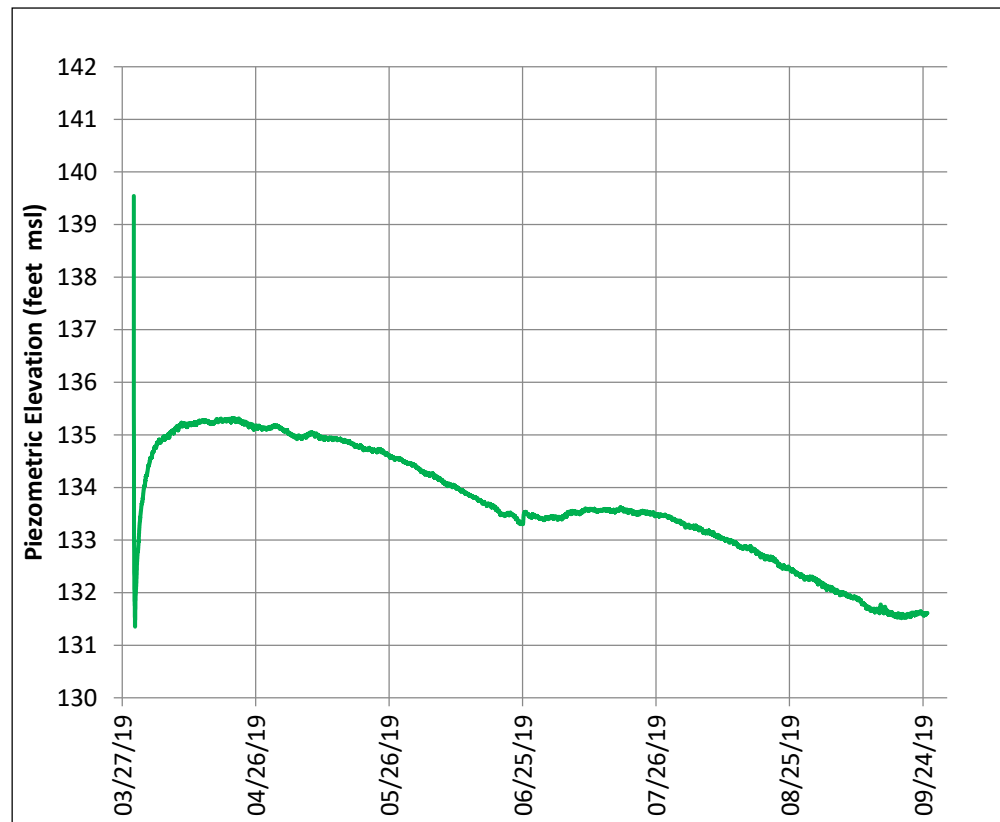
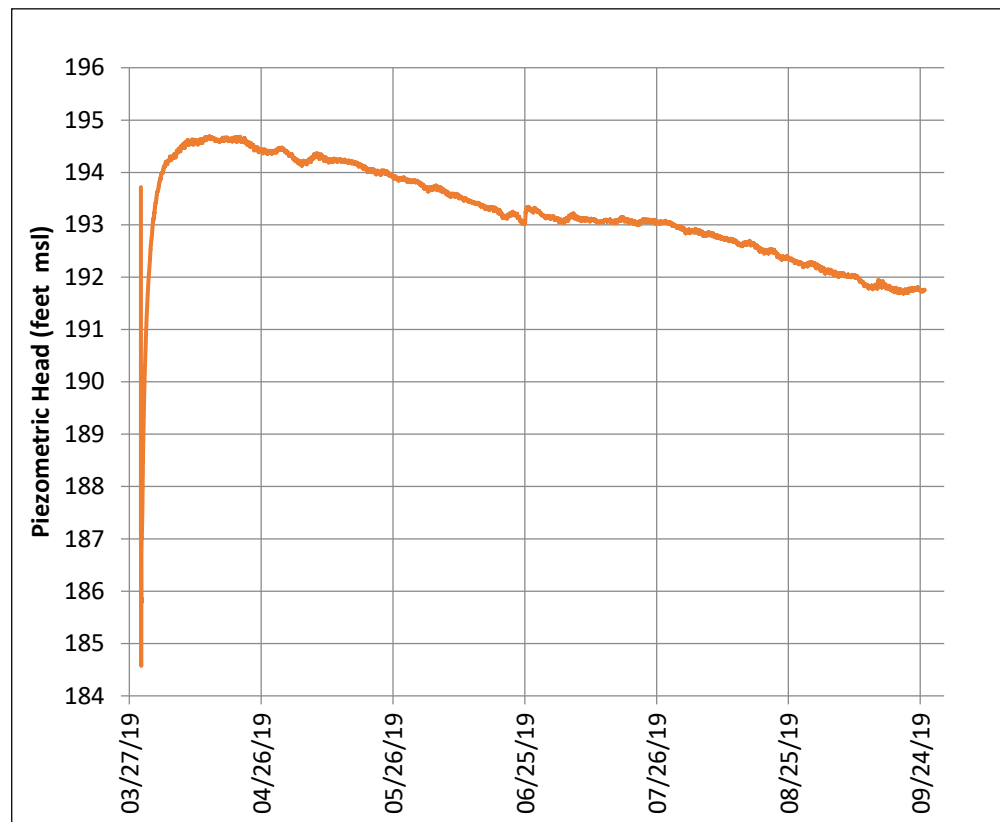
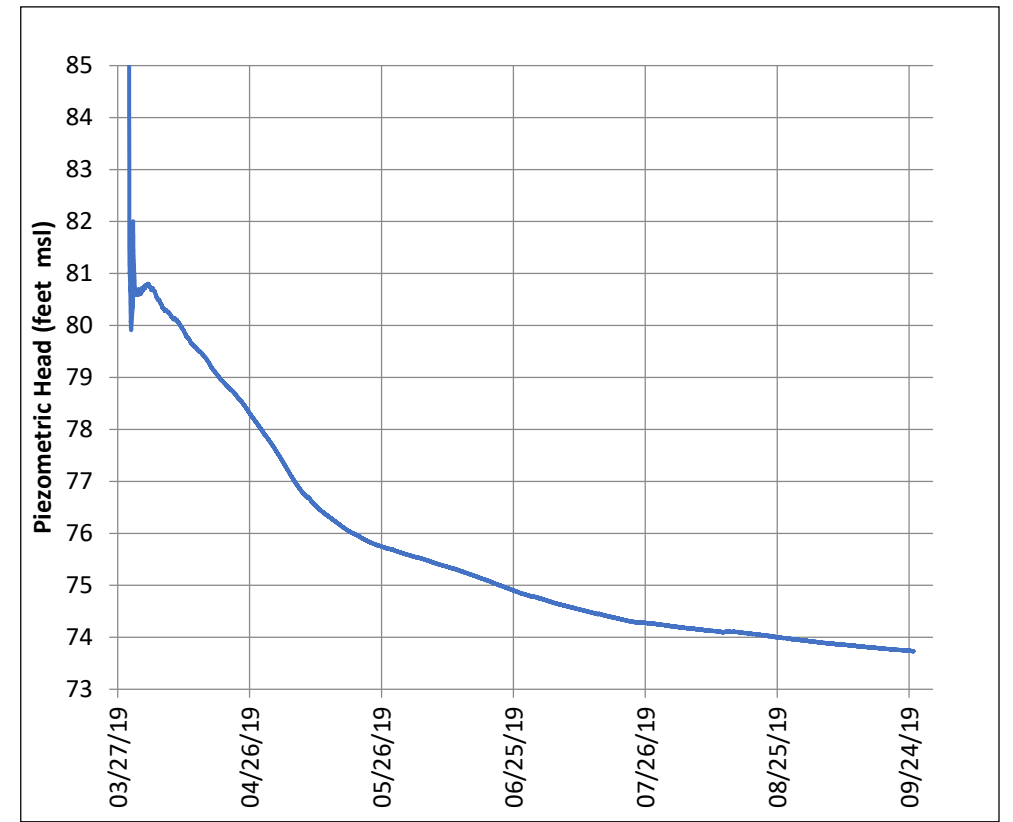
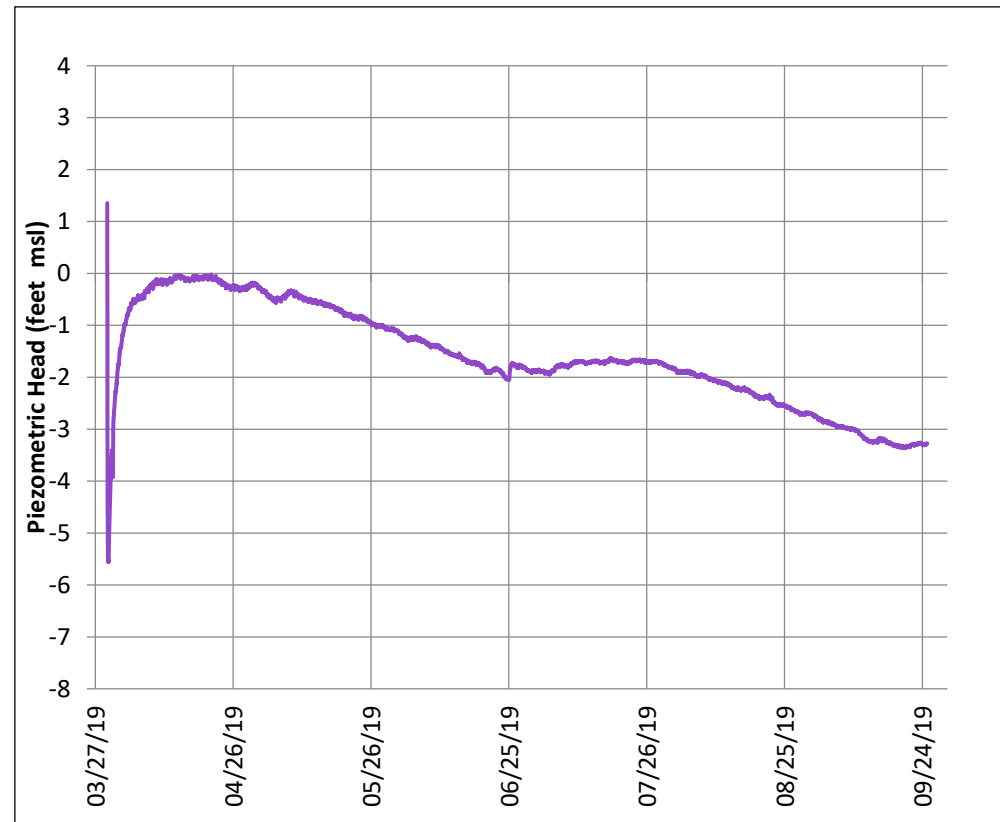
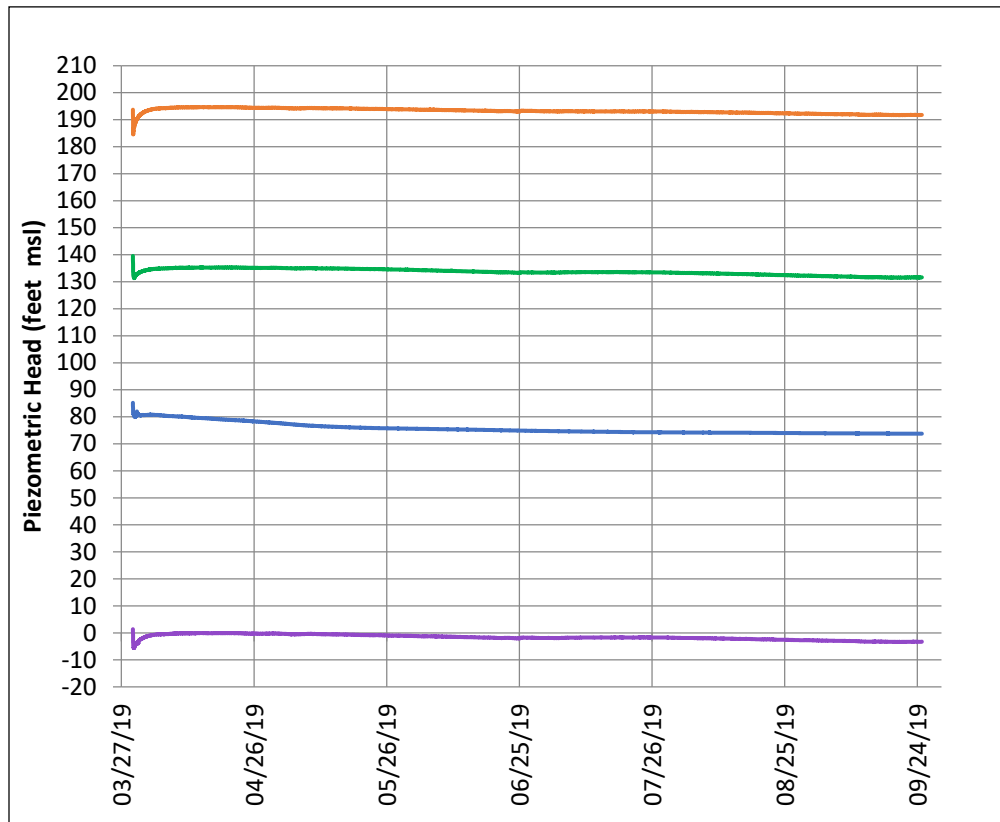




- LEGEND**
- Zone 5 – MOSDAX Transducer
  - Zone 4 – MOSDAX Transducer
  - Zone 3 – MOSDAX Transducer
  - Zone 2 – MOSDAX Transducer
  - Zone 1 – MOSDAX Transducer

<u>Zone</u>	<u>Generalized Geology</u>	<u>Zone Top (ft msl)</u>	<u>Zone Bottom (ft msl)</u>
5	Weathered Basalt	33.7	-11.6
4	Weathered Basalt	- 14.6	- 33.8
3	Weathered Basalt	- 86.8	- 145.1
2	Basalt	- 148.1	- 163.3
1	Basalt	- 249.3	- 273.2

**Appendix A.3**  
**RHMW15 – Long-Term Piezometric Heads**  
**Groundwater Flow Model Progress 09**  
**Red Hill Bulk Fuel Storage Facility**  
**JBPHH, O’ahu, Hawai’i**



LEGEND		Generalized Geology	Probe Elevation (ft msl)
Green Line	Zone 4	Saprolite	106
Orange Line	Zone 3	Saprolite	79
Blue Line	Zone 2	Saprolite	43
Purple Line	Zone 1	Basalt	-37

**Appendix A.4**  
**RHTB01 – Piezometric Heads**  
**Groundwater Flow Model Progress Report 09**  
**Red Hill Bulk Fuel Storage Facility**  
**JBPHH, O’ahu, Hawai’i**

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**Appendix B:  
RHMW15 Boring Log**

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**Project: CTO1850126 - Red Hill Bulk Fuel Storage Facility**

**Project Location: CTO18F0126**

**Project Number: 60571032**

**Log of Boring RHMW15**

Sheet 1 of 38

Date(s) Drilled	11/29/17 - 07/12/19	Logged By	M. Higley, Q. Meehan, B. Mintz	Checked By (Date)	J. Kronen
Drilling Method	HSA / HQ core / PQ core / air rotary	Drill Bit Size/Type	20" tricone / 10" HSA / 14 3/4" hammer / 9 7/8" tricone bit / HQ/PQ diamond bit	Total Depth of Borehole	590.0 feet
Drill Rig Type	Mobile B-59 / T3	Drilling Contractor	Valley Well Drilling	Approximate Surface Elevation	309.9996
Groundwater Level	19.5 feet msl	Location	RHSF	Inclination from Horizontal/Bearing	90°
Borehole Completion	Westbay Well			Hammer Data	N/A

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
0							<b>FILL</b> Dry, dark reddish-brown (2.5YR 3/3), Silty sandy gravel (GM), 50% subangular gravel to 1.5", 20% fine to coarse sand, 30% silt, no odor						11/29/17. Hand Dig. Clear to 2.5' bgs.
308	2						<b>VOLCANIC SAPROLITE</b> Highly to completely weathered volcanic rock. Weathers to - Dry, brown (7.5YR 4/3), sandy silt (ML), with sand						Begin HSA at 2.5' bgs.
306	4												
304	5						<b>WELDED TUFF</b> White (2.5Y 9/1) matrix with greenish black (GLE2 2.5/1) clasts and dusky red (10R 3/3) oxidation, welded, highly weathered, extremely weak, clasts are subangular to subrounded, coarse sand to gravel size up to 1.5"			0.0	[25]		20 ft drilling becomes difficult w/ HSA. Start HQ coring.
	6	1		100		0	<ol style="list-style-type: none"> <li>1. 5, J N, Cl, Fi, Ir, SR</li> <li>2. 0, J, VN, Fe, Su, Ir, R</li> <li>3. 2, J, N, Fe+Cl, Fi, Ir, R</li> <li>4. 20, J, VN, Fe, Su, Ir, R</li> <li>5. 20, J, N, Cl, Fi, Pl, Sr</li> <li>6. 2, J, VN, Fe+Mn, Su, Sr</li> <li>7. 2, J, VN, Fe+Mn, Su, SR</li> </ol>						
302	8						<b>BASALT Massive a'a</b> Greenish black (10Y 2.5/1), moderately weathered, weak to moderately strong						Water loss ~300 gal
300	10		1				<b>BASALT a'a Clinker</b> White (2.5Y 9/1) matrix with greenish black (10Y 2.5/1) clasts, welded, highly weathered, weak to medium strong, clasts are subangular to subrounded, coarse sand to gravel size			0.0	[42.9]		Water loss ~300 gal
298	12	2		100		48							
	13												

Report: CTO53 RED HILL WITH WELL AND PID. File: CTO18F0126 RED HILL CORE LOGS.GPJ. 12/2/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
296	13							<b>BASALT Massive a'a</b> dusky red (10R 3/3) oxidation, moderately weathered, strong						
	14						2 3 4 IF	← 10% vesicles 1mm  1. 5°, J, VN, Fe, Su, Ir, R 2. 45°, J, VN, Fe+Mn, Su, Pl, SR 3. 70°, J, MW, Fe+Mn, Su, Wa, SR 4. 60°, J, N, Fe+Mn, Su, Wa-Pl, SR				0.0	[20]	
294	15						M 1 M							
	16						M M 2	1. 20°, J, VN, Cl, Fi, Ir-Pl, SR 2. 90°, J, VN, Fe+Mn+Cl, Su-No, SR 3. 30°, J, VN, Fe+Mn, Pl, SR						
	17	3		100		0	M M							Water loss ~300 gal
292	18		2				M M M	▼ 10% vesicles 2-3mm						
	19						M M							
290	20						M 3	▼ dark greenish gray (10G 4/1)						
	21						M 1	▼ 5% lenticular vesicles 1-10mm						
288	22	4		100		46	M 2 M	1. 20°, J, N, Fe+Cl, Fi, Ir, SR 2. 90°, J, N, Fe+Mn+Cl, Fi, Pl, SR 3. 20°, J, VN, Fe+Mn, Su, Wa, R 4. 10°, J, VN, Fe+Mn, Su, Wa, R 5. 20°, J, VN, Fe+Mn, Su, Wa, R						Water loss ~300 gal
	23						3 4 5	▼ 10% lenticular vesicles 1-10mm						
286	24						IF 6 7 8 9	6. 10° J, VN, Fe+Mn, Su, Wa, R 7. 60° J, VN, Fe+Mn, Su, Wa, R 8. 20° J, N, Fe-Mn, Su, Pl, R 9. 45° J, VN, Fe-Mn, Su, St, R IF pieces: 0-45, J, VN, Fe+Mn, Su, Ir, R						
	25						1	<b>BASALT a'a Clinker</b> White (2.5Y 9/1) to dusky red (10R 3/4) matrix with very dark gray (7.5YR 3/1) clasts, welded, moderately weathered, very weak, clasts are subangular to subrounded, coarse sand to gravel size						
284	26		3				IF 2	1. 0, J, VN, Fe+Mn, Su, Ir, R IF zone: 0-45, J, VN, Fe+Mn, Su, Pl-Ir, Sr-R						Water loss ~250 gal
	27							<b>BASALT Pahoehoe</b> Weak red (10R 4/4), moderately weathered, very weak, 40% vesicles 1mm, all vesicles filled with pale yellow (2.5Y 8/2) clay						
282	28	5		100		68	3	2. 30, J, VN, Fe+Mn, Su, Ir, R 3. 20, J, VN, Fe+Mn, Sp, Wa, R 4. 60, J, VN, Fe-Mn, Su-Sp, Pl-Wa, SR 5. 20, J, VN, Fe-Mn, Su-Sp, Pl-Wa, R 6. 0, J, N, Fe-Cl, Pa, Wa, R						
	29													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/2/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %					Type	Number Blows per foot	PID (ppm)	
29														
280	30		3				4 M 5 6 1 2	~50% of vesicles filled with clay 1. 60°, J, T, Fe+Mn, Sp, Pl, R 2. 60°, J, T, Fe+Mn, Sp, Pl, R			0.0	[100]		
278	31						IF IF	dusky red (10R 3/2), weak, <20% of vesicles have clay infill IF pieces: 0-70, J, VN, Fe+Mn+Cl, Sp-Fi, Pl-Ir, SR-R, pale yellow (7.5Y 8/2) clay on fractures					Water loss ~200 gal	
276	32	6		100		70	3	occasional 5-10mm vesicles 3. 10°, J, N, Fe+Mn+Cl, Pa, St, R 4. 0°, J, VN, No, No, Wa, R 5. 10°, J, T, Cl, Sp, Ir, R						
274	33						4	grades to dark gray (5Y 4/1), slightly weathered, moderately strong						
272	34		4				5	10% lenticular vesicles 5-15mm			0.0	[100]		
270	35							40% 0.5-2mm rounded vesicles					Water loss ~200 gal	
268	36	7		100		40	1 2 3 4 M 5 6 7 8 9 10 M M M	1. 90°, J, VN, Fe+Mn, Su, Wa, R 2. 0°, J, VN, Fe+Mn+Cl, Sp, Pl, R 3. 20°, J, VN, Fe+Mn, Su, Wa, R 4. 90°, J, VN, Fe+Mn, Su, St, R 5. 90°, J, VN, Fe+Mn, Su, Wa, R 6. 45°, J, VN, Fe+Mn, Su, St, R 7. 70°, J, VN, Fe+Mn+Cl, Pa, Wa, R 8. 0°, J, N, Fe+Mn+Cl, Pa, Pl, R 9. 90°, J, N, Cl, Sp, Wa, R 10. 0°, J, N, Fe+Mn+Cl, Pa, Pl, R						
266	37						1 2 3 4 5	1. 70-90°, J, N, Cl, Sp, Ir, VR 2. M?; 0, J, N, Cl, Sp, Ir, R 3. 0°, J, N-MW, Cl, Fi, Pl, SR 4. 20°, J, N, Cl+Fe+Mn, Pa, R 5. 5°, J, VN, Cl, Sp, Pl, R			0.0	[150]		
266	38	8	5	80		18	M	<b>BASALT Massive a'a</b> Dark gray (10YR 4/1), moderately weathered, weak, <5% vesicles					Water loss ~200 gal. 40-45° lost circulation	
266	39						IF IF	IF zone: 0-90, J, VN-N, Fe+Mn+Cl, Sp-Fi, Pl-Ir, R-VR						
266	40						NR	no recovery						
266	41												End of drilling 11/29/17	

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
45														
-264	46						<b>BASALT a'a Clinker</b> Reddish black (2.5YR 2.5/1) to dusky red (10R 3/4), moderately weathered, weak, subangular to angular gravel size fragments, intensely fractured with very pale yellow (2.5Y 9.5/2) clay coating on fracture surfaces				0.0	[33.3]	Resume on 11/30/17. Core barrel plugged at 45.5', retract barrel at clear. Intermittent poor water return	
	47	9	5	46	0	NR	no recovery						Water loss ~325 gal	
-262	48													
	49													
-260	50					NR	grades with more clay on fracture surfaces				0.0	[75]	Intermittent poor WR	
	51													
-258	52	10		90	60		<b>BASALT Massive a'a</b> Very dark gray (Gley1 3/N), slightly weathered, strong, 20% vesicles 1-10mm, vesicles stretched and elongate						Water loss ~300 gal	
	53						1. 45°, J, T, Fe+Mn, Su, Wa, SR 2. 30°, J, N, No, No, IR, VR 3. 0°, J, T, Fe, Su, St, R 4. 5°, J, T, Fe+Mn+Cl, Sp, Wa, R 5. 20°, J, T, Fe+Mn+Cl, Sp, Wa, SR 6. 20°, J, T, Fe+Mn+Cl, Sp, St, R 7. 0°, J, VN, Fe+Cl, Sp, Wa, SR							
-256	54													
	55		6				grades to 15% vesicles 1-5mm, most very elongate				0.0	[75]	Intermittent poor WR	
	56						1. 75°, J, T, Fe+Mn, Su, Wa, S-SR 2. 0°, J, VN, Fe+Mn+Cl, Sp-Pa, Wa, SR 3. 15°, J, VN, Fe+Mn+Cl, Pa, Wa, SR 4. 0°, J, VN, Cl, Pa, Wa, R 5. 45°, J, T, Fe+Mn, Su, Pl, S							
-254	57						grades to 5% vesicles 1-2mm							
	58	11		84	47								Water loss ~300 gal	
-252	59						<b>BASALT a'a Clinker</b> Reddish brown (2.5YR 4/3) to dusky red (2.5YR 3/2), moderately to highly weathered, very weak, sandy gravel with traces of clay no recovery							
	60						becomes welded, moderately weathered, medium strong							
-250	60		7				1. 20°, J, VN, Cl, Sp, Pl, SR				0.0	[75]	Water loss ~300 gal	
	61						becomes non-welded, fine to coarse gravel size fragments							





Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
77		15		100		52	6							
-232	78		8				7	<b>BASALT a'a Clinker</b> Dusky red (2.5YR 3/2) with very dark gray (Gley1 3/N) clasts, welded, moderately weathered, weak						Water loss ~300 gal
	79						M	becomes non-welded, very weak, highly weathered, friable, broken to gravel and cobble size clasts						
-230	80						IF				0.0	[50]		Intermittent poor WR
	81						1	basalt boulder, slightly weathered, strong, 15% vesicles 1-3mm 1. 80°, J, VN, No, No, Wa, R						
-228	82	16		60		38	IF							Water loss ~300 gal
	83						NR							
-226	84													
	85										0.0	[21.4]		Intermittent poor WR
-224	86		9					no recovery						
	87													
-222	88	17		35		12	IF							Water loss ~400 gal
	89													
-220	90						M	<b>BASALT Massive a'a</b> Very dark gray (Gley1 3/N) to dusky red (2.5YR 3/2), slightly to moderately weathered, medium strong to strong, 10% vesicles 1mm, trace olivine 1. 20, J, VN, Fe+Mn, Su, Pl, SR 2. 30, J, T, Fe+Mn, Su, Pl, S 3. 0, J, N, No, No, Ir, VR 4. ? 5. 60, J, VN, Fe+Mn, Su, Wa, SR 6. 5, J, VN, Fe+Mn, Su, Wa, R			0.0	[42.9]		Intermittent poor WR
	91						1							
	92						2							
-218	92	18		100		68	IF	← 92.3-92.5 Dark reddish brown (2.5YR 3/4), intensely fractured zone, possibly clinker						Water loss ~450 gal
	93													



Project: CTO1850126 - Red Hill Bulk Fuel Storage Facility

Project Location: CTO18F0126

Project Number: 60571032

# Log of Boring RHMW15

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Report: CTO53 RED HILL WITH WELL AND PID: File: CTO18F0126 RED HILL CORE LOGS.GPJ: 12/2/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
109													Water loss ~450 gal	
200	110		10				1	no recovery						
	111						2	<b>BASALT Massive a'a</b> Very dark gray (Gley1 3/N), slightly weathered, strong, 5% elongate vesicles 1-3mm, 5% plagioclase				0.0	[100]	Poor WR
	112						3	becomes moderately weathered, moderately strong, vesicles 2-10mm						
198	112	22		92		62	4	1. 75° J, VN, Cl, Pa, Pl, S 2. 0° B, N, No, No, Ir, R 3. 0° B, N, No, No, Ir, R 4. 45° J, VN, Fe+Mn, Su, St, VR 5. 90° J, VN, Fe+Mn+Cl, Sp, Pl, SR 6. 75° J, VN, Fe+Mn+Cl, Sp, Ir, VR 7. 60° J, VN, Fe+Mn+Cl, Pa, Ir, VR Clay on joints is yellowish red (5YR 4/6)						Water loss ~300 gal
	113						5							
196	114						6							
	115		11				7							
	116						IF	<b>BASALT a'a Clinker</b> Very dark reddish brown (2.5YR 4/3) with very dark gray (Gley1 3/N) clasts, welded, moderately weathered, weak, clasts are angular, fine to coarse gravel size				0.0	[60]	Poor WR
194	117							<b>BASALT Massive a'a</b> Very dark gray (Gley1 3/N), fresh, strong to very strong, 20% 1-10mm elongate vesicles						
	118	23		100		70		3. 50° J, No, No, Ir, VR						Water loss ~300 gal
192	119													
	120						IF							
190	121													
	122						1	1. Mechanical						
	123						2	2. 85° J, N, Fe+Mn+Cl, Pa, Pl, S-SR						
188	124	24	12	100		96	3	3. 10° J, VN, Fe+Mn+Cl, Sp, St, S						
	125						4	4. 15° J, VN, Fe+Mn, Su, Pl, S						
	126							← large vesicles up to 1/4" with walls coated with traces of white secondary minerals (zeolites?)						Water loss ~300 gal
	127													Take WL readings. WL fell from 108.75' btoc to 112.81' btoc in 50 mins

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS		
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)	Drill Time [Rate, ft/hr]
125															
184	126	25		100		70		1. 60° J, N, Fe+Mn+Cl, Pa, Ir, SR 2. 90° J, N, Fe+Mn+Cl, Sp, Pl, S 3. 0° J, VN, Fe+Mn+Cl, Su, Pl, S 4. 75°-90° J, VN, Fe+Mn+Cl, Pa-Fi, Pl, S 5. 0° J, VN, Fe, Su, Pl, S 6. 0°-5° J, N, Fe, Sp, Wa, SR 7. 0°-5° J, N, Fe+Mn+Cl, Wa, SR 8. 90° J, N, Mn+Cl, Wa, SR 9. 60° J, N, Fe, Sp-Pa, Wa, SR 10. 20° J, N, Fe+Mn+Cl, Pa, Pl, S							Intermittent poor WR
182	128						becomes 5% vesicles ~1mm							Water loss ~300 gal	
180	130													Intermittent poor WR	
131	131		13				<b>BASALT a'a Clinker</b> Dark reddish brown (2.5YR 3/4) with very dark gray (Gley 1 3/N) clasts, welded, moderately weathered, moderately strong grades with brown (7.5YR 4/3), becomes moderately to highly weathered, weak, sand to gravel size fragments, non-welded								
178	132	26		70		12	1. 60 J, MW, Fe+Mn+Cl, Sp, Ir, SR 2. 75 J, ?, Fe+Mn+Cl, Sp, Wa, S							Water loss ~300 gal	
176	134						no recovery coarse gravel size fragments							Measured WL inside casing. WL fell from 111.1' btoc to 113.25' btoc in 65 mins End of drilling 11/030/17; begin 12/01/17	
174	136						no recovery							Water level at 136.68' btoc at start of shift (133.68' bgs)	
172	138	27		18		0	no recovery							No WR. Water loss ~250 gal	
170	140														
141															

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/2/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
141														
168	142	28		58		0	NR	no recovery						
	143							<b>BASALT Massive a'a</b> Reddish black (10R 2.5/1), slightly weathered, strong, 15% vesicles 3-10mm, intensely fractured to gravel and cobble size fragments ▼ becomes very dark gray (Gley1 3/N), slightly weathered to fresh, strong to very strong, 15% vesicles 1-10 mm, some elongate, some metallic gold flecks on core. Driller says it is from brass fittings on core barrel and bit					No WR. Water loss ~600 gal	
166	144													
	145						NR					0.0	[23.1]	High H2O pressure. Pull up inner barrel to make sure it is adjusted correctly to latch. Core barrel adjusted correctly. Pull out casing. Recovered additional 2' of core. Driller suspects it came from run 28.
164	146							no recovery						No WR. Water in casing fell from 150.6' bto c to 152.59' bto c in 10 mins. End of drilling 12/01/17; begin 12/04/17. Hole dry at start of shift. Borehole tagged to 150' bgs.
	147	29	14	52		33	IF							
162	148						M	▼ becomes fresh, very strong, 10% vesicles <1mm 1. 15°, J, T, Fe, Su, Pl, SR						
	149						1	zone of 30% vesicles 1-5mm						
160	150							<b>BASALT a'a Clinker</b> Red (2.5YR 3/6) to black (Gley1 2.5/N), gravel to cobble size, subangular fragments, moderately to highly weathered, weak, permeable				0.0	[45]	
	151	30		47		0	NR							No WR. Water loss ~150 gal
158	152							no recovery						
	153													[60] No WR. Water loss ~150 gal
156	154	31		65		17	IF	<b>BASALT Massive a'a</b> Very dark gray (Gley1 3/N), slightly weathered, strong to very strong, 30% vesicles 2-5mm 1. 15°, J, VN, Fe, Sp, Ir, R 2. 15°, J, T, Fe, Su, Wa SR 3. 15°, J, T, Fe+Mn, Su, Wa, SR						
	155						M	1. 5°-30°, J, VN, Fe+Mn, Su, Ir, SR 2. 30°, J, VN, Fe+Mn, Su, Ir, SR						[42.9] No WR. Water loss ~350gal
154	156						1	▼ becomes 15% vesicles 1-3mm						
	157						M							

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
157		32		106		72	M 2 3 4	▼ grades with vesicles up to 10mm 3. 45°, J, VN, Fe+Mn, Su, Pl, SR 4. 10°, J, T, Fe+Mn, Su, Pl, SR 5. 60°, J, T, Fe+Mn, Su, Pl, SR 6. 30°, J, T, Fe+Mn, Su, Pl, S 7. 80°, J, VN, Fe+Mn, Su, Pl, SR 8. 0°, J, N, Fe+Mn+Uk, Sp, Ir, VR 9. 60°, J, N, Fe+Mn+Uk, Sp, Pl, R Uk: pale yellow (5Y 7/4)					
152	158						M 5 6 7						
159			15				8 9						
150	160						1	▼ some vesicles filled with pale yellow mineral				[50]	No WR. Water loss ~350 gal
161							2 3 4						
148	162	33		92		56	M 5 6 7 8	1. 45°, T, N, Fe+Mn+Uk, Pa, Ir, VR 2. 85°, J, N, Fe+Mn+Uk, Sp, Ir, VR 3. 0°, J, N, Fe+Mn+Uk, Pa, Ir, VR 4. 5°, J, VN, Fe+Mn, Su, Pl, S 5. 80°, J, N, Fe+Mn+Uk, Pa, Wa, R 6. 45°, J, T, Fe+Mn, Su, St, R 7. Mechanical 8. 50°, J, N, Fe+Uk1+Uk2, Pa, Ir, R 9. 45°, J, T, Fe+Mn, Su, Pl, SR 10. 60°, J, VN, Fe+Mn+Uk, Pa, Pl, S 11. 30°, J, VN, Fe+Mn+Uk, Pa, Pl, S Uk2: white (5Y 8/1), waxy (halloysite?)					
163							8						
146	164						9 10 11						
165							NR	no recovery				[50]	No WR. Water loss ~350 gal
144	166		16				1	1. 30°, J, T, No, No, Pl, S 2. 45°, J, T, Fe+Mn, Pl, S 3. 80°, J, N, Fe+Mn+Uk, Pa, Wa, SR 4. 0°, J, N?, No, No, Pl, SR 5. 90°, J, N, Fe+Mn+Uk, Pa, Wa, SR 6. 30°, J, N, Fe+Mn+Uk, Pa, Pl, SR 7. 5°, J, N, Fe+Mn+Uk, Pa, Pl, SR 8. 0°, void, Fe+Mn+Uk, Su, Pl, SR					
167							2 3						
142	168		34			64	4 5						Drill string drops. Driller says 2' void: 167.5'-169.5' bgs. Pause for WL readings at 170'. WL fell from 169.56'-169.75' bgs
169							6 7 8						
140	170						9	Void				[37.5]	No WR. Water loss ~500 gal
171							NR	no recovery					
171							IF	BASALT a'a Clinker Red (10R 4/6) to very dark gray (Gley1 3/N), angular, coarse gravel size clinker fragments, moderately weathered, weak, with Uk mineral/ clay coating on some surfaces, permeable					
138	172		17			28	1	BASALT Massive a'a Dusky red (2.5YR 3/2), moderately weathered, medium					
173			35			70							

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
173								strong to strong, 20% 1-3mm vesicles					
136	174						IF	at 173.4 ft bgs becomes intensely fractured with Uk mineral coating on some fractures, broken to sand in some zones					
	175						4						
	175						1						
	175						2	becomes very dark gray (Gley1 3/N), slightly weathered, strong					[75] No WR. Water loss ~350 gal
134	176						3						
	176		17				5	1. 45°, J, VN, No, No, PI, R 2. 30°-60, J, VN, Fe+Mn, Su, PI, SR 3. 50°, J, VN, Fe+Mn, Su, PI, S 4. 50°, J, VN, Fe+Mn, Su, PI, S 5. 45°, J, T, No, No, PI, S					
	177						6	6. 5°, J, VN, Fe+Mn+Uk, Pa, PI, S					
	177						7	7. 45°, J, VN, Fe+Mn, Su, PI, SR					
	177						8	8. 60°, J, VN, Fe+Mn, Su, Wa, SR					
132	178	36		100		72	M	9. 10°, J, VN, Fe+Mn+Uk, Pa, PI SR 10. 30°, J, VN, Fe+Mn+Uk, Pa, PI R					
	179												
	180						10						
130	180						1	becomes fresh, strong to very strong, 7% elongate vesicles					[60] No WR. Water loss ~350 gal
	181							1. 20°, J, T, Fe+Mn, Su, Ir, SR 2. 0°, J, VN, Fe+Mn+Uk, Su, Ir, R 3. 0°, J, VN, Fe+Mn+Uk, Su, Ir, R 4. 0°, J, VN, Fe+Mn+Uk, Su, Ir, R 5. Mechanical					
	182						2	6. 5°, J, T, Fe+Mn+Cl, Su, PI, SR					
128	182						3	7. 0°, J, T, Fe+Mn, Su, PI, SR					
	182						4	8. 0°, J, T, Fe+Mn, Su, PI, SR					
	182	37		100		85		9. 5°, J, T, No, No, Wa, Sr 10. 0°, J, T, Fe+Mn, Ir, R					
	183						6						
	183						5						
	183						7						
126	184						8						
	184		18				9						
	185												
	185						IF						
124	186							<b>BASALT Pahoehoe</b> Dusky red (2.5YR 3/2), moderately weathered, medium strong, 50% vesicles up to 1mm, intensely fractured (mostly mechanical)					[75] No WR. Water loss ~500 gal
	187												
	187	38		50		0							
	187												
122	188						10	<b>BASALT a'a Clinker</b> Red (10R 4/6), dusky red (2.5YR 3/2), and very dark gray (Gley1 3/N), angular gravel size clinker fragments, moderately weathered, weak, permeable					
	188												
	189												



Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
189													
120	190						no recovery				0.0	[36]	No WR. Water loss ~250 gal
118	192	39	18	40		13	clinker (as above) 1. 5°, J, Fe+Mn, Su, Ir, SR 2. 10°, J, VN, Fe+Mn, Su, Ir, SR						
116	194	40		100		75	<b>BASALT Massive a'a</b> Very dark gray (Gley1 3/N), slightly weathered, strong, 20% vesicles 1-3mm 193-193.5' bgs 40% vesicles 1. 0°-90°, J, VN, Fe+Mn, Su, Wa, SR 2. 20°, J, VN, Fe+Mn, Su, Pl, S 3. 30°, J, VN, Fe+Mn, Su, Ir, R				0.0	[30]	No WR. Water loss ~100 gal
114	196						becomes 15% vesicles 1-10 mm				0.0	[26.3]	No WR. Water loss ~200 gal
112	198	41		100		40	vesicles become very elongate						
110	200	42		53		0	1. 70°, J, VN, Fe+Mn, Su, Pl, S 2. 70°, J, VN, Fe+Mn, Su, Wa, SR 3. 70°, J, VN, Fe+Mn, Su, Wa, SR 4. 0°, J, VN, Fe+Mn+Uk, Su, Ir, R 5. 0°, J, VN, Fe+Mn, Su, Wa, SR IF zone: fracture surfaces coated with Fe+Mn+Uk				0.0	[45]	Driller says core barrel stuck. Recovered additional 1.7' of core which was dropped from run 40. Add to run 40. Pause to collect WL readings. WL fell from 198.1' bgs to completely dry in 5 mins. No WR. Water loss ~100 gal
108	202	43		30		0	← IF zone mechanically fractured				0.0	[30]	No WR. Water loss ~700 gal
106	204						<b>BASALT a'a Clinker</b> Dusky red (2.5YR 3/2) to very dark gray (Gley1 3/N), subangular gravel size clinker fragments, moderately weathered, permeable						
	201						becomes very dark gray (Gley1 3/N) coarse sand size, very angular, possibly mechanically pulverized						
	203						no recovery						
	204												Drill string binding up. Difficult drilling
	205												

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
205						NR						0.0	[15]	No WR. Water loss ~1000 gal. Slower drilling
104	206	44		28		0		no recovery						
	207							clinker (as above)						
102	208							<b>BASALT Massive a'a</b> Very dark gray (Gley1 3/N), slightly weathered, strong, 20% vesicles 1-3mm, vesicles partially filled with clay from 208'-208.2' bgs 1. 0, B, W?, Cl, Sp, Ir, R 2. 30, J, VN, Fe+Mn, Su, St, SR 3. 70, J, VN, Uk, Pa, Ir, R				0.0	[18.8]	No WR. Water loss ~350 gal
	209	45		100		96								
100	210		20											
	211							becomes fresh, very strong						
	212							1. 10°, J, N, Fe+Mn, Su, Wa, SR 2. 45°, J, VN, Fe+Mn, Su, Pl, SR 3. 40°, J, VN, Fe+Mn+Uk, Sp, Pl, S 4. 75°, J, N, Fe+Mn, Su, Ir, R 5. 50°, J, N, Fe+Mn, Su, Ir, R 6. 45°, J, VN, Fe+Mn, Su, Pl, SR 7. 45°, J, VN, Fe+Mn, Su, Pl, SR 8. 85°, J, VN, Fe+Mn, Su, Ir, R 9. 85°, J, VN, Fe+Mn, Su, Ir, R						
98	213													
	214	46		90		54								Driller says hole is very tight. Squeezing drill string
96	215							no recovery						
	216							1. 60°, J, VN, Fe+Mn, Su, Wa, R 2. 50°, J, VN, Fe+Mn, Su, Wa, R 3. 45°, J, VN, Fe+Mn, Su, Pl, SR 4. vesicles elongate, up to 20mm						
94	217							4. Mechanical 5. 5°, J, N, Fe+Mn, Su, St, R 6. 30°, J, VN, Fe+Mn, Sp, Pl, SR 7. 75°, J, VN, Fe+Mn, Sp, Wa, S 8. 15°, J, VN, Fe+Mn, Sp, Ir, R 9. 25°, J, VN, Fe+Mn, Sp, Ir, R 10. 15°, J, VN, Fe+Mn, Sp, Pl, SR 11. 5% vesicles 1-2mm						
	218	47	21	100		54								
92	219													
	220							11. 5°, J, VN, No, No, Wa, SR 12. 60°, J, T, Fe, Su, Pl, S 13. 60°, J, T, Fe, Su, Pl, S 14. 70°, J, VN, Fe+Mn, Su, Ir, R						Record WL inside casing. WL fell from 203.9' bgs to 210.92 bgs in 30 mins. End of drilling 12/04/17. begin 12/05/17
90	221							<b>BASALT a'a Clinker</b> Dusky red (2.5YR 3/2) to black (Gley1 2.5/N), angular gravel to cobble size clinker fragments, moderately to highly weathered, weak, permeable <b>BASALT Pahoehoe</b> Dusky red (2.5YR 3/2) to very dark gray (Gley1 3/N),						Record WL at start of shift. DTW=214.57' bgs and falling slowly

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
221														
88	222	48	21	100	34	1	slightly to moderatel weathered, strong, 40% vesicles 1-3mm, some bentonite on fractures and in vesicles from 220'-222' bgs							Driller added ~150 lbs bentonite powder and 120 gal H2O before start of run.
	223					2								No WR. Water loss ~250 gal
86	224					3	1. 0°, J, VN, No, No, Pl, R							
						4	2. 0°, J, VN, No, No, Pl, R							
						5	3. 75°, J, N, Fe+Mn, Su, Wa, R							
						6	4. 0°, J, N, Fe+Mn, Su, Pl, R							
						IF	5. 90°, J, VN, Fe+Mn, Su, Wa, R							
	225					1	6. 0°, J, VN, Fe+Mn, Su, Wa, R							
							▼ vesicles increase to 2-6mm, very dark gray (Gley1 3/N)						[60]	No WR. Water loss ~350 gal
84	226					2	1. 5°, J, N, Fe, Su, Wa, R							
						IF	2. 5°, J, N, Fe+Cl, Sp, Pl, R							
							3. 50°, J, N, Fe+Cl, Sp, Wa, R							
							IF zone: partial red (2.5YR 4/8) clay fill on fractures							
	227	49		100	48	3	▼ vesicles 1-3mm							
82	228		22			4	4. 30°, J, N, Fe+Mn, Su, Ir, R							
						5	5. 30°, J, Vn, Fe+Mn, Su, Pl, SR							
						6	6. 30°, J, VN, Fe+Mn, Su, Pl, R							
						7	7. 45°, J, VN, Fe+Mn, Cl, Pa, Wa, SR							
						8	8. 40°, J, VN, Fe+Mn+Cl, Pa, Wa, SR							
80	230					IF	▼ becomes dusky red (2.5YR 3/2) to very dark gray (Gley1 3/N), moderately weathered							
							1. 70°, J, N, Fe+Mn+Cl, Sp, Wa, R							[100]
							IF zone: Fe+Mn+Cl							No WR. Water loss ~350 gal
							2. 10°, J, N, Fe+Mn+Cl, Pa, Ir, VR							
							3. 30°, J, VN, Fe+Mn+Cl, Sp, Pl, SR							
							4. 45°, J, N, Fe+Mn+Cl, Su, Wa, SR							
							5. 45°, J, N, Fe+Mn+Cl, Su, Wa, SR							
78	232	50		100	22	1	▼ moderately to slightly weathered, very dark gray (Gley1 3/N)							
						2	6. 45°, J, N, Fe+Mn+Cl, Su, Wa, SR							
						3	7. 45°-80°, J, N, Fe+Mn+Cl, Su, Wa SR							
						4	8. 15°, J, VN, Fe+Mn+Cl, Su, Ir, R							
						5	9. 50°, J, VN, Fe+Mn+Cl, Su, Ir, VR							
						6	10. 5°, J, W, Fe+Mn, Su, Ir, R							
						7	11. 30°, J, N, Fe+Mn+Cl, Sp, Ir R							
76	234					8	▼ becomes dusky red (2.5YR 3/2) to very dark gray (Gley1 3/N), with ropey pahoehoe structure							
						9								
						10								
						11	IF zone contains clay on fractures							
	235					IF	▼ vesicles 0.5-1mm							[150]
							▼ very dark gray (7.5YR 3/1) to dusky red (2.5YR 3/2) and red (2.5YR 4/8), moderately to highly weathered, weak, friable, intensely fractured, ropey pahoehoe fragments, possible flow margin							Driller says possible void ~236'-237'
74	236		23			IF	no recovery/possible void							
	237													

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
237		51	66			38		no recovery/possible void					No WR. Water loss ~350 gal
72	238						1	1. 5°, B, W, Cl, Pa, Ir, VR					
							2	2. 45°, J, VN, Fe+Mn, Su, Wa, SR very dark gray (Gley1 3/N), slightly weathered, strong, 30-40% vesicles 0.5-2mm					
	239		23				3	3. 45°, J, VN, Fe+Mn+Cl, Pa, Pl, SR 20% vesicles 1-4mm, some elongate					
70	240						1	abrupt change to 50% vesicles 0.5-1mm					
							2	1. 0°, J, N, Fe+Mn+Cl, Su, Pl, SR					[75] No WR. Water loss ~350 gal
							3	2. 0°, J, N, Fe+Mn+Cl, Su, Pl, SR					
	241						4	3. 0°, B, N, Fe+Mn+Cl, Pa, St, R					
							5	4. 10°, J, N, Cl, Fi, Pl, SR					
							6	5. 45°, J, N, Cl, Fi, Ir, SR					
							7	IF zone contains thick clay					
68	242						8	black (Gley1 2.5/N) to dark reddish brown (2.5YR 3/4) flow boundary					
							9	dusky red (2.5YR 3/2) to very dark gray (Gley1 3/N), moderately weathered, moderately strong					
	243	52	90			60	6	6. 5°, J, VN, Fe+Mn+Cl, Sp, Wa, R					
							7	7. 0°-30°, J, VN, Fe+Mn, Su, Pl, SR					
	244						8	very dark gray (Gley1 3/N), slightly weathered, vesicles 1-3mm					
66							9	8. 30°, J, VN, Fe+Mn, Su, Pl, SR					
							10	9. 90°, J, VN, Fe+Mn+Cl, Sp, Wa, R					
	245							no recovery					
			24				1	1. 0°, J, VN, Fe+Mn, Su, Pl, SR					
							2	2. 90°, J, VN, Fe+Mn, Su, Pl, SR					
64	246						3	3. 0°, J, VN, Fe+Mn, Su, Ir, R					
							M	vesicles 3-15mm					
								large vug					
	247						4	vesicles 0.5-2mm					
62	248	53	100			86	4	4. 10°, J, VN, No, No, Pl, SR					
							IF	IF zone contains clay on joint surfaces, surfaces highly irregular and rough, possible vug					Pause to record DTW inside casing. See field log for details.
	249						M						
60	250						1	very dark gray (Gley1 3/N), slightly weathered, strong, 40% vesicles grade to 0.5-1mm					[150] No WR
							M	gray (Gley1 5/N) flow/alteration boundary					
	251						2	1-3mm vesicles					
			25				M	50% vesicles, 5mm with yellowish red (5YR 5/8) clay infill, moderately weathered, moderately strong					
58	252						1	1. 70°, J, N, Fe+Mn+Cl, Pa, Pl, SR					Lost bottom 3' core upon core barrel retrieval. Then recovered rest of core.
							2	2. 90°, J, N, Fe+Mn+Cl, Sp, Wa, R					
							3	3. 0°, J, T, Fe+Mn, Su, Wa, R					
	253	54	100			78	4	vesicles grade to 0.5mm, slightly weathered, strong					

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Type	Number Blows per foot	PID (ppm)	
253													
56	254						30% 3-5mm vesicles 4. 0°, J, VN, Fe+Mn, Su, Wa, R 5. 0°, J, VN, Fe+Mn, Su, Ir, R 6. 70°, J, T, Fe+Mn, Su, Pl, R 7. 70°, J, T, Fe+Mn, Su, Pl, R						
	255		25				no recovery 40% 0.5-1mm vesicles IF zone consists of natural fractures with Fe+Mn surface stains and yellowish red (5YR5/8) clay spotty fill on fracture planes, grayish olive (10Y 5/2) alteration on many fracture planes					[100]	
54	256						30% 1-5mm vesicles 1. 70°-45°, J, N, Fe+Mn, Su, Wa, SR 2. 45°, J, VN, Fe+Mn+Cl, Sp, Pl, SR 3. 20°-45°, J, T, Fe+Mn, Su, Wa, SR 4. 70°, J, MN, Fe+Mn+Cl, Pa, Ir, SR 5. 45°, J, MN, Fe+Mn+Cl, Pa, Ir, SR 6. 20°, J, VN, Fe+Mn+Cl, Sp, Pl, R						
52	258	55		88		62							
	259						40% 0.5-1mm vesicles 30% 1-3mm vesicles						
50	260		26										[60]
	261						10% 2-5mm vesicles 40% 0.5-1mm vesicles 25% 1-5mm vesicles 5% 3-10mm vesicles						
48	262						30% 1-3mm vesicles 40% 0.5-1mm vesicles						
	263	56		100		78	40% 1-3mm vesicles						
46	264						1. 90°, J, VN, Fe+Mn+Cl, Pa, SR 2. 20°, J, T, Fe+Mn+Cl, Sp, Pl, R 3. 70°, J, N, Fe+Mn+Cl, Pa, Pl, R 4. 45°, J, VN, Fe+Mn+Cl, Sp, Pl, R 5. 90°, J, VN, Fe+Mn+Cl, Pa, Wa, R 6. 5°, J, N, Fe+Mn+Cl, Pa, Pl, R 7. 10°, J, N?, Fe+Mn+Cl, Pa, Pl, R IF. 0°-90°, J, VN, Fe+Mn+Cl, Pa, Pl-Ir, R						
	265												
44	266		27				<b>BASALT - a'a' Clinker</b> partially cemented clasts, very dark gray (5YR 3/1) reddish brown (5YR 4/3), clay - reddish yellow (5YR 6/8) moderately weathered, medium strong.						
	267						1. 0°, J, VN, No, No, Wa, SR 2. 0°, J, VN, No, No, Wa, SR 3. 10°, J, VN, No, No, Wa, R 4. 20°, J, VN, No, No, Wa, R						
42	268	57		100		66	becomes loose clinker, rounded to subrounded clasts						
	269		28										

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/2/2019 RHMW15

Measure DTW. WL fell from 255.93' bgs to 256.06' bgs in 45 mins  
 End of drilling 12/05/17

Resume coring 7/1/19, clear out bentonite plug 255' to 265' bgs from 0851 - 0916

WL = ~500 gals, No WR, Lost circulation.

Reamed to 265' bgs with 9 7/8" on 2/11/18, set 5" steel conductor casing to 265' and grout on 2/12/18.

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS			
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)	Drill Time [Rate, ft/hr]	
269																
40	270		28				<p><b>BASALT - Massive a'a'</b>                      very dark gray (5YR 3/1), moderately to slightly weathered, strong, 5% 1-10mm irregular, some elongate vesicles, partially infilled with reddish yellow (5YR 6/8) clay.</p> <p>5. 45°, J, VN, Clay, Sp, Wa+St, SR                      6. 0°, J, VN, Clay, Sp, Pl, S                      1. 45°, J, VN, Mn+Fe+Clay, Sp, Wa, SR                      2. 20°, J, VN, Mn+Fe, Sp, Clay, Su, Wa, S</p>									
	271						<p><b>BASALT - a'a' Clinker</b>                      loose, subangular to subrounded clasts, very dark gray (5YR 3/1), clay - reddish yellow (5YR 6/6) moderately to highly weathered, medium strong, clay coating on most clasts.</p>									
38	272	58		100		12.5										
	273															
36	274		29				<p><b>BASALT - Massive a'a'</b>                      black (GLE Y1 2.5/N) slightly weathered, strong, 5% 1-5mm subrounded, elongate vesicles.</p> <p>1. 50°, J, VN, Mn+Fe+Clay, Sp, Wa, S                      2. 30°, J, VN, Mn+Fe+Clay, Sp, Wa, S                      3. 30°, J, VN, Mn+Fe+Clay, Sp + Su, Wa, S                      4. 30°, J, VN, Mn+Fe+Clay, Sp + Su, Wa, S</p> <p>becomes 10% 2-35mm subrounded irregular, elongate vesicles</p>									
	275															
34	276	59		100		82.5										
	277						<p>← vug ~ 35mm x 50mm, partially infilled with reddish yellow (5YR 6/8) clay</p>									
32	278		30													
	279	60		100		20	<p><b>BASALT - a'a' Clinker</b>                      loose, very dark gray (GLE Y1 3/N) clay - yellowish red (5YR 3/8), moderately weathered, medium strong, mostly clay coated rounded to subangular.</p>									
30	280						<p>no recovery</p>									
	281						<p>← becomes highly weathered, very weak, very broken up</p>									
28	282		31				<p><b>BASALT - Pahoe-hoe</b>                      very dark gray (GLE Y1 3/N), slightly weathered, strong, 10% 1-10mm rounded to subangular vesicles, partially infilled with clay. heat alteration, possible flow contact, brown (7.5YR 5/3) and yellow (10YR 7/6) at 282.4' very dark gray (7.5YR 3/1) slightly to moderately weathered, medium to strong, 15% &lt;2mm rounded vesicle at 282.5'.</p>									
	283	61		94		26										
26	284		32				<p>IF pieces: Mn+Fe, Sp, clay, Su                      1. 45°, J, VN, Mn+Fe Sp, Clay, Su, St, SR                      2. 20°, J, VN, Mn+Fe+Clay, Sp, Wa, SR                      3. 50°, J, VN, Mn+Fe+Clay, Sp, St, SR</p> <p>← heat alteration, black (GLE Y N/1), yellow (10YR 7/6)</p>									
	285															

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
285														
24	286		33				dark brown (7.5YR 4/3), slightly weathered moderate strength, 20% <2mm rounded vesicles very dark gray (7.5YR 3/1), slightly weathered moderate strength, 15% <2mm rounded vesicles M+IF pieces angled and rounded from mechanical					[50]	High pressure water came out when pulling drill rod up. Drilling paused 1340 barrel came loose.	
	287													
22	288	62		60		8								WR, WL = 100 gal Could not get WL because pulled casing - drilling paused WL-170-38 @288 ft bgs.
	289						becomes yellowish red (5YR 4/6), black (5YR 2.5/1), moderate strength, 20% <1mm rounded vesicles.							
20	290		34				1. 90°, J, VN, Mn+Fe, Sp, Wa, SR 2. 2.5°, J, VN, No, No, St, R					[42.86]	Resume on 7/2/19 at 0647, 288ft bgs 288-390 WL = 500gal, no WR	
	291													
18	292	63		100		40	flow contact, dark reddish brown (2.5YR 3/4) 40% 2-10mm subrounded vesicles black (7.5YR 2.5/1), slightly weathered strong, 10% <2mm subrounded vesicles becomes 20% <2mm subrounded vesicles							WL = 500gal, No WR, Lost circulation
	293													
16	294						dark reddish brown (5YR 3/3) and black (5YR 2.5/1) rosey texture, moderately weathered, moderate strength, 15% <2mm subrounded vesicles.							
	295		35				black (7.5YR 2.5/1), slightly weathered strong, 10%, 1-5mm subrounded vesicles.					[100]		
14	296						rosey texture visible near end of core. Highly weathered, very weak, broken up pieces dark reddish brown (5YR 3/4), dark reddish brown (5YR 3/2), black (2.5YR 2/1), ground up, angled and rounded pieces.							
	297	64		76		26	1. 90°, J, VN, Mn+Fe+clay, Sp, Pl, SR							Void - per driller, WL = 300 gals
12	298													
	299		36											
10	300						no recovery							
	301													

Project: CTO1850126 - Red Hill Bulk Fuel Storage Facility

Project Location: CTO18F0126

Project Number: 60571032

# Log of Boring RHMW15

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Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
301													
8	302	65	36	86		0	IF						WL = 300gal, No WR for rest of log
	303						IF						
6	304												
	305											[42.86]	
4	306						IF						
	307	66		44		0							WL = 400 gal
2	308		37				NR	no recovery					
	309												
0	310												
	311							1. ropey texture, possible flow contact yellowish brown (10YR 5/4), becomes black (7.5YR 2.5/1), slightly weathered, strong, 5% 2-20mm subrounded to subangular, elongate vesicles, 2% weathered olivine 2. 3.					
-2	312	67		100		0		becomes intensely fractured/broken up, black (7.5YR 2.5/1), dark reddish brown (5YR 3/4), highly weathered, weak					WL = 300 gal
	313						IF	1. 0°, J, VN, Mn < Fe, SP, St, SR 2. 80°, J, VN, Mn, Fe, Sp, Wa, SR 3. 5°, J, VN, Mn, Fe, Sp, Wa, SR					
-4	314		38										
	315						IF	black (7.5YR 2.5/1), slightly weathered, strong, 5% 1-5mm rounded to subrounded vesicles reddish brosh (5YR 4/1), moderately weathered, medium strong, 10% <2mm rounded vesicles black (7.5YR 2.5/1), slightly weathered, strong, 15% <4mm rounded vesicles, 2% weathered olivine					[150]
-6	316						IF	1. 40°, J, VN, Mn, Fe, Sp, Wa, SR 2. 0°, J, VN, No, No, Wa, R					WL = 300 gal
	317												



Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/2/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
317		68		100		30		3. 80°, J, VN, Mn, Fe, Sp, Wa, R 10% 2-10mm subrounded to subangular vesicles					
-8	318		39				IF	15% <4mm rounded vesicles					
	319						IF	4. 5°, J, VN, clay, Sp, Wa, R					
-10	320						IF	intensely fractured ropey textured pieces, becomes black (7.5YR 2.5/1), brown (7.5YR 4/2), moderately weathered, medium strong, 10% <2mm rounded vesicles				[100]	
	321		40				NR	no recovery black (10YR 2.5/1), moderately weathered, strong, 15% 2-10mm subangular vesicles partially infilled with yellowish red (5YR 5/8) clay, slightly weathered, strong, 10% 1-15mm rounded to subrounded vesicles at 321.5					
-12	322							1. 5°, J, VN, clay, Sp, Wa, SR 5% <4mm rounded vesicles					WL = 300 gal
	323	69		88		62	IF	IF pieces: covered with yellowish red (5YR 5/8) clay 2. 90°, J, VN, Mn+Fe+clay, Sp, St, SR becomes very dusky red (2.5YR 2.5/2)					
-14	324							possible flow contact red (2.5YR 4/6) black (10YR 2.5/1) unweathered, strong, 20% 1mm rounded vesicles 5% 1-4mm rounded to subrounded vesicles 15% 2-5mm rounded to subrounded vesicles partially infilled with yellowish red (5YR 5/6) clay					
	325							2% 3-10mm subrounded vesicles 5% 1-4mm rounded vesicles				[50]	
-16	326		41					2% 3-10mm subrounded vesicles					
	327						M	1. 75°, J, VN, clay, Sp, Wa, SR 2. 65°, J, VN, clay, Sp, Wa, SR black (7.5YR 2.5/1), slightly weathered, strong, 2% <2mm rounded to subrounded vesicles, 1% unweathered olivine					WL = 300 gal - High pressure when retrieving barrel, water release.
-18	328		70			94	M	black (10YR 2.5/1), slightly weathered, strong, 5% 2-10mm rounded to subrounded vesicles					
	329							15% 4mm rounded vesicles partially infilled with clay yellowish red (5YR 5/8) dark reddish brown (2.5YR 3/4), unweathered, strong, 15% <2mm subrounded to subangular vesicles				[50]	
-20	330						IF	possible flow contact/heat alteration red (2.5YR 4/6) black (10YR 2.5/1) unweathered, strong, 15% <2mm rounded vesicles					
	331							10% 2-8mm subrounded vesicles					WL = 400 gal
-22	332		43					red (2.5YR 4/6) slightly weathered, strong, 10% <1mm rounded vesicles					
	333		71			66							

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
333			43				8	← black (10YR 2.5/1) unweathered, strong, 15% <3mm rounded vesicles 1. 15, J, VN, Mn+clay, Sp, Wa, R 2. 90, J, VN, Mn+clay, Sp, Wa, R 3. 20, J, VN, Mn+Fe+clay, Sp, Wa, SR 4. 5, J, VN, Mn+clay, Sp, Wa, SR 5. 5°, J, VN, Mn+clay, Sp, Wa, SR 6. 0°, J, VN, Mn+clay, Sp, Wa, SR 7. 0°, J, VN, Mn+clay, Sp, Wa, R 8. 0°, J, VN, clay, Sp, St, SR						
-24	334													
	335		44										[75]	
-26	336													Paused drilling because barrel stuck - retrieve core around 1315 up to 4.3'
	337	72		100		76	M							WL = 300 gal
-28	338		45				M							4.3 ft - 5.0 ft retrieved from 1315 to 1318.
	339						IF	↓ some clay on surface of intensely fractured pieces yellowish red (5YR 6/8) ← IF+M pieces: with some clay infilling, reddish brown (2.5YR 4/3), black (10YR 2.5/1), slightly weathered, weak, 5% 1-10mm rounded to subrounded vesicles						WL = 300 gal - water level at ~290' bgs
-30	340						IF	← black (5YR 2.5/1), slightly weathered, strong, 15% 1-3mm rounded vesicles partial clay infilling reddish yellow (5YR 7/8)					[17.65]	
	341						1 M	1. 15°, J, VN, Mn, Fe, Sp, clay, Su, Wa, SR						
	342		46				2 M	2. 45°, J, VN, Mn, Fe, clay, Sp, Wa, SR						
-32	343	73		70		30	IF	↓ intensely fractured pieces covered with clay reddish yellow (5YR 7/8)						WL = 400 gal. 340-342 barrel stuck - paused drilling for day 7/2 at 342.5' bgs.
	344						M							
-34	345						NR	no recovery						
	346		47				M							
-36	347	74		100		32	IF	1. 90°, J, VN, No, No, Wa, SR						[75]
	348						IF	BASALT - a'a' Clinker loose, red (2.5YR 4/6), clack (2.5YR 2/1) moderately weathered, weak, partially clay coated/infilled, strong brown (2.5YR 5/6)						
-38	349						IF	BASALT - Massive a'a' gray (GLEYS 5/N) moderately weathered, strong, 2%						

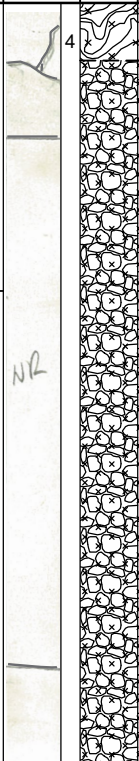
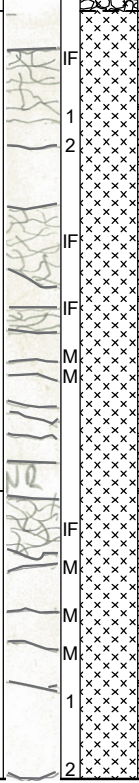
Report: CTO63 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/3/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
349							IF	irregular, elongate vesicles, yellowish red (5YR 5/8) clay coating on some pieces					
-40	350		48				IF					[30]	
	351						1						WL = 450 gal
-42	352	75		60	10	M	1. 40°, J, VN, clay, Su, Wa, SR						
	353					NR	no recovery						
-44	354		49				same as above						
	355					IF						42.856]	
-46	356					IF & M							
	357	76		100	56								WL = 450 gal - high pressure release when barrel pulled out.
-48	358					1	becomes 10% 1-10mm elongate irregular vesicles						
	359		50			IF & M	becomes 5% 6mm elongate irregular vesicles, some 10x10mm 1. 85°, J, VN, Mn+clay, Sp, Pl, S 2. 5°, J, VN, MN, clay, Sp, Wa, S IF pieces: yellowish red (5YR5/8) clay on most pieces						
-50	360					M	becomes black (7.5YR 2.5/1), slightly weathered, strong, 10% 2-20mm subrounded to elongate vesicles						
	361					1							
	362					2							
-52	362		51			3							
	363	77		100	52	4							WL = 450 gal
	364					5							
-54	364					M	10x70mm vug						
	365		52			6							
	365					7							

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
365							IF	IF pieces: Fe+Mn+clay, Sp					[37.5]	
-56	366		52				IF							
	367	78		104		28	IF	IF pieces: yellowish red (5YR 6/8) clay Sp, Su, Mn+Fe, Sp						WL = 450 gal
-58	368		53				IF							
	369						1	becomes gray (GLE Y1 5/N) slightly weathered, very strong, 2% 1-5mm subrounded - subangular vesicles. 1. 20°, J, VN, clay+Mn, Sp, Wa, SR						
-60	370						M						[60]	
	371							<b>BASALT - a'a' Clinker</b> loose, red (2.5YR 4/6), black (2.5YR 2/1) dark reddish brown (2.5YR 3/4), clay coating on most pieces, reddish yellow (5YR 7/6) moderately weathered, medium strong.						
-62	372	79	54	100		10	1	<b>BASALT - Pahoehoe</b> black (5YR 2.5/1) dark reddish brown (5YR 3/4) along fractures, moderately weathered, medium strong, 10% 3/20mm subrounded to subangular vesicles.						WL = 450 gal
	373						2							
	374						3							
	375						4	dark gray (5YR 4/1) moderately to slightly weathered, moderate strength, 5% 2-20mm subrounded vesicles						DTW - 289.7 ft bgs, drilling paused on 7/3/19 at 375' bgs.
-64	374						5	1. 85°, J, VN, clay+Mn+Fe, Sp, Su, Wa, SR 2. 45°, J, VN, Fe+Mn, Sp, Wa, SR						
	375						6	dark reddish brown (5YR 3/3) moderately weathered, medium strong, 20% <2mm rounded vesicles, partially infilled with reddish yellow (7.5YR 6/6) clay						
-66	376						1	3. 45°, J, NV, Fe+Mn, Sp, Wa, SR 4. 10°, J, VN, Mn+Fe, Sp, Wa, S 5. 5°, J, VN, Mn+Fe, Sp, clay, Su, Wa, S 6. 20°, J, VN, Mn+Fe+clay, Sp, Wa, S						[60] Resume coring on 7/8/19 - DTW = 290.01' bgs.
	377		55				2	becomes very dusky red (2.5YR 2.5/1) moderately weathered, moderate strength						
	378	80		100		50	IF	becomes very dark brown (10YR 2/2) slightly weathered, strong, 18% 2-15mm rounded vesicles						WL = 300 gals, paused to replace piece that connects barrel.
-68	378							becomes black (2.5YR 2.5/1) slightly weathered, strong, 15% <10mm irregular vesicles						
	379							becomes 10% 2-15mm rounded vesicles, 2% >30mm rounded vesicles. reddish yellow (5YR 7/8) clay infill.						
	380		56				3	1. 75°, J, VN, Clay, Fe, Su, St, R 2. 5°, J, VN, Clay, Sp, Wa, SR 3. 5°, J, VN, Clay, Fe, Sp, St, VR 4. 60°, J, VN, No, Wa, SR						
-70	380						4							
	381													[75]

Elevation, feet	ROCK CORE						Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number				Type	Number Blows per foot	PID (ppm)	
381							← becomes 25% <2mm rounded vesicles						
-72 382	81		100		56	1	← possible flow contact - becomes very dark gray (5YR 3/1) moderately weathered, medium strong, 25% <2mm rounded vesicles						
383		57				2	▼ becomes very dark gray (10YR 3/1) slightly weathered, strong 15% 1-5mm subrounded to rounded vesicles						
-74 384						IF	1. 20°, J, VN, Clay, Sp, Wa, SR 2. 0°, J, VN, Clay, Su, Wa, S 3. 90°, J, VN, Clay, Sp, Wa, S						WL = 250 gal, slight pressure release when lifting barrel out.
385						1	▼ becomes 20% <3mm rounded to subrounded vesicles						
-76 386						2	▼ becomes slightly weathered, moderate strength, 20% 2-8mm rounded to subrounded vesicles						
387						3	1. 85°, J, VN, Clay, Sp, St, SR 2. 30°, J, VN, Clay, Sp, Wa, SR 3. 5°, J, N, Clay, Sp, St, SR 4. 90°, J, VN, Mn, Clay, Sp, Wa, S 5. 20°, J, VN, Clay, Sp, Wa, SR 6. 0°, J, VN, Clay, Sp, Wa, S				[21.43]		
388	82		102		64	IF	▼ becomes dark reddish gray (2.5YR 2/1) slightly weathered, moderate strength, 20% <2mm rounded vesicles						WL = 200 gal
-78 389						4	▼ becomes very dark gray (10YR 3/1) slightly weathered, strong 15% 2-5mm subrounded vesicles						
390						5	▼ becomes 5% 3-5mm rounded to subrounded vesicles, 2% 20-28mm vugs						
-80 391		59				6	▼ becomes 10% 1-4mm rounded vesicles partially infilled with red (2.5YR 5/5) clay						
392						M	▼ becomes reddish black (2.5YR 2.5/1) slightly weathered, strong, 20% <2mm rounded vesicles						WL = 200 gal
-82 393	83		90		64	M	1. 40°, J, VN, Mn, Fe, Sp, Clay, Su, Wa, S, Clay = (2.5YR 5/8) 2. 0°, J, VN, Clay, Sp, Wa, SR 3. 45°, J, VN, Clay, Sp, Wa, SR 4. 5°, J, VN, Clay, Sp, Wa, SR						
-84 394		60				2							
395						3	no recovery						
-86 396						IF	← black (10YR 2/1) moderately weathered, strong, 15% 5-10mm subrounded vesicles, partially infilled with reddish yellow (7.5YR 6/8) clay						WL = 200 gal
397		61				1	1. 90°, J, VN, Clay, Su, Wa, SR 2. 5°, J, Vn, Clay, Sp, Wa, SR 3. 10°, J, VN, Clay, Sp, Wa, SR 4. 65°, J, VN, Clay, Sp, Wa, SR						

Report: CTO53 RED HILL WITH WELL AND PID. File: CTO18F0126 RED HILL CORE LOGS.GPJ. 12/4/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
397		84	66	0		4		<p><b>BASALT - a'a' Clinker</b>                      loose, dark reddish brown (5YR 2.5/1) reddish brown (2.5YR 5/4), dark reddish gray (5YR 4/2) some clay coated pieces reddish yellow 5YR 6/8) moderately weathered, medium strong, subangular to subrounded.</p>					Driller notes presence of voids  Driller notes presence of voids  WL = 250 gal	
-88 398														[50]
399														
-90 400		61				NR		no recovery						
401														
-92 402		85	24	0				<p><b>BASALT - Massive a'a'</b>                      very dark gray (10YR 3/1), slightly weathered, strong, 3% &lt;1mm - 25mm angular to subrounded, elongate vesicles.</p> <p>1. 5° J, VN, No, No, Wa, SR                      2. 0° J, VN, No, No, Wa, SR</p>					WL = 300 gal	
403														
-94 404														
405														
-96 406		62				IF		becomes 5% 1-30mm subrounded, irregular, elongate vesicles.						
407						1								
408						2								
-98 409						IF								
410						IF								
-100 410		63				IF		no recovery						
411						M								
412						M								
-102 412		87	96	52		1		becomes 3% 1-15mm elongate irregular vesicles						
413						2								

[27.27] High pressure release when barrel comes up



Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
429													
-120	430												Pull pipe to switch but and adjust setup, pause drilling 7/8/19
	431		67										
-122	432												Resume coring on 7/9/19 at 0657. Jaws stuck, trip pipe, core retrieved on 7/10/19
	433	91		34		16							WL = 300 gal
-124	434												
	435												
-126	436		68										Resume coring 7/10/19 at 1050
	437												
-128	438		92		100	10							WL = 500 gal
	439												
-130	440		69										
	441												
-132	442		93		100	42							
	443												
-134	444		70										
	445												

Report: CTO53 RED HILL WITH WELL AND PID: File: CTO18F0126 RED HILL CORE LOGS.GPJ: 12/4/2019 RHMW15



Report: CTO63 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/4/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
445							1 reddish brown (5YR 4/3) slightly weathered, strong, 20% <2mm rounded to subrounded vesicles.					[60]	
-136	446		71				1. 5°, J, VN, Mn, Sp, Wa, SR 2. 0°, J, VN, Mn, Clay, Sp, Wa, SR 3. 20°, J, VN, Clay, Mn, Fe, Sp, Wa, SR 4. 0°, J, VN, Clay, Mn, Fe, Sp, IR, SR ▼ becomes black (7.5YR 2.5/1) slightly weathered to unweathered, strong to very strong, 15% <1-6mm subrounded vesicles						WL = 500 gal
447		94		106	32		5. 20°, J, VN, Clay, Mn, Fe, Sp, St, SR ▼ becomes 20% <2mm rounded to subrounded vesicles.						
-138	448					IF	6. 50°, J, VN, Clay, Sp, Wa, R 7. 90°, J, VN, Clay, Sp, Wa, R 8. 0°, J, VN, Clay, Sp, Wa, R 9. 5°, J, VN, Clay, Halloysite, Mn, Fe, St, SR						
449						6	▼ becomes dark reddish gray (2.5YR 3/1) slightly weathered, strong to very strong 15% 1-3mm rounded vesicles						
-140	450		72				1. 5°, J, VN, Mn, Fe, Sp, St, SR 2. 20°, J, VN, Mn, Fe, Clay, Sp, Wa, SR 3. 15°, J, VN, Mn, Clay, Sp, PI, SR					[37.5]	
451							1 ← alteration - yellowish red (5YR 4/6) 2						
-142	452		95	100	70	IF	▼ black (5YR 2.5/1) and yellowish red (5YR 4/6) slightly weathered, strong, 10% <2mm rounded vesicles 4. 30°, J, VN, Mn, Sp, PI SR 5. 45°, J, VN, Mn, Fe, Sp, Wa, SR						WL = 500 gal
453						3	▼ very dark gray (10YR 3/1) unweathered, very strong 15% <1mm subrounded to rounded vesicles. becomes 10% 2-6mm subrounded to rounded vesicles at 453.5'.						
-144	454					4	▼ reddish black (2.5YR 2.5/1) unweathered, very strong 20% <2mm rounded to subrounded vesicles						
455						IF	1. 20°, J, VN, No, No, St, R 2. 10°, J, VN, No, No, St, R					[75]	
-146	456						▼ gray (5YR 5/1) slightly weathered, strong, 25% 1-5mm subrounded vesicles. black (5YR 2.5/1) slightly weathered, strong, 20% 1-4mm rounded vesicles at 456.1'. ▼ gray (GLEYS 5/1) slightly weathered, strong 15% <3mm subrounded vesicles, some reddish yellow (7.5YR 7/8) clay infill. becomes very dark gray (10YR 3/1) slightly weathered, strong, 5% 3-18mm subrounded vesicles at 456.9'. becomes 15% 2-4mm rounded vesicles at 457.4'.						WL = 500 gal
457						1	▼ dark reddish gray (2.5YR 3/1) and reddish brown (2.5YR 4/4) slightly weathered, strong, 20% <3mm rounded to subrounded vesicles						
-148	458					2							
459						IF	IF pieces: reddish brown (5YR 4/3) Mn+Fe, Su, pale brown (3.5Y 8/4) clay, Sp, white (2.5YR 5/1) halocite, Sp						
-150	460						no recovery					[60]	
461							<b>BASALT - a'a' Clinker</b>						



Report: CTO63 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/4/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
477		100		100		0								barrel out.
-168	478						IF	black (5YR 2.5/1) slightly weathered, moderate strength, 5-10% <4mm rounded vesicles. very shark angled fragments						
	479			79										
-170	480												[100]	
	481							<b>BASALT - a'a' Clinker</b> loose, dark reddish brown (5YR 3/2), very dark gray (5YR 3/1) moderately weathered, halloysite SP +Su on some clasts.						
-172	482	101		106		24	IF	<b>BASALT - Massive a'a'</b> black (GLE1 2.5/N) slightly weathered, strong, 15% 1-10mm subangular, irregular vesicles. clay on IF pieces surfaces becomes very dark gray (GLE1 3/N) unweathered, very strong, 10% 1-8mm subrounded to subangular, irregular/elongate vesicles, no clay on IF pieces/ surfaces						WL = 500 gal - high water pressure release when pulling inner barrel out.
	483			80										
-174	484							<b>BASALT - a'a' Clinker</b> loose, reddish brown (5YR 4/3), dusky red (10R 3/4), dark reddish brown (5YR 3/2), black (5YR 2.5/1), moderately weathered, subrounded, some ground up.						
	485						IF	<b>BASALT - Pahoehoe</b> very dark gray (5YR 3/1) moderately weathered, medium strong, 2% 1-5mm subrounded vesicles, halocite infilling some vesicles. becomes very dark gray (5YR 3/1) slightly weathered, strong, 15% <2mm rounded to subrounded vesicles						[37.5]
-176	486			81			1	1. 0°, J, VN, No, No, St, SR 1. 25°, J, VN, No, No, Wa, R						
	487							thermal alteration / flow contact						
-178	488	102		100		32		<b>BASALT - a'a' Clinker</b> loose, red(10R 4/8), reddish black (10R 2.5/1), dark reddish brown (2.5YR 3/4) becomes welded dark reddish gray (5YR 4/2) very dark gray (5YR 3/1), black (10YR 2/1) moderately weathered, medium strong to weak, yellowish red (5YR 5/8) clay infilling voids and vesicles						WL = 500 gal - high water pressure release when pulling inner barrel out.
	489													
-180	490			82				1. 5°, J, VN, Clay, Sp, Wa, SR 2. 0°, J, VN, Clay, Sp, IR, SR 3. 0°, J, VN, Clay, Sp, Wa, SR 4. 0°, J, VN, Clay, Sp, Wa, SR 5. 5°, J, VN, Clay, Sp, IR, SR 6. 0°, J, VN, Clay, Sp, Wa, SR 7. 10°, J, VN, Clay, SP, Wa, SR						[27.27]
	491													WL = 500 gal - bentonite from old rod that had bentonite in it?
-182	492													
	493	103		94		60		basalt boulder, very dark gray (10YR 3/1) slightly weathered, medium strong						

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
493													
-184	494		83				← become loose clasts becomes welded clasts dark gray (GLE Y1 4/N) moderately weathered, strong, 5% 1-8mm subrounded, elongate, irregular vesicles, partially infilled with yellowish red (5YR 6/8) clay and dark reddish gray (5YR 4/2) pieces no recovery					[27.27]	
495													
-186	496						1. 0°, J, VN, Clay, SP, IR, SR 2. 90°, J, VN, Clay, Sp, Su, Wa, S 3. 10°, J, VN, Mn, Clay, Sp, Wa, SR 4. 80°, J, VN, Mn, Sp, Wa, S 5. 0°, J, VN, Mn, Sp, Clay, Sp, Su, Wa, S						
497		104		100		80							WL = 600 gal
-188	498		84				<b>BASALT - Massive a'a'</b> gray (GLE Y1 5/N) moderately weathered, strong, 5% 1-18mm elongate, irregular vesicles.						
499													
-190	500						← IF pieces: surface covered in reddish yellow (5YR 6/3) clay, some oxidation on fracture surfaces					[20]	
501							1. 5°, J, VN, Clay, Sp, Wa, S 2. 0°, J, VN, Mn, Sp, Wa, S 3. 0°, J, VN, Clay, Sp, Su, Mn, Sp, Wa, S						
-192	502		85										WL = 600 gal - high water pressure release when pulling inner barrel out.
503		105		96		44							
-194	504												
505							<b>BASALT - a'a' Clinker</b> welded, dark reddish brown (5YR 3/3) matrix gray (GLE Y 5/1), clay infilling - reddish yellow (5YR 5/8), weathered, moderate strength no recovery					[21.43]	
-196	506		86				← becomes loose clinker dark reddish brown (5YR 3/3), red (2.5YR 4/6), reddish black (2.5YR 2.5/1) moderately to slightly weathered, coated with reddish yellow (5YR 6/6) clay						
507													
-198	508						<b>BASALT - Pahoehoe</b> red (2.5YR 5/6) moderately weathered, medium strong, 2% <3mm rounded vesicles. IF pieces: Mn Sp, clay Su - reddish yellow (5YR 6/8)						WL = 600 gal - add bentonite as drilling mud, 55 gallon drum with 1 bag bentonite.
509		106		90		0	← becomes reddish brown (5YR 4/3), slightly weathered, strong, 10% 1-4mm rounded to subrounded vesicles. IF pieces: partially infilled with reddish yellow (5YR 7/8) clay, other pieces Mn Sp, clay Sp & Su						



Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
525														
-216	526		91					partial reddish yellow (5YR 7/8) clay infilling of vesicles 1. 90°, J, VN, clay, Su, Me+Fe, Sp, IR, SR 2. 5°, J, VN, clay, Mn+Fe, Sp, Wa, S 3. 0°, J, VN, clay, Mn+Fe, Sp, IR, SR 4. 90°, J, VN, clay, Mn+Fe, Sp, Wa, SR IF pieces: reddish yellow (5YR 7/8) clay Su, Mn Sp black (5YR 2.5/1), slightly weathered, strong, 15% <2mm rounded to subrounded vesicles partially infilled with reddish yellow (5YR 7/8) clay						
	527	110		100		92		very dark gray (10YR 3/1), slightly weathered, very strong, 15% 2-6mm subrounded vesicles partially infilled with reddish yellow (5YR 7/8) clay. becomes unweathered, very strong, 10% 2-10mm subrounded vesicles at 527.8' dark gray (10YR 4/1), slightly weathered, strong, 5% 2-10mm subrounded vesicles partially infilled with reddish yellow (5YR 7/8). becomes 15% 1-6mm subrounded to subangular vesicles at 529'. 5% 4-14mm subrounded vesicles						
-218	528		92					slightly weathered, very strong, 20% <1mm rounded to subrounded vesicles						
	529							unweathered, very strong, 20% <2mm rounded vesicles 1. 85°, J, VN, Mn, Sp, Wa, S2. 85°, J, VN, Mn+Fe, Sp, Wa, S3. 10°, J, VN, Mn+ Fe, Sp, Wa, SR 4. 0°, J, VN, No, No, Wa, SR 5. 50°, J, VN, Mn+Fe, Sp, Wa, SR 6. 10°, J, Vn, Mn+Fe+clay, Sp, St, S 7. 45°, J, VN, clay+Mn, Sp, Wa, SR 8. 10°, J, VN, clay+Mn+Fe, Sp, Wa, SR						
-220	530							15% <5mm rounded to subrounded vesicles						
	531							5% 3-15mm subrounded to subangular vesicles 15% <5mm rounded to subrounded vesicles						
-222	532	111	93	100		92		20% <4mm rounded vesicles						
	533							15% 1-6mm rounded to subrounded vesicles						
-224	534							15% <1mm rounded vesicles						
	535							very dusky red (2.5YR 2.5/2), unweathered, very strong, 15% <2mm rounded vesicles 1. 0°, J, VN, Mn+Fe, Sp, Wa, S 2. 90°, J, VN, Mn+Fe, Sp, Wa, SR3. 5°, J, VN, No, No, Wa, SR 4. 5°, J, VN, Mn+Fe, Sp, IR, S						
-226	536		94					pipe vesicles						
	537					56		20% 1-3mm rounded to subrounded vesicles						
-228	538													
	539		95											
-230	540													
	541													

WL = 500 gal - high water pressure release when pulling inner barrel out.

WL = 400 gal - high water pressure release when pulling inner barrel out.

WL = 400 gal - high water pressure release when pulling inner barrel out.

WL = 400 gal

Report: CTO63 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/3/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS	
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot		PID (ppm)
541								becomes 10% 2-6mm rounded to subrounded vesicles 1. 50°, J, VN, Mn+Fe, Sp, St, S- oxidation evident						
-232	542	113	96	106		106	2	← 20% <1mm rounded vesicles ← 15% 1-8mm subrounded vesicles						
	543						3	← 15% <4mm subrounded vesicles						
-234	544						4	2. 0°, J, VN, Mn+Fe+clay, Sp, Wa, SR 3. 75°, J, VN, Mn+Fe+clay, Sp, Wa, SR 4. 90°, J, VN, Mn+Fe, Sp, Wa, R						
	545							← 20% <1mm rounded vesicles					[50]	
-236	546		97				1	1. 80°, J, VN, Mn+Fe, Sp, Wa, SR 2. 0°, J, VN, Mn+Fe, Sp, St, SR						
	547						IF	▼ slightly weathered, strong, 20% <1mm rounded vesicles partially infilled with clay IF pieces: Mn+Fe, Sp, yellow (2.5YR 7/6) clay, Sp+Su, flow textures present, reddish brown (2.5YR 5/4) faces						
-238	548		98				IF	▼ reddish black (2.5YR 2.5/1), slightly weathered, strong, 10% <2mm subrounded vesicles ▼ becomes slightly weathered, very strong, 5% 1-10mm subrounded vesicles						
	549							← becomes 20% <2mm rounded vesicles ▼ becomes 5% <8mm rounded to subrounded vesicles					[60]	
-240	550						1	1. 15°, J, VN, Mn+Fe, Sp, IR, SR						
	551		99				2	2. 90°, J, VN, Mn+Fe, Sp, Wa, SR						
	552						3	← heat alteration black (GLEYS 2.5/N) 10mm wide, dark reddish brown (2.5YR 3/3), slightly weathered, very strong, 15% <3mm rounded to subrounded vesicles						
-242	552		115	100		66	IF	IF pieces: Mn+Fe, Sp ▼ becomes reddish black (2.5YR 2/1), 20% <2mm rounded vesicles						WL = 400 gal
	553						IF	3. 20°, J, VN, Mn+Fe, clay, Sp, Wa, S 4. 0°, J, VN, Mn+Fe, Sp, clay, Su, Wa, S pipe vesicles IF pieces: Mn+Fe, Sp, faces red (2.5YR4/6) - oxidation evident						
-244	554						IF	← pipe vesicles IF pieces: Mn+Fe, Sp, faces red (2.5YR4/6) - oxidation evident						
	555		100				1	▼ becomes very dark gray (10YR 3/1), unweathered, very strong, 15% 1-9mm rounded to subrounded vesicles					[50]	
-246	556						2	1. 85°, J, VN, Mn+Fe+clay, Sp, Wa, SR 2. 0°, J, VN, Mn+Fe+clay, Sp, Wa, SR 3. 85°, J, VN, Mn+Fe, Sp, Wa, S4. 10°, J, VN, Mn+Fe, Sp, SR- oxidation evident5. 70°, J, VN, Mn+Fe, Sp, Wa, SR6. 0°, J, VN, Mn+Fe, Sp, Wa, S- oxidation evident"						WL = 600 gal
	557													

WL = 400 gal - high water pressure release when pulling inner barrel out for remaining runs unless otherwise noted.

WL = 400 gal

WL = 600 gal

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
557		116	104	76		2	<ul style="list-style-type: none"> <li>5% &lt;1mm rounded vesicles</li> <li>15% 1-4mm subrounded vesicles</li> <li>25% &lt;1mm rounded vesicles</li> <li>15% 1-19mm subrounded vesicles</li> </ul>						
-248	558		101			M							
559						3	<ul style="list-style-type: none"> <li>reddish black (2.5YR 2.5/1), unweathered, very strong, 25% &lt;1mm rounded vesicles</li> </ul>						
-250	560					4							
561			102			5	IF pieces: Mn Fe Sp, red (2.5YR 4/6) faces				[50]		
-252	562					1	<ul style="list-style-type: none"> <li>20% 1-5mm rounded vesicles</li> </ul>						
563		117	104	70		2	<ul style="list-style-type: none"> <li>15% &lt;2mm rounded vesicles</li> </ul>					WL = 400 gal	
-254	564		103			3	<ul style="list-style-type: none"> <li>1. 90°, J, VN, Mn+Fe, Sp, Wa, SR</li> <li>2. 0°, J, VN, Mn+Fe, Sp, Wa, SR</li> <li>3. 15°, J, VN, Mn+Fe, Sp, Wa, R</li> <li>4. 5°, J, VN, Mn+Fe, Sp, Wa, SR</li> </ul>						
565						4	1. 10°, J, VN, Mn+Fe, Sp, Wa, S				[33.33]		
-256	566					1							
567		118	72	32			<b>BASALT - a'a' Clinker</b> loose, dark brownish red (2.5YR 3/4) very dusky red (2.5YR 2.5/2) reddish black (2.5YR 2.5/1) moderately weathered, clasts covered with clay - reddish yellow (5YR 7/6), subrounded clasts					WL = 500 gal	
-258	568		104			NR	no recovery						
569													
-260	570						<b>BASALT - Massive a'a'</b> dark gray (10YR 4/1) slightly weathered, strong, 5% 1-9mm subangular - subrounded, elongate, irregular vesicles.				[25]		
571						IF						WL = 600 gal	
-262	572	119	105	90		1	IF pieces: Mn, Fe, Sp						
573						2	<ul style="list-style-type: none"> <li>1. 5°, J, VN, Mn+Fe, Sp, Wa, S</li> <li>2. 10°, J, VN, Mn+Fe+clay, Sp, Wa, SR</li> <li>3. 90°, J, VN, Mn+Fe, clay, Sp, Wa, SR</li> </ul>						




Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 12/2/2019 RHMW15

Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
573							3 4	4. 20°, J, VN, Mn+Fe, clay, Wa, SR					
-264	574		105				3 4	<b>BASALT - a'a' Clinker</b> loose, dark reddish brown (5YR 3/3), very dark gray (5YR 3/1) slightly weathered - clay on some clasts, reddish yellow (7.5YR 7/6) no recovery					
575							1 2					[50]	
-266	576		106				1 2 3	<b>BASALT - Pahoehoe</b> dark reddish gray (5YR 4/2) unweathered, very strong, 20% <2mm rounded to subrounded vesicles. reddish black (2.5YR 2.5/1), unweathered, very strong, 20% <2mm rounded vesicles ← becomes slightly weathered					WL = 500 gal
577		120		102		58	4 5						
-268	578						IF	IF pieces: Mn, Fe, Sp, brownish yellow clay (10YR 5/5) Su					
579							1 2 3 4 5	1. 90°, J, VN, Mn+Fe, Sp, Wa, R 2. 30°, J, VN, Mn+Fe, Sp, Wa, SR 3. 20°, J, VN, Mn+Fe, Sp, Wa, SR 4. 90°, J, VN, Mn+Fe, Sp, Wa, SR 5. 10°, J, VN, Mn+Fe+clay, Sp, Wa, SR					
-270	580		107				IF	very dusky red (2.5YR 2.5/2), slightly weathered, very strong, 20% <1mm rounded to subrounded vesicles IF pieces: Mn, Fe, Sp, brownish yellow (10YR 6/6) clay, Su, some faces dark reddish brown (2.5YR 3/4)				[42.86]	
581							1 2 3 4 5	← clay partially infilling some vesicles 1. 5°, J, VN, Mn+Fe+clay, Sp, Pl, S 2. 20°, J, VN, Mn+Fe+clay, Sp, Wa, SR- oxidation evident 3. 85°, J, VN, Mn+Fe+clay, Sp, Wa, SR- oxidation evident					
-272	582		121			68	6 7 8 9	4. 5°, J, T, clay, Wa 5. 10°, J, VN, Mn+Fe+clay, Sp, Wa, SR 6. 5°, J, VN, Mn+Fe+clay, Sp, Wa, SR- oxidation evident 7. 10°, J, VN, clay, Sp, Wa, SR 8. 5°, J, VN, clay, Sp, Wa, SR 9. 90°, J, VN, clay+Mn+Fe, Sp, Wa, SR					WL = 500 gal
583							1 2 3 4 5	1. 85°, J, VN, Mn+Fe+clay, Sp, Wa, SR 2. 5°, J, VN, clay, Sp, Wa, SR 3. 90°, J, VN, Mn+Fe+clay, Sp, Wa, SR 4. 20°, J, VN, Mn+Fe, Sp, Wa, S- oxidation evident 5. 5°, J, VN, Mn+Fe, Sp IR, SR- oxidation evident 6. 20°, J, VN, Mn+Fe, Sp, IR, SR 7. 30°, J, VN, Mn+Fe+clay, Wa, SR 8. 0°, J, VN, Mn+Fe+clay, Sp, Wa, S 9. 0°, J, VN, Mn+Fe, Sp, Wa, R					
-274	584		108				6 7						
585							IF						
-276	586						1 2 3 4 5						
587		122	109	108		0	IF						WL = 500 gal
-278	588						6 7						
589							IF						

Project: CTO1850126 - Red Hill Bulk Fuel Storage Facility  
 Project Location: CTO18F0126  
 Project Number: 60571032

# Log of Boring RHMW15

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Elevation, feet	Depth, feet	ROCK CORE					Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES			FIELD NOTES AND TEST RESULTS
		Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %				Fracture Drawing Number	Type	Number Blows per foot	
589													
			110					← dusky red (2.5YR 3/2), slightly weathered, very strong, 15% <2mm subrounded vesicles					
-280	590												Completed coring on 7/12/19
	591												
-282	592												
	593												
-284	594												
	595												
-286	596												
	597												
-288	598												
	599												
-290	600												
	601												
-292	602												
	603												
-294	604												
	605												

1  
2

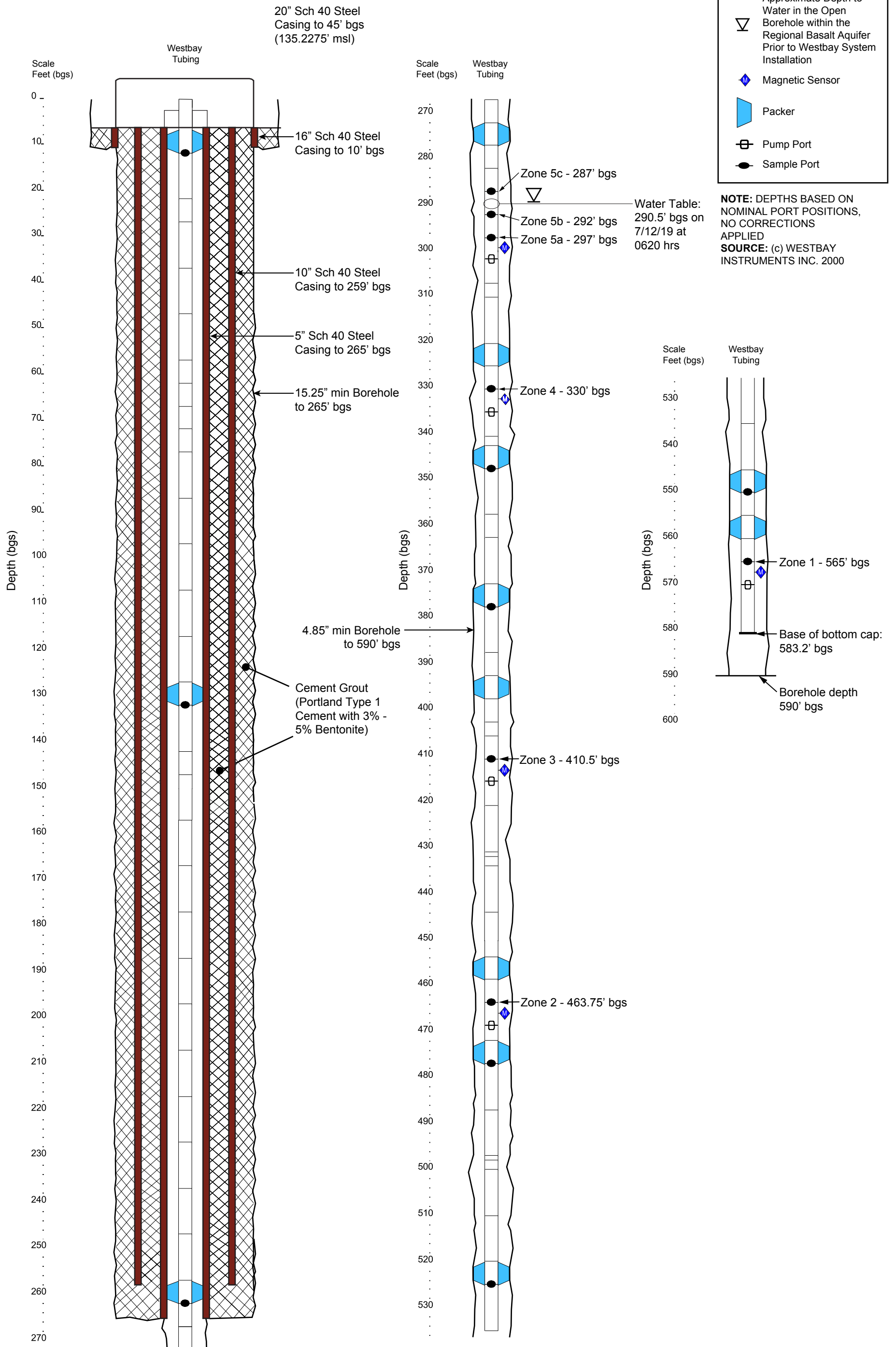
**Appendix C:  
RHMW15 Well Construction Diagram**

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### RHMW15 Monitoring Well

Legend	
	Approximate Depth to Water in the Open Borehole within the Regional Basalt Aquifer Prior to Westbay System Installation
	Magnetic Sensor
	Packer
	Pump Port
	Sample Port

**NOTE:** DEPTHS BASED ON NOMINAL PORT POSITIONS, NO CORRECTIONS APPLIED  
**SOURCE:** (c) WESTBAY INSTRUMENTS INC. 2000



**Cross Section RHMW15 Monitoring Well**  
 Red Hill Bulk Fuel Storage Facility  
 JBPHH, O'ahu, Hawaii

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