Groundwater Model Progress Report 08, Red Hill Bulk Fuel Storage Facility

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

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

August 5, 2019
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Comprehensive Long-Term Environmental Action Navy
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ACRONYMS AND ABBREVIATIONS

3D	three-dimensional
AOC	Administrative Order on Consent
bgs	below ground surface
BWS	Board of Water Supply, City and County of Honolulu
CF&T	contaminant fate and transport
CLN	connected linear network
COPC	chemical of potential concern
CSM	conceptual site model
CWRM	Commission on Water Resource Management
DLA	Defense Logistics Agency
DLNR	Department of Land and Natural Resources, State of Hawai‘i
DOH	Department of Health, State of Hawai‘i
DON; Navy	Department of the Navy, United States
EPA	Environmental Protection Agency, United States
ft	foot/feet
GMS	Geometric Mean Scheme
GWMWG	Groundwater Modeling Working Group
IRR	Investigation and Remediation of Releases
LNAPL	light non-aqueous-phase liquid
msl	mean seal level
PEST	Parameter Estimation software
QC	quality control
SME	subject matter expert
SOW	scope of work
TFN	transfer function-noise
TWG	Technical Working Group
U.S.	United States
UH	University of Hawai‘i
WP	work plan

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1. Introduction

This *Groundwater Model Progress Report 08* is the eighth in a series of modeling 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 AOC 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 objective of AOC Statement of Work Sections 6 and 7 is to take steps to ensure that the drinking water resources in the vicinity of the Facility are protected and to ensure that the Facility is operated and maintained in an environmentally protective manner. 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 collective work conducted under Section 7 will be used to inform changes to the current Red Hill *Groundwater Protection Plan* (DON 2014).

Reporting Period 08 covered in this report represents progress for the eighth approximately 4-month period (April 4, 2019 – July 15, 2019) following conditional approval of the project WP/SOW by the Regulatory Agencies, which was received by the United States (U.S.) Department of the Navy (DON; Navy) on December 5, 2016 (EPA Region 9 and DOH 2016). *Groundwater Flow Model Progress Reports 01, 02, 03, 04, 05, 06* and *07* were submitted previously (DON 2017c, 2017d, 2017f, 2018a, 2018b, 2018d, 2019a).

2. Work Completed this Reporting Period

2.1 CURRENT STATUS

Groundwater Modeling Working Group (GWMWG). The GWMWG is composed of representatives from the Navy, Defense Logistics Agency (DLA), U.S. Geological Survey, 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 (CF&T) 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.

No GWMWG meetings were held during this reporting period. Future scheduled GWMWG meetings include:

- *GWMWG Meeting #15, August 1,2019*

AOC Parties and Subject Matter Experts (SMEs) Meetings. The AOC Parties Technical Working Group (TWG) met four times during this reporting period, on April 17, April 22, May 17, and July 11, 2019. The main topics covered at each meeting are described below:

- *TWG Meeting #16, April 17, 2019:*
  - Groundwater modeling timeline considerations
  - Potential simplified three-dimensional (3D) light non-aqueous-phase liquid (LNAPL) model
  - LNAPL conceptual site model (CSM)
  - Alignment discussions
- *TWG Meeting #17, April 22, 2019:*
  - DOH presented an estimate of the extent of groundwater impacts derived from a data-driven (non-modeling) approach
- *TWG Meeting #18, May 17, 2019:*
  - Current status of evaluation of the LNAPL modeling approach
    - AOC agreements
    - Deliverables extension – applicability to LNAPL modeling
    - Navy currently evaluating possibly conducting modeling
  - Model limitations and use of model
  - Navy presentation of possible simplified 3D LNAPL modeling approach and parameterization table
  - Water development tunnel alignment discussions
- *TWG Meeting #19, July 11, 2019:*
  - Review of Aloha Terminal data
  - MAGNAS modeling by DOH
  - Regulatory review discussion of Navy's proposed LNAPL transport model

Future scheduled AOC Party/SME meetings include:

- *TWG Meeting #20, July 26, 2019*
- *TWG Meeting #21, Day 1, July 30, 2019*
- *TWG Meeting #22, Day 2, July 31,2019*

2.1.1 Technical Progress

2.1.1.1 GROUNDWATER SAMPLING

During this reporting period, the Navy performed the Second Quarter 2019 groundwater monitoring event. The following monitoring locations were sampled during this event: RHMW2254-01, RHMW01, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, RHMW08, RHMW09, RHMW10, RHMW11 Zone 5, HDMW2254-01, and OWDFMW01. The parameters were the same as the previous sampling event.

2.1.1.2 FIELD ACTIVITIES

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

- **RHMW11:** Purged water from Westbay Zone 7.
- **RHMW14:** Completed installation of Westbay multilevel well. Data collection and evaluation are ongoing. Details are discussed in Section 2.1.1.3. Additional completed activities include:
  - Performed plumbness and alignment survey.
  - Performed well development.
  - Installed Westbay multilevel well.
  - Installed transducers in Zones 2–8.
  - Downloaded transducer data every 2–3 weeks.
  - Purged water from Westbay Zones 3, 4, 5, and 7.
- **RHTB01:** Completed installation of vibrating wire transducers. Data collection and evaluation are ongoing. Details are discussed in Section 2.1.1.3. Additional completed activities include:
  - Completed video and geophysical logging, and plumbness and alignment survey.
  - Installed vibrating wire transducers at four different depths.
  - Grouted borehole.
  - Conducted piezometer acceptance test.
  - Downloaded transducers every 2–3 weeks.
  - Confirmed proper location of transducers using a Megger TDR900 Portable Handheld Time Domain Reflectometer.
- **RHMW15:** Resumed drilling of RHMW15 on February 11, 2019 by reaming the borehole and installing 5-inch steel conductor casing to 265 feet (ft) below ground surface (bgs) on February 12, 2019. Resumed drilling of RHMW15 with PQ coring from 265 ft bgs on July 1, 2019.
  - Completed PQ coring from 265 to 590 ft bgs.
  - Conducted well development.
  - Performed video logging, geophysical logging, and plumbness and alignment survey.

  RHMW15 planned future activities:
  - Meet with DOH SME for RHMW15 core review and preliminary well design.
  - Meet with DLNR/CWRM and DOH SME to review and finalize well design.
  - Install Westbay multilevel well.
- **RHMW12:** Commenced drilling operations at RHMW12 on May 8, 2019:
  - Field verified absence of subsurface utilities at drill site to 4.3 ft bgs.
  - Advanced hollow-stem augers from 4.3 to 9 ft bgs.

- Completed HQ coring from 9 to 129 ft bgs.
- Conducted detailed geologic logging while coring.
- Reamed hole with 17.5-inch bit to 13 ft bgs.
- Expanded hole with 24-inch core bucket bit to 58.5 ft bgs.
- Installed 18-inch steel surface casing and grouted to 56.5 ft bgs.
- Reamed hole with 17-inch bit to 123.2 ft bgs.
- Installed 10-inch steel conductor casing to 122.7 ft bgs.
- Completed HQ coring from 129 ft bgs to 210 ft bgs.
- Bailed open hole (123–210 ft bgs).
- Monitored water levels inside open hole.
- Conducted video logging.
- Reamed borehole with $9^{7}/_{8}$-inch bit and installed 5-inch steel conductor casing to 200 ft bgs.
- Completed PQ coring from 200 to 215 ft bgs (total depth).
- Bailed open hole (200 to 215 ft bgs).
- Monitored water levels inside open hole.
- Secured borehole and moved to RHMW15 while discussing future completion with DLNR/CWRM approval.

RHMW12 planned future activities:

- Conduct well development.
- Meet with DOH SME for RHMW12 core review and preliminary well design.
- Meet with DLNR/CWRM and DOH SME to review and finalize well design.
- Perform gyroscopic survey.
- Perform additional well development.
- Install Westbay multilevel well.
- Potentially drill and complete a companion borehole in proximity to RHMW12, with Westbay zones completed above and below the regional basal aquifer piezometric surface.

- **RHMW13:** Completed site preparation activities (vegetation clearing, utility surveys, access road and drill pad construction).

2.1.1.3 RECENTLY COLLECTED HYDROGEOLOGIC DATA

RHMW14

Drilling of multilevel well RHMW14 was completed at a total depth of 495 ft bgs; the Westbay well was constructed in early 2019 in accordance with the Red Hill *Monitoring Well Installation Work Plan* and addenda (DON 2016, 2017a, 2017e, 2018c). The boring log of RHMW14 is included in Appendix A. Low-permeability saprolite, which consists of clay-rich materials and weathered basalt, extends from approximately 79 to 106 ft above mean sea level (msl) at the well location, approximately

54 ft above the regional basal aquifer piezometric head. Complete water loss occurred at a depth of approximately 353 ft bgs (173 ft msl), indicating hydraulic communication with the regional basal aquifer at this depth and below.

RHMW14 was completed with eight discrete monitoring intervals (also referred to as zones) that are independently sealed and isolated using a series of Westbay System packers (as illustrated on the boring log in Appendix A). The well is constructed with Zone 1 as the deepest zone and with each subsequent zone completed at a shallower depth. Zone 8, the uppermost or shallowest zone, is the only zone completed above the expected piezometric surface of the regional basal aquifer.

Non-vented MOSDAX transducers were deployed in Zones 2–8 from April 15 to June 24, 2019. The transducers were removed to allow purging of select RHMW14 zones in advance of future sampling. The deepest three zones (Zones 1–3) were completed in unweathered basalt, and Zones 4–8 were completed in highly to moderately weathered basalt. Information on Westbay zone completion at RHMW14 is presented in Table 1.

Table 1: RHMW14 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 8	130.0	149.0	49.8	30.8	Weathered basalt
Zone 7	154.0	169.0	25.8	10.8	Weathered basalt
Zone 6	147.0	199.0	32.8	-19.2	Weathered basalt
Zone 5	204.0	216.0	-24.2	-36.2	Weathered basalt
Zone 4	245.0	265.2	-65.2	-85.4	Weathered basalt
Zone 3	320.2	337.1	-140.4	-157.3	Basalt
Zone 2	410.4	423.6	-230.6	-243.2	Basalt
Zone 1	453.6	464.8	-273.8	-285.0	Basalt

Notes: Approximate land surface elevation = 179.8 ft msl.

Hydrographs for RHMW14 during this reporting period are presented in Appendix B. Zones 1–3 have piezometric head measurements of approximately 19 ft msl, which is the expected piezometric surface of the regional basal aquifer. Head measurements in Zone 1 are based on individual pressure profiles. The head in Zone 4 is approximately 2 ft above the heads in Zones 1–3. Heads in Zones 5 and 6 are approximately 16 ft above the heads in Zones 1–3. Heads in Zones 7 and 8 appear to have come into hydraulic equilibrium with the formation in the beginning of May 2019, and both are approximately 22 ft above the expected piezometric surface of the regional basal aquifer.

On June 24, 2019, the transducers were removed from RHMW14 to purge Zones 3, 4, 5, and 7 prior to sampling them for the Third Quarter (July) 2019 groundwater monitoring event. After purging was complete, the transducers were reinstalled on June 28. During reinstallation, the MOSDAX probe for Zone 7 did not land properly in the Westbay measurement port, and therefore results for Zone 7 from June 24–June 28 are not available. All transducers will be removed prior to the start of groundwater sampling activities at RHMW14, and will be reinstalled properly at the completion of the sampling effort to continue monitoring piezometric heads.

RHTB01

Test boring RHTB01 was completed at a total depth of 281 ft bgs in early 2019, in accordance with the Red Hill *Monitoring Well Installation Work Plan* and addenda (DON 2016, 2017a, 2017e, 2018c).

The boring log for RHTB01 is included in Appendix A. Low-permeability saprolite, which consists of clay-rich materials and weathered basalt, extends from approximately 136 ft above msl to 17 ft below msl at the boring location; the regional basal aquifer piezometric head is approximately 20 ft above msl. Complete water loss occurred at approximately 260 ft bgs (-35 ft msl), indicating hydraulic communication with the regional basal aquifer at this depth and below.

Four grouted-in-place vibrating wire piezometers were installed in the test boring in four separate zones on March 29, 2019. Information on the piezometer zones is listed in Table 2. The depths of the vibrating wire piezometers were confirmed with a Megger TDR900 Portable Handheld Time Domain Reflectometer. The Zone 1 transducer was installed in unweathered basalt approximately 46 ft below the regional basal aquifer piezometric head. Zones 2, 3, and 4 were installed in the saprolite, above the regional basal aquifer.

Table 2: RHTB01 Grouted in Piezometer Zone Completion Summary

Zone Identifier	Probe Elevation (ft msl)	Generalized Geology
Zone 4	106	Saprolite
Zone 3	79	Saprolite
Zone 2	43	Saprolite
Zone 1	-37	Basalt

Notes: Approximate land surface elevation = 225 ft msl.

Hydrographs for RHTB01 during this reporting period are presented in Appendix B. The heads in all four zones were declining based on the most recent data and may not have come into equilibrium with the surrounding formations. Piezometric heads in Zone 1 were measured at -1 to 0 ft msl; prior to installation of the grouted in piezometers, the heads in Zone 1 were anticipated to be at the piezometric surface of the regional basal aquifer (approximately 20 ft msl). Piezometric heads at Zone 2 ranged from 76 to 81 ft msl and were still declining as of the latest data download. Heads in Zone 3 (194–195 ft msl) were unexpectedly higher than heads in Zone 4 (134.5–135.5 ft msl). As stated above, it is not believed that this is due to a misplacement or misidentification of the vibrating wire piezometer. While additional monitoring is required, this may be evidence of variability in the perched zone(s) within the valley fill.

RHMW11

A discussion on RHMW11 Westbay construction is presented in the CSM Revision 01 (DON 2019c). Monitoring in RHMW11 used a non-vented MOSDAX pressure transducers in all eight zones and a USGS 700H vented pressure transducer in the Westbay center tube. Monitoring was performed with pumping port 8 open from January 12 to February 23, 2018, and with pumping port 5 open from August 10, 2018 to July 2019. The pressure transducers were removed to facilitate quarterly groundwater monitoring events. Groundwater levels in all zones appear to either have equilibrated or are asymptotically approaching equilibration within the formations they are completed in. Hydrographs for RHMW11 during this reporting period are presented in Appendix B. Data from monitoring well UMW-1, located at the Hālawa Correctional Facility, have been added to these hydrographs for comparison.

RHMW15

Drilling of multilevel well RHMW15 was completed at a total depth of 590 ft bgs, and the well was constructed in July 2019 in accordance with the Red Hill *Monitoring Well Installation Work Plan* and addenda (DON 2016, 2017a, 2017e, 2018c). A boring and well construction log of RHMW15 will be

provided in the next *Groundwater Model Progress Report*. Low-permeability saprolite and residual soil, which consists of clay-rich materials and weathered basalt, extends to only approximately 5 ft bgs at the borehole location, approximately 285 ft above the regional basal aquifer piezometric head (approximately 20 ft above msl). Complete water loss occurred at approximately 290 ft bgs (20 ft msl), indicating hydraulic communication with the regional basal aquifer at this depth and below.

RHMW12

The RHMW12 borehole was completed at a total depth of 215 ft bgs in accordance with the Red Hill *Monitoring Well Installation Work Plan* and addenda (DON 2016, 2017a, 2017e, 2018c). A boring log of RHMW12 will be provided in the next *Groundwater Model Progress Report*. Alluvium, including weathered clays and weathered basalt, extends to approximately 59 ft bgs, approximately 178.5 ft above msl at the borehole location. During drilling, complete water loss did not occur, indicating that the depth where there is hydraulic communication with the regional basal aquifer was not reached.

2.1.1.4 THERMAL PROFILING

The Navy conducted vertical thermal profiling in ten monitoring wells during April 29 – May 2, 2019 to facilitate evaluation of the stability of the thermal data in wells underlying the tank farm and how they may contrast with areas outside the tank farm. The results will be presented in the forthcoming *Investigation and Remediation of Releases* (IRR) *Report*.

2.1.1.5 GROUNDWATER MODELING

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

- Held weekly groundwater modeling team progress meetings to establish short-term milestones and resolve technical issues as they arose.
- Targets within connected linear network (CLN) nodes (e.g., Red Hill Shaft) were not passed from MODFLOW (the code that does the groundwater flow calculations) to PEST (Parameter Estimation software, the code that assists in the calibration process). Worked with Aquaveo (GMS modeling software vendor) to diagnose and correct PEST file-creation errors. Developed a workaround to create correct PEST files and maintain forward progress while the vendor investigated and corrected the issue.
- Refined and performed quality control (QC) on calibration targets derived from the transfer function-noise (TFN) analysis. The first 15 days after a pumping change are being simulated and compared to TFN-derived targets.
- Revised representation of Red Hill Shaft and Hālawa Shaft geometry to match as-built drawings and assigned CLN nodes to appropriate model layers based on as-built elevations.
- Revised and performed QC on calibration targets derived from the TFN analysis. Initially, the previous targets were not based on the TFN results. The TFN analysis went through multiple revisions, resulting in additional revisions to the targets. This provides drastically reduced model run times when calibrating to one "pure" aquifer response to pumping at each pumping center, as compared to simulating dozens of on/off cycles with confounding effects from weather and non-coordinated interfering pumping at other locations.
- Reviewed and performed QC on the process and tools used to calibrate directly to drawdowns and head differences between wells, in addition to absolute elevation heads. This enables focusing of the calibration effort directly on aquifer responses to pumping and gradient magnitudes, with less effort spent on elevation-survey quality and precision issues.

Developing this process and these tools was necessary because the groundwater modeling graphical user interface does not support use of drawdown as a calibration target.

- Developed head-difference targets between well pairs to improve the modeling team's ability to evaluate gradients and the team's ability to direct PEST to emphasize matching those differences. Developed a utility to compute the simulated differences from MODFLOW output so that PEST can evaluate the differences during the calibration process.
- Performed transient model calibration runs with PEST for two alternative saprolite interpretations. Each PEST run consists of several hundred MODFLOW runs. Comparing calibration quality of the two interpretations is currently in progress.
- Through the calibration process, identified that a homogeneous basalt hydraulic conductivity distribution (identical permeability at Red Hill Shaft and Hālawa Shaft) appears incapable of closely matching pumping responses at both Red Hill Shaft and Hālawa Shaft. This suggests that at a minimum, these two areas require separate hydraulic conductivity zones.
- Developed a model using a heterogeneous basalt hydraulic conductivity distribution. Several dozen pilot points (with greater density at the site) are used to define the hydraulic conductivity field through the autocalibration process. The heterogeneous basalt calibration is currently in progress.
- Used the Geometric Mean Scheme (GMS) Tikhonov regularization implementation to define a preferred condition of homogeneity for the heterogeneous model (i.e., only the minimum necessary heterogeneity should be added by PEST). For all other parameters, developed preferred-value regularization targets to stabilize the parameter-estimation process. Adding regularization reduces PEST's incentive to (e.g.) adjust hydraulic conductivity by a factor of 100 to achieve a 0.001-ft improvement to a single target, and reduces the likelihood of PEST assigning extreme values to aquifer parameters.

2.1.1.6 Red Hill Shaft Water Development Tunnel Alignment

During this reporting period, it came to the attention of the Navy that the shapefile for the water development tunnel used for the groundwater model to date did not match the orientation presented in ca. 1942 Navy as-built drawings and in the Stearns (1943) section and plan view of the tunnel. The Navy evaluated the orientation of the Red Hill water development tunnel relative to what was in the previous modeling file and what was reported by Stearns (1943). The Navy also inquired with Dr. Kolja Rotzoll (UH and USGS, modeler for the 2007 TEC model) about the source of the water development tunnel files for the 2007 document (DON 2007). A decision was made based on the preponderance of evidence to use the orientation that is consistent with the 1942 Navy as-builts, Stearns (1943), and Navy shapefiles. In response, the orientation of the water development tunnel was updated in the groundwater flow model. The revised file is depicted on Figure 2. The decision is documented in "Red Hill Shaft" email correspondence between relevant AOC Parties during April 25 – May 6, 2019.

2.1.2 Technical Issues

No other technical issues were identified during this reporting period.

2.2 Submittal of Modeling Deliverables

Relevant deliverables submitted during this reporting period include:

- *Final First Quarter 2019 - Quarterly Groundwater Monitoring Report* (DON 2019b)

- *CSM Revision 01* (DON 2019c)

3. Anticipated Work for Next Reporting Period

Anticipated work for upcoming Reporting Period 09 (July 16 – November 15, 2019) includes:

- Continue to download and evaluate data from RHMW11, RHMW14, and RHTB01.
- Complete RHMW12 and potential proximal companion well.
- Continue drilling and monitoring well installation efforts.
- Conduct Third and Fourth Quarter 2019 quarterly groundwater monitoring events.
- Continue groundwater flow modeling.
- Prepare October 2019 *Groundwater Flow Model Report*.
- Prepare October 2019 *IRR Report.*
- Potentially perform simplified 3D LNAPL modeling based on discussions with AOC Parties and Navy senior management.

Anticipated deliverables due during upcoming Reporting Period 09 (July 16 – November 15, 2019) include:

- *Final Second Quarter 2019 - Quarterly Groundwater Monitoring Report*
- *Draft Third Quarter 2019 - Quarterly Groundwater Monitoring Report*
- *Groundwater Flow Model Report, Revision 00*
- *Investigation and Remediation of Releases Report, Revision 00*

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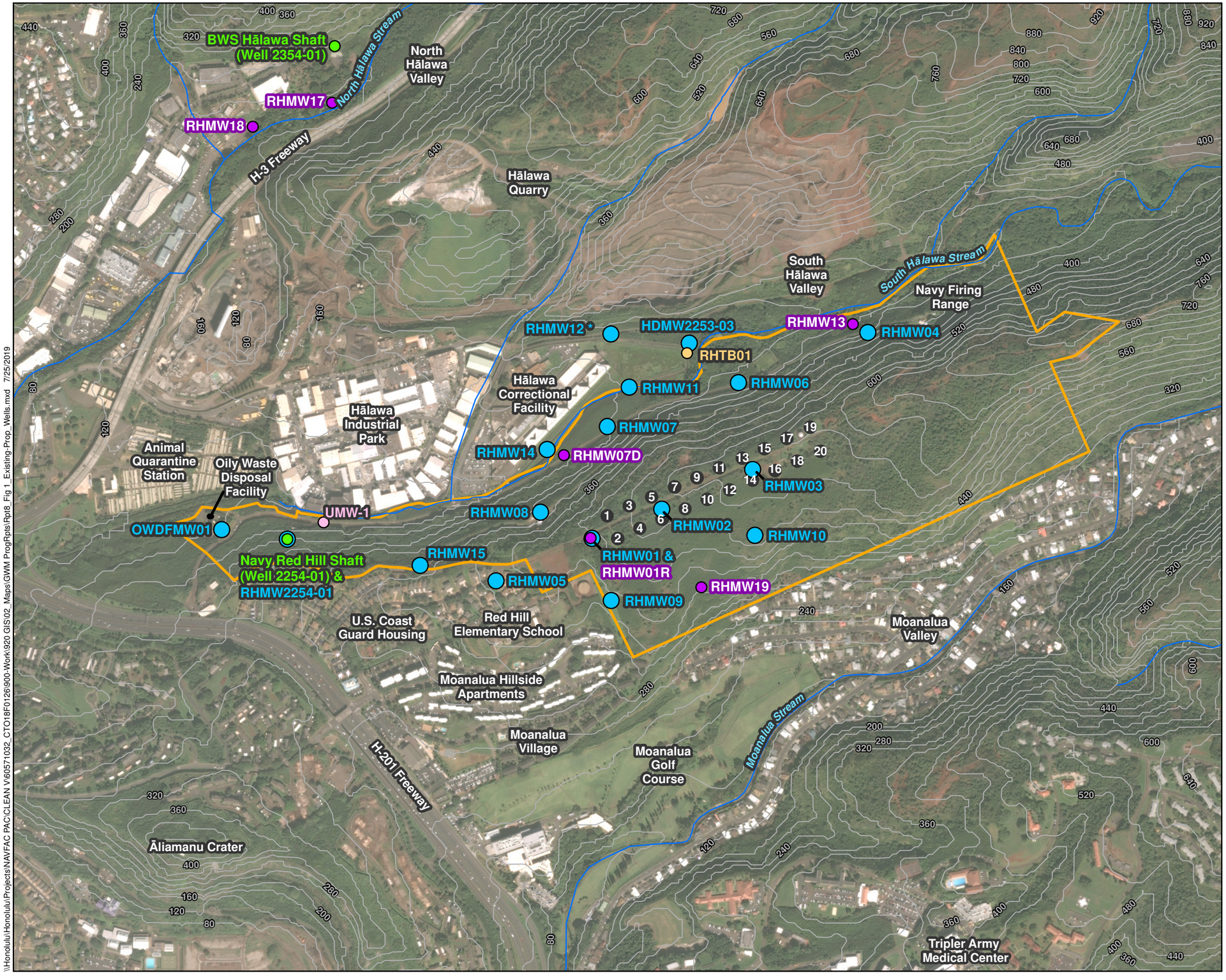
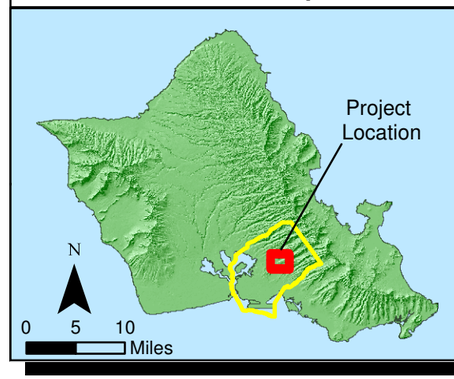


Location Map



Legend

- Existing Monitoring Location
- Test Boring
- Proposed Monitoring Well
- Water Supply Well
- UMW-1
- Stream
- Topographic Contour (feet mean sea level)
- Red Hill Facility Boundary
- Red Hill Fuel Storage Tank
- Groundwater Model Area

Notes

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

* Currently under construction

N

0 500 1,000 2,000 Feet

Figure 1
Existing and Proposed Groundwater Monitoring and Test Boring Locations
Groundwater Flow Model Progress Report 08
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

\\Honolulu\Honolulu\Projects\NAVFAC PAC\CLEAN V\60571032_CTO18F01126900-Work\920 GIS\02_Maps\GWM ProgRpts\RptB_Fig 1_Existing-Prop_Wells.mxd 7/25/2019

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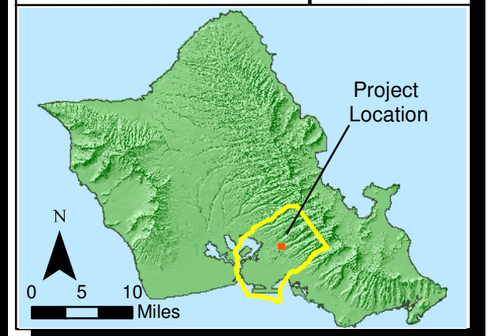
redacted: Navy infrastructure

Location Map



Legend

- TEC 2007 Modeling files, provided by the Navy
- As depicted by Stearns, 1942
- Provided by Navy, April 26, 2019
- Provided by Rotzoll, May 7, 2019

Notes

1. Map projection: NAD 1983 Hawaii State Plane Zone 3
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015
3. Widith of polylines do not necessarily reflect width of feature.

N

0 50 100 200 Feet

Figure 2
Red Hill Shaft
Water Development Tunnel Alignment
Groundwater Flow Model Progress Report 08
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

Z:\Projects\NAVFAC PAC\CLEAN V\60571032_CTO18F0126\900-Work\920 GIS\02_Maps\GWM ProgRpts\Rpt8_Fig 2_Shaft_Orientation.mxd 7/5/2019

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Appendix A:
Boring Logs

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

Log of Boring RHMW14

Date(s) Drilled	**10/26/18 - 02/25/19**	Logged By	**M. Higley, Q. Meehan, B. Mintz**	Checked By (Date)	**J. Kronen**
Drilling Method	**Core bucket, HSA, HQ core, PQ core**	Drill Bit Size/Type	**24" core bucket/prod auger, 10" HSA, HQ/PQ core diamond bit**	Total Depth of Borehole	**495.0 feet**
Drill Rig Type	**Mobile B-59 / Mobile B-90/ Watson 1100 and 2000**	Drilling Contractor	**Valley Well Drilling**	Approximate Surface Elevation	**180.23**
Groundwater Level	**El. ~20.45' (2/26/19)**	Location	**Halawa Correctional Facility**	Inclination from Horizontal/Bearing	**90°**
Borehole Completion	**Westbay Well**	**Packer**	**⊗ Sample Port**	**Measurement Port**	Hammer Data **140 lbs/30-inch drop**

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery,%	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
180	0								**FILL** Moist, dark brown (7.5YR 3/3), Silty Sandy GRAVEL (GM) with cobbles and boulders, sub rounded to rounded, 60% coarse, 20% sand, 20% fines, no odor							Air Knife for utility clearance. Visually logged open hole
	1								1-2 ft bgs boulder 22" x 13"							
	2															
178									2.2-3 ft bgs boulder 36" x 24"							End airknife at 3 ft bgs due to boulder obstructions
	3								Moist, brown (10YR 4/3), Clayey GRAVEL with Sand (GC), contains cobbles and boulders, gravel subrounded to subangular, fine to coarse, 60% coarse, 20 % sand, 20% fines							Resume drilling on 11/20/18 at 11:22 with 24" core bucket auger
	4															Core bucket grinding at 3.5 ft. Driller adding ~1 gal water/ft
176																
	5															
	6								Brown (10YR 5/3), GRAVEL with Silt and Sand (GW-GM), grades with more gravel, 70% gravel, 20% sand, 10% fines, well graded, boulders ~1 ft diameter							Intermittent grinding 4 ft - 9 ft
174																
	7															
	8															9-10 ft boulder
172																
	9								Boulder 9'-10'							10 ft easier drilling
	10								Brown (10YR 5/3) with gray (5Y 6/1) and pale yellow mottles (5Y 7/4) and yellowish brown (10YR 5/4), well graded GRAVEL with Silt and Sand (GW-GM), many cobbles and boulders							
170																
	11															
	12								**ALLUVIUM** Moist, brown (10YR 5/3) with gray (5Y 6/1) and pale yellow mottles (5Y 7/4) and yellow brown (10YR 5/6), Sandy CLAY with gravel (CH), rounded, weathered,					56.6		At 12 bgs, strong odor, PID=56.6 ppm. Grinding hard at 9ft pull up,
168																
	13															

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	13								friable, 60% fines, 25% sand, 15% gravel, strong odor, with cobbles and boulders 0.25-0.75 ft, highly to moderately weathered, angular to rounded					bucket and rock still left in hole Collect ERH 717 from ~12-19 bgs for TPHd/o and PAH from cuttings, 1 gal ziplock bag
166	14													
	15								Same, strong odor, cobbles and boulders have black surface stains, possibly manganese, some fracture surfaces have slight irridescence			63*		At 14.5 ft switch to auger bucket. *PID in tilt bin equals 63 ppm. Down hole = 38 ppm
164	16								Seepage into hole observed at 16 ft bgs					At 16.4 ft switch back to core barrel. **PID= 256 ppm in tilt bin.
	17													At 17.4 ft very easy drilling
												256**		At 18 ft ***PID=250 ppm in tilt bin, PID=156 ppm on rock
162	18											250***		
	19											5****		At 19 ft, ****PID=5.0 ppm on bottom of core 14:14 hrs at 19.58 ft
	20											20.9		Water trickling in at ~16 ft bgs End drilling at 21.5 ft at 14:30 on 11/20/18.
160	21													
	22								Moist, brown (10YR 4/3) with reddish (7.5YR 6/5), yellow Sandy Fat CLAY (CH) with gravel, 15% gravel, 20% sand, 75% fines, subrounded to subangular fine to coarse gravel predominantly coarse gravel, no odor, PID=0.0ppm					Resume drilling from 21.5 ft at 10:20 on 01/03/19
158	23													
	24								Wet, dark yellowish brown (10YR 4/4) with reddish yellow (7.5YR 6/5), Sandy SILT (ML) with gravel, 30% sand, 20% gravel, 50% fines with cobbles and gravel, rounded to subangular basaltic, fine to coarse, no odor, PID=0.0ppm					
156	25													
	26								Same color as above, cobbles became angular possibly broken up boulders, black staining surfaces			0.0		
154	27								Same color as above, cobbles become angular possibly broken up boulders, black staining surfaces with roots					
	28								Grades with more cobbles, some angular, very wet because water accumulated in hole bottom during lunch ~2 ft of water in 40 min, water infiltrates in ~ 16 ft bgs			0.0		
152	29													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

Project: CTO1850126 - Red Hill Bulk Fuel Storage Facilty
Project Location: CTO18F0126
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Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	29								Moist, dark brown (10YR 3/3) with dark gray (10YR 4/1) and brownish yellow (10YR 6/6/), Sandy Fat CLAY (CH) with gravel matrix, with angular highly weathered friable basalt cobbles, black staining on fractured surfaces, 20% sand, 15% gravel, 65% fines			0.0		
150	30													
	31													
148	32													Driller adding water from top of hole
	33													
146	34								Moist, gray (10YR 5/1) with dark yellowish brown (10YR 3/4) and yellow (10YR 7/6), fat CLAY with sand, 5% gravel, 20% sand, 75% fines (CH).					Driller adding water from top of hole
	35													
	36													Driller adding water from top of hole
144												0.0		
	37								Grades with some cobbles			0.0		
142	38													Driller adding water from top of hole
	39											0.0		
140	40													
	41								Wet, dark yellowish brown (10YR 4/4), Clayey GRAVEL with Sand (GC), friable, angular, highly weathered, possible perched zone at 42 ft bgs					Driller adding water from top of borehole. Water appears to be infiltrating in at ~42 ft bgs. See logbook 6 pg.139 for water level monitoring. Install 20"0D steel conductor to 45 ft bgs, and tremie grout cement bentonite into annulus
	42													
138	43													
	44													
136														
	45													Drill to 45.2 ft bgs

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

Log of Boring RHMW14

Sheet 4 of 32

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	45								Wet, dark brown (7.5YR 3/2) to brown (7.5YR 4/2), gravelly Fat CLAY (CH) with sand, 30% gravel, 15% sand, 55% clay, contains cobbles and possible boulders, fine to coarse, subrounded to angular. Driller says formation is soft.			1				Boring resumed on 1/10/19 from 45 ft bgs using 10" OD HSA (6 5/8" ID). Auger bit advanced with slide hammer and auger casing follows. Formation is soft. Bulk sample 1 obtained by slide hammering 6" concrete coring bit into center of HSA casing (to ensure plumbness) to retrieve auger bit.
134	46															
	47															
132	48															
	49															
130	50															
	51								Becomes moist, grades with mottles of strong brown (7.5YR 5/6) and dark brown (7.5YR 2.5/2) weathered gravel, friable			2	5 15 35	0.0		Sampling with downhole hammer on wireline and modified california sampler
128	52			100												
	53															
	54								Becomes dark gray (5YR 4/1) and strong brown (7.5YR 4/6)			3	4 4 16	0.0		
126				87												
	55								Dark greenish gray (10Y 4/1) BASALT, moderately weathered, weak, friable, black stains of fracture surfaces, probably boulder			4	15 50/6"	0.0		
				100												
124	56								IF very dark greenish gray (10Y 3/1), a'a BASALT, slightly weathered, strong, 15% vesicles, vertical joints						[13.8]	Augering slow, driller suspects boulders. After sampling to 56 ft tag bottom of hole at 55 ft bgs. Then drill auger casing without center bit to 57 ft bgs. Prepare to begin coring. Boring paused at 56 ft bgs on 1/10/19 at 15:45.
	57	5		67					IF Joints 0-90, J, VN, Mn/Fe, Su, Wa, R 56-59 ft light brown water return, water loss ~5 gal							
122	58						NR		no recovery							
	59								Strong brown (7.5YR 4/6) to very dark greenish gray, Fat CLAY (CH) with trace of basaltic gravel. Core sample stuck inside core barrel, very high plasticity, very stiff clay. Leave in for now, will need to use pressure to push out. Recovered 1.5 ft of core from barrel on 1/22/19						[37.5]	Resume drilling at 56 ft bgs on 1/11/19 at 08:35 using HQ core. Tag hole to 59 ft bgs after run 5
120	60		2													
	61															

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet / Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type / Number / Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
61													
62	6		54		0								Light brown water return, water loss ~10 gal
118													
63													High back pressure when casing joint broke
64													
116								Moist, greenish gray (10BG 5/11) and strong brown (7.5YR 4/6), Gravelly Fat CLAY (CH) with sand and gravel fine to medium, very weathered friable, subrounded to angular, 20% gravel, 10% sand, 60% fines			0.0	[30]	
65						1 2 3		very dark greenish gray (10Y 3/1), basalt boulder, 30% vesicles, slightly weathered					Light brown water return, water loss ~10 gal
66						4							
114	7		100		13			grades back to Gravelly Fat CLAY (CH) with sand and bands of dark brown (10YR 3/3), fat clay, very stiff 1-3. 45, J, VN, Mn/Fe, Sp, Wa, SR 4. 5, J, VN, Mn/Fe, Su, IR, R 5. 5, J, VN, Mn/Fe, Su, Wa, SR					
67													
68													
112								Basalt cobble at 68.2 ft					
69						5		greenish black (10Y 2.5/1), basalt pahoehoe boulder, slightly weathered, medium strong, 40% vesicles			0.0	[60]	
70								basalt boulders, mixed pahoehoe and a'a with clay seams and gravel					
110								heat alteration, possible flow boundary noted in boulder					Light brown water return, water loss ~5 gal
71													
72	8		80		22								
108								grades with more gravel, subangular to angular, medium to coarse, highly to slightly weathered					
73						NR							
74								no recovery					
106						F		**SAPROLITE** Dark greenish gray (5GY 4/1), BASALT Massive a'a, slightly weathered, strong, 5% vesicles, intensely fractured.			0.0	[17.5]	Light grayish brown water return, water loss ~10 gal
75								Massive a'a cobblestones/boulders with dark grayish brown (2.5Y 3/2), Gravelly Fat CLAY (CH) with sand seams, gravel fine to coarse, subrounded to angular, slightly to highly weathered					
76	9		100		0			75.3 - 76 ft clay seam					
104													Drill string water pressure high
77													

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	77								very dark greenish gray (10Y 3/1) with streaks of brown (7.5YR 4/2) basalt massive a'a, slight weathering, strong, 5% vesicles (elongate)							High water back pressure when casing joint broken
	78								At 77.5 ft becomes very dark gray (N3), smaller vesicles ~1 mm, more spherical					0.0	[30]	
102		10		67		36										Light grayish brown water return
	79						NR		no recovery							
									At 78 ft very dark greenish gray (10Y 3/1), 20% vesicles, slight to moderately weathered, clay seam in between two boulders likely washed out						[25]	
	80								At 79.3 ft Moist, dark reddish brown (5YR 3/2) Sandy Fat CLAY (CH) with gravel, gravel is slightly to moderately weathered, subrounded to angular, contains very dark gray (3N), slightly weathered basalt a'a cobbles 5-10% vesicular, cobbles appear to be from the same flow and clay is completely weathered basalt, weathered in place.							
100																Light brown water return, water loss ~10 gal
	81	11		84		0										
	82															
98																
	83						NR		no recovery							
	84								becomes dark reddish brown (5YR 2.5/2 to 5YR 3/4), Fat CLAY (CH) with sand, contains traces of gravel, coarse, angular, slightly weathered and basalt a'a cobbles					0.0	[25]	
96																
	85															Light brown water return, water loss ~50 gal
	86															
94		12		84		0										Boring paused on 1/11/19 at 89 ft at 12:04. Pull out HQ casing and prepare for 10" casing install
	87															
	88															10" steel casing installed to 88 ft bgs on 1/17/19
92							NR		no recovery							
	89								Very dark gray (N3), pahoehoe cobble 89-89.5 ft, 35% vesicles, slight weathering					0.0	[33.3]	
									Dark reddish brown (5YR 3/2), Fat CLAY (CH) with 25% gravel, angular, basaltic, with basaltic cobbles, slightly to moderately weathered, black stains on fracture surfaces							Resume drilling on 1/22/19 at 08:08
90	90															
	91								91-92 ft Sandy Fat CLAY with gravel (CH), 25% sand, 15% gravel, 60% fines							
		13		100		2										Dark grayish brown water return, no water loss
88	92															
	93															

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

Log of Boring RHMW14

Sheet 7 of 32

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	93								93-93.5 ft basalt pahoehoe cobble, moderately weathered							
86	94						F		Massive basalt a'a boulder/cobbles, very dark gray (N3), slightly to moderately weathered, strong with possible washed out clay seams in joints					0.0	[60]	
	95								Dark reddish brown (5YR 3/2) Sandy Elastic SILT (MH) with gravel, 15% gravel, 20% sand, 65% fines. Gravel is subrounded to angular, poorly graded							Dark brown water return, no water loss
84	96	14		86		0			Massive basalt a'a cobble, very dark gray (N3), slighlty weathered, hard, 15% stretched vesicles							
	97								96.75 ft dark reddish brown (5YR 3/2) Gravelly Elastic Silt (GM) wih sand, 30% gravel, 15% sand, 55% fines. Gravel subangular, well graded							
									Massive basalt a'a cobble, as above with black stains on fracture surfaces (97.5-97.8 ft)							
82	98															
	99						NR		no recovery							
									At 99 ft dark reddish brown, Sandy Elastic SILT (MH) with gravel, 15% gravel, 20% sand, 65% silt, contains slightly weathered basalt cobbles, gravel sub angular, moderate to highly weathered					0.1	[30]	
80	100															Dark brown water return, no water loss
	101						1		**BASALT Pahoehoe**							
		15		92		36	2		Moderately weathered, very dark gray (N3) to dark gray (N4), strong to medium strong, 35% vesicles, spherical, 0.5-1 mm							
78	102						3									
							4									
	103						5									
							6		grades with bands of vesicles <0.5 mm							
							7		1. 50, J, N, Sd, Si, Fe, Pa, Wa/Ir, R 2. 0, J, N, Sd/Si/Fe, Pa, Wa, R 3. 0, J, VN, Mn/Fe, Su, Pl, SR 4. 10, J, VN, Si/Mn/Fe, Pa, Pl, SR 5. 45, F, VN, Mn/Fe, Su, Wa, SR 6. 10, J, VN, Mn/Fe, Su, ST, R 7. 60, J, VN, Mn/FE, Su, Pl, Se							
76	104						1							0.0	[60]	
							2		At 104 ft grades to 40% vesicles							
	105						3		1. 0, J, VN, Mn, Sp, Pl, SR 2. 90, J, VN, Fe, Mn, Su, Wa, SR 3. 30, J, VN, Mn, Sp, ST, R 4. 5, J, VN, Fe/Mn, Su, Wa, R 5. 60, J, VN, Fe/Mn, Su, Wa, R 6. 50, J, VN, Fe/Mn, Sp, Pl, SR 7. 0, J, VN, Fe/Mn, Su, Wa, R 8. 2, J, VN, Fe/Mn, Su, Pl, S 9. 50-40, VN, Fe/Mn, Su, ST, SR, Joint 10. 10, J, VN, Fe/Mn, Su, Wa, SR							
							4									
	106						5									Dark brown water return
74		16		108		70	6									
							M									
	107						7									
							8		107.2-107.4 ft zone of 10% vesicles <0.5 mm							
	108						9									
72																
							10		At 108.75 ft becomes highly weathered, yellowish red (5YR 4/6), weak, possible flow boundary							
	109															

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
70	109						1		1. 5, J, N, Cl, Fe, Mn, Pa, Ir, VR			0.1	[100]	
	110						2		becomes dusky red (2.5YR 3/2) to reddish black, moderate to highly weathered, weak to medium strong 2-3. 10, J, VN, Fe, Mn, Sp, Wa, SR 4. 5, J, VN, Fe, Mn, Cl, Sp, Wa, SR 5. 46, J, VN, Fe, Mn, Cl, Sp, Wa, SR 6. 5, J, VN, Fe, Mn, Su, Ir, Vr 7. 60, J, VN, Fe, Mn, Cl, Pa, Ir, Vr 8. 15, J, VN, Fe, Mn, Cl, Pa, Wa, R					Dark brownish gray water return, water loss ~10 gal
	111	17		100		84	3							
68	112						4							
	113						5							
	114						6					0.0	[75]	
66							7							
	115						8							Dark brownish gray water return, water loss ~10 gal
	116						1		115-116.4 ft contains weathered olivine and plagioclase phenocrysts 0.5-1 mm, 2-5% 1. 40-80, J, Cl, Fe, Mn, Pa, Ir, R, VN becomes slightly to moderately weathered, very dark gray (N3), moderately strong to strong, 20-30% vesicles 2. 5, J, Cl, Sp, Ir, VR, VN					
64		18		100		84	2							
	117						3		At 115 ft becomes slightly weathered to fresh, strong to very strong, vesicles up to 10 mm 3. 35, J, Fe, Cl, Mn, Sp, Pl, SR, VN					
							4		At 115.7 ft vesicles become 1-5 mm 4. 35, J, N, Fe, Mn, Cl, Pa, Pl, SR					
62	118						5		At 116.4 ft becomes reddish black to very dark gray, slightly to moderately weathered, medium strong, vesicles <0.5 mm, some filled with clay 5. 0, J, N, Cl, Si, Pa, Pl, SR					
							6		At 117.75 ft becomes slightly weathered, strong, very dark gray (N3), 35% vesicles (1-2 mm) 6. 50, J, N, Cl, Mn, Fe, Pa, Pl, R					
	119						7		7. 5, J, N, Cl, Fe, Mn, Pa, Ir, R 8. 10, J, VN, Cl, Fe, Mn, Sp, Pl, SR			0.1	[150]	
							8		At 119.2 ft becomes moderately weathered, weak, vesicles filles with clay					
60	120						1		becomes slightly weathered to fresh, strong, 40% vesicles 1-2 mm, traces of weathered olivine ~1% 1. 50-20, J, VN, Cl, Mn, Fe, Sp, Ir, SR 2. 15, J, VN, Cl, Sp, Wa, SR 3. 0, J, VN, Cl. Sp, Pl, SR 4. 75, J, VN, Cl, Fe, Mn, Pa, Ir, R 5. 10, J, VN, Cl, Fe, Mn, Sp, Wa, SR					Dark brownish gray water return, water loss ~10 gal
	121	19		94		78	2							
							3							
58	122						4							
									vesicles 0.5-1 mm					
	123						5		122.7-122.8 ft moderate weathering around fracture					
									vesicles 1-2 mm					
	124						NR		no recovery At 124 ft becomes 30% vesicles			0.1	[150]	Driller says no water return 124-125 ft
56														
	125								At 124.8 ft becomes reddish black (2.5YR 2.5/1)					

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	125								with reddish yellow (7.5YR 7/6), vesicles infill, moderate to highly weathered, medium strong to weak, vesicles 0.5-1 mm					
							1		1. 10, J, N-VN, Cl, Mn, Fe, Pa-Sp, Ir, R					
	126						2		2. 20, J, N-Vn, Cl, Mn, Fe, Pa- Sp, Ir, R					
54							3		3. 75, J, VN, Cl, Mn, Fe, Sp, Pl, SR					Dark brownish gray water return, water loss ~10 gal
		20		96		56	4		4. 60, J, N-VN, Cl, Mn, Fe, Pa-Sp, Ir, R					
									5. 5, J, N, Cl, Pa, Ir, S, reddish yellow filling					
	127						5		6. 50, J, Cl, Mn, Fe, Pa, Ir, R					
							6		7. 50, J, Cl, Mn, Fe, Pa, Ir, R					
									8. 20, J, Cl, Mn, Fe, Pa, Pl, SR					
							NR		no recovery					
							IF		127.5-127.85 becomes intensely fractured, likely clay infill washed out					
52	128						7							
							8		becomes slightly weathered, very dark gray (N3), medium strong to strong, vesicles 1-2 mm					
							M							
	129		9						becomes 0.5-1 mm vesicles			0.1	[100]	
									1. 5 J, N, Cl, Mn, fe, Pa, IR, R					
									2. 60, J, N-VN, Cl, Mn, Fe, Pa, Pl, SR					
									3. 45, J, N-VN, Cl, Mn, Fe, Pa, Sa-R					
	130													
50							1		becomes brown (7.5YR 4/4), moderate to highly weathered, medium strong to weak, 5% vesicles (filled by clay)					Dark brownish gray water return, water loss ~10 gal
							2							
							3		becomes very dark gray, slighly weathered, medium strong to strong, 30-35% vesicles, 0.5-1 mm					
	131						4							Water loss in HQ casing fell 21.5 ft from 79.7 ft btoc to 101.2 in 21 min
							5							
		21		96		62	6		becomes brown (7.5YR 4/3), moderate to highly weathered, medium strong to weak, 10% vesicles, 0.01-0.5 mm					
	132								4. 10, J, VN, Cl, Mn, Fe, Sp to Su, Pl, S					
48							7		5. 60, J, VN, Cl, Mn, Fe, Sp, Pl, S					Boring paused at 11:25 on 1/22/19 at 134 ft bgs. Plan to install 5" casing to 134 ft bgs
									6. 5, J, N-MW, Cl, Mn, Fe, Pa, IR, R					
									7. 0, J, N-VN, Cl, Mn, Fe, Sp, Pl, SR					
	133						8		8. 5, J, N, Cl, Mn, Fe, Pa, IR, R					
							9		9. 80, J, VN, Cl, Mn, Fe, Sp, Pl, S					
							IF							
														134-135 ft was drilled out with 9 7/8" tricone, no core available. 5" steel casing installed to 135' bgs on 1/24/19
46	134						NR		no recovery					
	135								becomes slightly weathered, very dark gray (N3), strong to medium strong, 30-35% vesicles (0.5-2 mm) spherical			0.0	[75]	Resume coring from 135 ft using PQ core on 2/18/19
							M							
	136													
44							M							
									grades with dark red (2.5YR 3/6) on fracture surface, possible flow contact.					
							M							
	137						1							
							2		slightly to moderatly weathered, very dark gray, medium strong, 20% vesicles (1-5 mm), spherical to stretched					Dark brownish gray water return, water loss ~10 gal
		22		84		44	3							
									137.3-137.5 ft Welded Clinker					
	138						IF		Moderately weathered, dark red (2.5YR 3/6), yellowish brown (10YR 5/6) and black (N2.5)					
42									At 137.5 ft becomes intensely fractured with yellowish red (5YR 5/6) clay on fracture surfaces and in vesicles, moderately weathered					
	139						IF							Faster drilling at ~139 ft bgs
							NR		no recovery					
	140		12											
40							1		1. 45, B, VN, Fe, Mn, Cl, Sp, IR, SR			0.1	[50]	
							2		2. 50, J, VN, Fe, Mn, Cl, Sp, IR, R					
									3. 20, B, N, Fe, Mn, Cl, Sp, ST, R					
	141						3							

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	141								At 140 ft greenish black (10Y 2.5/1) with yellowish red (5YR 5/6) clay in vesicles, moderately weathered, medium strong, 20% vesicles less than 1 mm					
	142							F	At 141.2 ft becomes intensely fractured with yellowish red (5YR 5/6) clay on fracture surfaces 1. 0, J, VN, Fe, Mn, Su, Pl, SR 2. 0, J, VN, Fe, Mn, Cl, Sp, Pl, SR 3. 0, J, VN, Fe, Mn, Cl, Sp, Pl, SR 4. 30, J, VN, No, No, Ir, SR					Dark brownish gray water return, water loss ~100 gal
-38		23		100		34								
	143								At 142.5 ft vesicles become 1-3 mm, less clay infill					
	144							4						
-36														
	145		13					1	grades without clay in vesicles, fractures still have clay infill 1. 70, J, VN, Fe, Mn, Cl, Sp, Pl, SR 2. 70, J, VN, Fe, Mn, Cl, Sp, Wa, SR			0.1	[50]	
	146							2						
-34								F	becomes very dark gray (7.5YR 3/1) to strong brown (7.5YR 4/6), intensely fractured, highly weathered, very weak					
	147													
	148	24		100		48		3	3. 60, J, VN, Fe, Mn, Cl, Sp, Wa, SR					
								4	Becomes greenish gray (10Y 2.5/1), slight to moderate weathering, medium strong, 15-20% vesicles 0.5-3 mm, predominantly <1 mm					
-32								5	4. 90, J, VN, Fe, Mn, Cl, Sp, Wa, SR					
								6	5-6. 50, J, VN, Fe, Mn, Cl, Sp, IR, SR					
	149								7. 25, J, VN, Fe, Mn, Cl, Sp, IR, SR 8. 20, J, VN, Fe, Mn, Cl, Sp, IR, R					
								7						
								8						
	150								becomes moderately weathered, weak to medium strong			0.1	[60]	
-30								1						
	151								black (N 2.5), yellowish red (5YR 5/6) and dark brown (7.5YR 3/4), alteration probable flow boundary. 150.9-151.3 ft with clay infill in vesicles					
								2	At 151.2 ft becomes very dark gray (N3), slightly weathered, strong, 15-20% vesicles 1-5 mm some stretched					Dark gray brown water return, water loss ~100 gal
	152								At 151.5 ft grades without vesicle infill					
-28		25		104		96		3	1. 0, J, VN, Cl, Sp, Pl, SR 2. 0, J, Vn, Fe, Mn, Cl, Sp, Pl, SR 3. 10, J, Vn, Fe, Mn, Su, Pl, SR					
	153								4. 5, J, VN, Cl, Fe, Mn, Sp, ST, SR					
								4	5. 5, J, VN, Cl, Sp, IR, R					
								5	6. 50, J, VN, Fe, Mn, Cl, Sp, Pl, SR					
								6	7. 5, J, VN, Cl, Sp, IR, R					
								7	8. 80, J, VN, Mn, Su, Pl, SR					
-26	154							8						
								M						
	155							M				0.1	[60]	
								M						
	156		16											
-24								M						
	157								vesicles become 0.5-1 mm, some infilled with clay					

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Project Location: CTO18F0126
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Log of Boring RHMW14

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	157													
		26		96		76			1. 45, J, VN, Cl, Fe, Mn, Sp, Pl, S 2. 15, J, VN, Fe, Mn, Su, Pl, S 3. 85, J, VN, Fe, Mn, Su, Wa, SR 4. 0, J, VN, No, No, Wa, SR 5. 75, J, VN, Fe, Mn, Cl, Pa, Pl, SR					Dark grayish brown water return, water loss ~100 gal
-22	158													
	159		17											
	160								becomes black (N 2.5), highly weathered, weak, most vesicles filled with clay			0.1	[42.9]	
-20														
	161								becomes moderately weathered, weak to medium strong 1. 70, J, VN, Fe, Mn, Cl, Sp, Wa/SR 2. 60, J, VN, Mn, Su, Wa, SR 3-4. 0, J, VN, Cl, Sp, Pl, SR					
	162								grades with trace clay infill in vesicles. Intensely fractured zone contains high angle joints with Fe, Mn stains and clay 5. 5, J, VN, Cl, Sp, IR, R					
-18		27		110		62								
	163													
	164								grades with more clay infill 6 and 8. 5, J, VN, Cl, Mn, Sp, IR, R 7. 90, J, VN, Cl, Mn, Sp, IR, R 1. 15, J, VN, Cl, Sp, Wa, S/R					Clean out circulation pit
-16	165		19									0.1	[60]	
									becomes highly weathered, weak, most vesicles filled with clay, 35-40% vesicles less than 0.5 mm 2. 0, J< VN, Cl, Sp, IR, SR 3. 30, J, Cl, Mn, Sp, IR, R					
-14	166													Dark gray water return, water loss ~100 gal. Tighter formation, drill string binding
	167													
		28		96		50			becomes very dark gray (N3), slight to moderately weathered, strong, 20-30% vesicles 0.5-3 mm 4. 0, J, VN, Cl, Sp, Wa, SR					
-12	168													
	169								becomes very dark gray (N3) to dark reddish brown (5YR 3/2), moderately weathered, medium strong, possible flow boundary at 168.8 ft, vesicles 0.5-1 mm filled with clay 5. 40, J, VN, Cl, Mn, Sp, Wa, SR 6. 60, J, VN, Cl, Fe, Mn, Sp, Wa, SR					
	170											0.1	[37.5]	
-10									becomes very dark gray (N3), moderately weathered, medium strong, vesicles 1-3 mm with no infill 1. 10, J, VN, Cl, Sp, IR, SR 2. 90, J, VN, Cl, Sp, Wa, SR					Dark gray water return, water loss ~100 gal
	171													
	172								vesicles become 0.5-1 mm and filled with clay 3. 0, J, VN, Cl, Sp, Pl, SR 4. 10, J, VN, Cl, Sp, Pl, SR 5. 80, J, VN, Fe, Mn, Cl, Sp, Pl, S 6. 35, J, VN, Cl, Sp, IR, SR					
-8		29		100		90								
	173													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	173						5		7. 90, J, VN, Cl, Fe, Mn, Sp, Wa, SR					
							6		173.5-173.6 ft brown (7.5YR 4/4), alteration band angled ~45 degrees					
	174						7		8. 0, J, VN, Cl, Fe, Su, IR, SR					
6							8		9. 5, B, N, No, No, IR, R					
							9		**BASALT Welded a'a Clinker**					
	175								Dark reddish brown (2.5YR 2.5/4) to (5YR 2.5/2), moderately weathered, medium strong			0.1	[33.3]	
							1		1. 5, J, VN, Fe, Mn, Cl, Sp, IR, R					
									2. 15, J, VN, Mn, Su, Wa, SR					Grayish brown water return
	176								3. 0, J, VN, No, No, IR, R					
4							IF		4-5. 0, J, VN, No, No, IR, R					
									becomes dusky red (2.5 YR 3/2) to reddish black (2.5YR 2.5/1), moderately weathered, weak to medium strong					
	177	30		100		64	2		6. 5, B, VN, Mn, Su, IR, R					
	178						3							
2							4							
							5		becomes weak, more friable					
	179		23											
							6							
	180						1		**BASALT Massive a'a**			0.1	[42.9]	
0									Very dark gray (N3), slightly weathered to fresh, strong to very strong, traces of olivine ~1%, 10% vesicles ~1 mm, stretched					
	181								1. 5, J, VN, Mn, Su, IR, SR					
							2		2. 10, J, VN, Mn, Fe, Su, Pl, SR					
									3. 10, J, VN, Mn, Fe, Su, Pl, SR					Gray water return
	182						3		4. 20, J, VN, Mn, Fe, Cl, Sp, Pl, S					
-2							4		5. 15, J, VN, Mn, Fe, Su, Pl, SR					
		31		100		84								
	183						5		vesicles become more stretched, ~15% vesicles					
									6. 10, J, VN, Mn, Fe, Su, Pl, SR					
	184						6							
-4							M							
							M							
	185						1		1. 5, J, VN, Mn, Fe, Su, Pl, SR			0.1	[60]	
							2		2. 5, J, VN, Mn, Fe, Su, Pl, SR					
							3		3. 10, B, N, No, No, IR, R					
	186								**BASALT a'a clinker**					
-6							NR							
	187													Driller says easy drilling at end of run
		32		18										Recovered 0.9 ft of core, remaining core dropped down hole. Will pull casing next shift
	188								no recovery					
-8														
	189													

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	189								no recovery							Boring paused at 190 ft bgs on 2/18/19 at 15:17
-10	190								Loose gravel, dark reddish brown (2.5YR 2.5/3) and dark red (2.5YR 3/6) mottled with yellowish brown (10YR 5/6), consolidated, low permeablity, highly to completely weathered, very weak, friable, weathered to Sandy SILT (ML)					0.0	[60]	Boring resumed on 2/19/19 at 08:08. Driller able to get core barrel to latch without pulling casing. No additional core recovered. Brown water return, water loss ~150 gal
	191	33		100		0										
-12	192								grades with dark reddish brown (2.5YR 2.5/3)					0.0	[60]	
	193															Brown water return, water loss ~150 gal
		34		77		0										
-14	194															
	195								no recovery							Boring paused at 195 ft bgs on 2/19/19 at 08:23 due to rain
							IF		**BASALT Pahoehoe**					0.0	[50]	Resume coring on 2/20/19 at 07:02. DTW = 134.9 ft btoc
-16	196								Dark reddish brown (5YR 2.5/2) to very dark gray (5YR 3/1), moderate to highly weathered, medium strong, ~10% olivine phenocrysts, 25% vesicles 1-2 mm, intensely fractured							
									At 196 ft grades with red (2.5YR 4/6), becomes highly to completely weathered, very weak							
	197	35		100		7										Light brown water return, water loss ~150 gal
-18	198								becomes very dark gray (N3) to greenish black (5GY 2.5/1), moderate to highly weathered, medium strong, 15% olivine, some weathering, 25-30% vesicles							
	199															
	200								becomes moderately weathered, vesicles 1-5 mm					0.0	[33.3]	
-20							1		1. 5, J, VN, Mn, Fe, Su, Wa, SR							
	201		28				2		2. 75, J, VN, Mn, Fe, Cl, Sp, Wa, SR 3. 10, J, VN, De, Mn, Su, IR, R 4. 10, J, VN, Fe, Mn, Su, Wa, SR 5. 10, J, VN, Fe, Mn, Su, Pl, SR							Brownish gray water return, water loss ~150 gal
	202						3									
-22		36		84		50	4									
	203						5		very elongate vesicles							
							IF									
							IF		Possibly mechanically broken when opening shoe							
-24	204															
							NR		no recovery							
	205															

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	205						IF		**BASALT a'a clinker** Welded, dark reddish brown (5YR 3/2) and black (2.5N) clasts with yellow (10Y 7/6) weathering and alteration, moderately weathered, weak to medium strong, less permeable 1. 5, J, VN, No, No, IR, R 2. 5, J, VN, No, No, IR, R 3. 0, J, VN, No, No, IR, R			0.0	[30]	Cored 1 ft to pick up any possible dropped core. Recovered 1 ft of core (welded clinker)
		37		130		40	1							
-26	206						2					0.0	[21.8]	
	207						1 IF		becomes loose clinker fragments, coarse gravel size, with yellow (10Y 7/6) to strong brown (7.5YR 5/6) clay on surfaces					Grayish brown water return, water loss ~150 gal
							IF		**BASALT Massive a'a** Very dark gray (N3) to greenish black (5GY 2.5/1) and spots of dark yellowish brown (10YR 3/6) weathering and alteration; moderate to highly weathered, medium strong to weak, 15% vesicles 1-3 mm 1. 60, J, VN, Fe, Mn, Su, Pl, SR 2. 0, J, VN, Fe, Mn, Su, Pl, SR 3. 0, J, VN, Fe, Mn, Su, Pl, SR 4. 10, J, VN, Fe, Mn, Su, Pl, SR 5. 20, J, VN, Fe, Mn, Su, IR, R					
-28	208	38		93		8	1							
	209						2 3 4 5							
	210						IF		Large vug at 210 ft bgs (contains Fe coating), evidence of core griding on fractures 1 and 4. Intensely fractured zone at 208.2 ft bgs contains fracture healed with 3 mm thick white clay			0.0	[17.6]	
-30	211						1		At 210 ft becomes very dark gray (N3), slightly to moderately weathered, medium strong to strong					
							2		At 211 ft high angle light gray striations (possibly from core barrel), 15% vesicles <0.5 mm					
-32	212													
		39		100		38	3							
	213						4 5							
									BASALT a'a clinker Loose clinker fragments, very dark gray (N3) and black (2.5N) clasts with yellow (10YR 7/6) highly weathered, weak to medium strong. IF is highly angled with Fe and Mn staining 1. 5, J, N, No, No, Pl, SR 2. 75, J, VN, Fe, Mn, Su, Wa, R 3. 75, J, VN, Fe, Mn, Su, Wa, R 4. 5, J, VN, Fe, Su, Wa, SR 5. 90, J, VN, Fe, Mn, Su, Wa, R					
-34	214													
	215											0.0	[37.5]	
							IF		**BASALT Pahoehoe** Dark reddish brown (2.5YR 4/4), moderate to highly weathered, weak to moderately strong, 20% vesicles <0.5 mm					Grayish brown water return, water loss ~150 gal
-36	216						1		At 216 ft becomes dark reddish brown (2.5YR 3/3), moderately weathered, medium strong to strong, 25% vesicles <0.5 mm to 0.5 mm 1. 90, J, VN, Fe, Mn, Cl, Su, Wa, R 2. 0, J, VN, Fe, Mn, Cl, Su, Su, Wa, R 3. 0, J, VN, No, No, Wa, SR					
	217						2							
		40		100		46	M							
	218						3 4							
-38									becomes reddish/yellowish red (5YR 4/3), highly weathered, weak, alteration zone, 30% vesicles 0.5-1 mm					
	219						IF 5		becomes reddish black (2.5YR 2.5/1), slightly weathered, medium strong to strong, contains yellow (10YR 7/6) clay veins 4. 25, J, VN, Fe, Mn, Cl, Su, Wa, R 5. 5, J, VN, No, No, Wa, SR					
	220		33						becomes reddish black (2.5YR 2.5/1) to black (2.5N) with yellow (10YR 7/6) clay veins and vesicle infill, slightly weathered, medium strong to strong, 30% vesicles 0.5-1 mm			0.0	[27.3]	Grayish brown water return, water loss ~150 gal
-40							M		At 220.6 ft grades to <0.5 mm					
	221													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	221								1. 0, J, VN, No, No, Pl, SR 2. 75, J, VN, No, No, Pl, SR 3. 10, J, VN, Fe, Mn, Cl, Su, Wa, S 4. 80, J, VN, Fe, Mn, Cl, Sp, Wa, SR 5. 80, J, VN, Fe, Mn, Cl, Sp, Wa, SR					
-42	222	41		94		64			**BASALT Massive a'a** Very dark gray (N3), moderately weathered, medium strong, vesicles 3% 1-2 mm irregularly shaped. Grades to 5% vesicles 0.5-1 mm irregularly shaped, flow boundary heat alteration contact black (5YR 2.5/1)					
	223													
-44	224								no recovery					
	225								At 225 ft becomes moderately weathered, strong, 5% vesicles 1-10 mm irregular shaped, predominantly >3 mm			0.0	[33.3]	When retrieving core from run 42, only 0.5 ft was recovered, send core barrel back down and try and recover. Unable to recover with core barrel, trip out rods, remaining core from run 42 was recovered after casing was pulled Grayish brown water return, water loss ~150 gal
	226								becomes slightly weathered, strong to very strong, hard to very hard. IF is a mix of natural fractures and mechanical fractures, Fe, Mn, clay surface staining 1. 90, J, VN, Fe, Mn, clay, Sp, Pl, S 2. 5, J, VN, No, No, Pl, SR					
-46	227													
	228	42		100		82								
-48	229													
	230								becomes very dark gray (N3), slightly weathered, strong, 10% vesicles, 5-15 mm, 5% weathered olivine phenocrysts 1. 0, J, VN, No, No, Wa, SR 2. 30, J, VN, No, No, Wa, SR 3. 0, J, VN, Mn, Cl, SP, R			0.0	[75]	
-50	231		36											
	232								becomes 25% vesicles, 5-15 mm					
-52	233	43		100		84			becomes 30% vesicles, 1-5 mm, 2% weathered olivine phenocrysts					
	234								**BASALT Pahoehoe** Reddish black (2.5YR 2.5/1) with yellow (10YR 7/6) clay veins and vesicle infill, slightly weathered, medium strong, 20% vesicles <1 mm, contact flow boundary heat alteration 1. 0, J, VN, Fe, Mn, clay, Sp, Wa, SR 2. 0, J, VN, Fe, Mn, clay, Sp, Wa, SR 3. 0, J, VN, Fe, Mn, clay, Sp, Wa, SR 4. 0, J, VN, No, No, Wa, SR 5. 5, J, VN, Fe, Mn, clay, Sp, Wa, SR 6. 45, J, N, clay, Fi - infilled clay			0.0	[50]	Brown water return Faster drilling: 236-237 ft and 238-239 ft
-54	235		37											
	236								236.2-236.6 ft zone of slightly weathered, weak, clay infilled vesicles					
-56	237		38											

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type / Number / Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	237						6							
		44		100		32	3		Contact flow boundary, heat alteration reddish brown (5YR 4/4)					
-58	238						4		At 237.6 ft becomes reddish brown (5YR 5/3) with very pale brown (5YR 8/2) clay veins, moderate to highly weathered, weak, 20% vesicles 1-5 mm, irregular, 5% Mn					
							IF							
	239													239-240 ft reddish brown water return
	240						5		becomes reddish brown (5YR 4/3), moderately weathered, medium strong, 25% vesicles <1 mm			0.0	[42.9]	
-60							1		clay infilled vesicles with very pale brown (10YR 2/3)					Grayish brown water return, water loss ~ 150 gal
	241						2		becomes 15% vesicles, 1-5 mm					
							M							
	242								Contact, flow boundary, heat alteration, dark reddish brown (5YR 3/3), 3% vesicles <2 mm, some vesicles infilled with clay, moderately weathered, weak to medium strong rock					
-62		45		92		76	M		242.8-244 ft clay veins gray (6/N)					
	243								1. 20, J, VN, Mn, Cl, Sp, Wa, R 2. 20, J, VN, Mn, Sp, Wa, SR 3. 0, J, VN, Mn, Sp, Cl, Su, Wa, SR					
							3							
	244						IF							
-64									becomes yellowish red (10YR 5/6), highly weathered, weak					
							NR		no recovery					
	245								becomes brown (7.5YR 4/3), 15% Mn, moderate to highly weathered, weak			0.0	[50]	
							IF		becomes very dark grayish brown (10YR 2/2), 20% vesicles <2 mm. IF likely partly mechanical					Grayish brown water return, water loss ~150 gal
	246		40				M		becomes highly weathered, weak					
-66							1		moderately weathered, medium strong, 20% vesicles <5 mm					
	247						2		highly weathered, weak, 40% vesicles <1 mm, partially infilled with clay, Mn and Fe					
		46		104		42	IF							
	248													
-68							3		black (10YR 5/1), slightly to moderately weathered, medium strong, 30% vesicles, rounded, <2 mm, 3% Mn, 1% olivine					
	249		41						1. 0, J, VN, No, No, Pl, R 2. 60, J, VN, Mn, Sp, Pl, S 3. 5, J, VN, No, No, Wa, R 4. 0, J, VN, Mn, Fi, No, No					
							4							
	250								becomes brown (10YR 4/3) with yellow (10YR 8/8) clay infills, 5% Mn, highly weathered, weak			0.0	[50]	
-70														
	251						IF		becomes very dark gray (10YR 3/1), 30% vesicles <1 mm, partially infilled with clay, highly weathered, weak					Grayish brown water return, water loss ~150 gal
	252													
-72		47		100		10			yellowish brown (5YR 4/6), angled, 20 mm wide discoloration					
	253													

Project: CTO1850126 - Red Hill Bulk Fuel Storage Facilty
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Log of Boring RHMW14

Sheet 17 of 32

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	253													
-74	254						IF		**BASALT a'a clinker** Loosely cemented, black (5YR 2.5/1) with dark reddish brown (5YR 3/4) with traces of yellow (10YR 5/6) clay, highly weathered, weak, intensely fractured	⊗				
	255											0.0	[27.3]	
	256						M							Grayish brown water return, water loss ~150 gal
-76							M		**BASALT Massive a'a** Very dark gray (10YR 3/1), slightly weathered, medium strong					
	257						IF		256.6-257 ft includes very pale brown (10YR 8/4) clay infills					
		48		100		68			257-257.6 ft becomes gray (6/N) with pale brown (2.5Y 8/2) clay infills, moderately weathered, medium strong, 5% vesicles, irregular, <1 mm					
-78	258						1		At 257.8 ft elongate vesicles increased to 10%, <1 mm 1. 0, J, VN, Fe, Mn, Cl, Su, Wa, S					
							2		2. 10, J, VN, Fe, Mn, SP, P, S 3. 0, J, VN, No, No, P, S 4. 0, J, VN, Cl, SP, P, S					
	259						3		interconnected 10-50 mm, elongate vesicles					Boring paused at 260 ft on 2/20/19 at 14:42
							4		10% vesicles, <5 mm 5. 10, J, VN, Cl, Sp, P, S					
	260		44				5					0.0	[50]	Boring resumed on 2/21/19 at 07:17. DTW = 122.4 ft btoc
-80							1		1. 25, J, VN, Mn, Fe, some Cl, Sp, P, S					
							2		2. 0, J, VN, Mn, Fe, Cl, Sp, P, S 3. 0, J, VN, Mn, Cl, Sp, Wa, S 4. 75, J, VN, Mn, Cl pinkish white (10YR 8/1), Su, Wa, SR					
	261						3		50 mm vug with Me, Fn, clay 5. 60, J, VN, No, No, Wa, S					
							4		6. 5, J, VN, Cl (pockets), Sp, Wa, S					
	262						M							
-82							5		becomes black (10YR 2/1), slightly weathered, strong, 10% elongated vesicles, 1-30 mm					
		49		94		11	M		7. 0, J, VN, Mn, Fe, Cl, Sp, P, S 8. 5, J, VN, No, No, Wa, SR					
	263						6							Easier drilling 263-265 ft
							7		**BASALT a'a clinker** Welded, very dark brown (5YR 3/1) clasts with reddish brown (5YR 4/4) alteration, highly weathered, very weak. Grading with depth to red (2.5YR 4/8) reddish brown (5YR 4/4) dark reddish brown (5YR 3/4), likely from alteration, highly weathered, very weak					
-84	264						8							Grayish brown water return
							IF		**BASALT Pahoehoe** Dusky red (2.5YR 3/2) and dark grayish red (2.5 YR 3/4), highly weathered, very weak					
	265											0.1	[33.3]	
									At 265.2 ft becomes dark gray (5YR 4/1), moderately weathered, medium strong to strong, 10-15% vesicles <1 mm					
-86	266						1							Grayish brown water return
	267						2		zone of intense 50% vesicles, rounded, <5 mm					
		50		106		81	3							
	268								becomes moderately weathered, moderate strength, 10-15% vesicles, <5 mm, partially infilled with very pale brown (10YR 8/4) clay					
-88							M		1. 0, J, VN, No, No, P, S 2. 0, J, VN, No, No, Wa, R 3. 5, J, VN, Fe, Mn, Cl, Sp, Wa, R					
	269													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	269						M 4		4. 10, J, VN, No, No, Wa, R 269.2-269.6 ft zone of intense 50% vesicles, rounded, <2 mm					
-90	270						1					0.1	[50]	
			47											
	271						IF		becomes highly weathered, very weak, with yellowish brown (10YR 5/8) alteration and 10% Mn					
							M		becomes dark gray (5YR 4/1), moderately weathered, weak, with clay veins and vesicle infills, very pale brown (10YR 8/4), Mn infills, vesicles 5-10%, <2 mm					Grayish brown water return
-92	272						2		1. 0, J, VN, Mn, Fe, clay, Su, Wa, SR					
		51		100		52	3		2. 5, J, VN, Mn, clay, Su, Wa, S					
							4		3.10, J, VN, Fe, clay, Sp, Wa, R					
	273						5		273-273.2 ft zone of intense 50% vesicles, rounded, <1 mm 4. 65, J, VN, Mn, Fe, Cl, Sp, Wa, R 5. 65, J, VN					
-94	274						IF M		becomes yellowish brown (10YR 5/4), highly weathered, very weak, clay and Mn veins and vesicle infills, 15% Mn, Fe, clay, Sp, Wa, R					
									becomes very dark gray (10YR 3/1), 10-15% vesicles infilled, Fe staining, highly weathered, very weak					
	275						M 1		very dark gray (10YR 3/1), moderately weathered, weak, 2% vesicles <2 mm, Fe vesicle infills and staining, very pale brown (10YR 8/3) infills and staining			0.1	[33.3]	Grayish brown water return
-96	276						IF M M		276.4-277.1 ft dark gray (10YR 4/1), moderately weathered, medium strong, 10% vesicles 5-10 mm, some 30 mm, clay and Fe infills					
							M		At 276.6 ft Fe, Mn, clay infilled vesicles and staining					
	277						2		becomes moderately weathered, weak, with dark reddish brown (2.5YR 3/3) alteration, 30% vesicles <0.5 mm, mostly infilled with clay white (10YR 8/1)					
		52		100		60	3		At 277.8 ft becomes dark gray (5YR 4/1), 10-30% vesicles <0.5 to 5 mm, Fe, Mn and clay infills and staining olive brown (2.5Y 4/3) clay staining					
-98	278						4 5		1. 20, J, VN, Cl, Sp, Wa, R 2. 10, J, VN, Cl, Sp, P, S					
									3. 5, J, VN, No, No, P, SR					
	279						6		4. 0, J, VN, Fe, Cl, Sp, ST, R					
							7 8		5. 0, J, VN, Fe, Cl, Sp, ST, R 6. 0, J, VN, No, No, ST, SR 7. 0, J, VN, Fe, Cl, Sp, Wa, R					
-100	280								8. 65, J, VN, Fe, Mn, Cl, Su, P, S			0.0	[33.3]	280-284 ft grayish brown water return
							1		becomes moderately weathered, medium strong, 5-15% vesicles, 1-10 mm 1. 5, J, VN, Mn, Fe, Cl, Su, P, S					
	281						2		2. 15, J, VN, Mn, Fe, Cl, Su, Wa, S					
							M 3		3. 85, J, VN, Mn, Fe, Cl, Su, Wa, S					
							M		becomes highly weathered, intensely fractured, strong brown (5YR 4/6) clay, Mn staining.					
-102	282						IF		**Residual soil**, Sandy SILT (MH), F 50%, S 40%, G 10%, completely weathered, brown (7.5YR 4/2), strong brown (5YR 4/6) matrix with very pale brown (10YR 8/4), relic fractures (fractures vesicles veins present)					
		53		64		38								
	283						M		**BASALT, Pahoehoe** highly weathered, very weak, dark reddish gray (5YR 4/2) clast, yellowish red (5YR 5/6) alteration, dark reddish brown (5YR 2.5/2), clay infills very pale brown (10YR 8/3), Mn infill staining At 283.4 ft dark reddish gray (5YR 4/2), moderately weathered, weak, 30% vesicles <0.5 mm partially infilled with clay					
-104	284													284-285 ft brown water return
									BASALT a'a clinker					
	285													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	285								no recovery					0.0	[25]	
									no recovery							Grayish brown water return
-106	286								Loose clinker, moderately weathered, weak, very dark gray (5YR 3/1), reddish brown (5YR 4/4), Fe staining, clay infills and staining very pale brown (10YR 8/3), round cobbles 10-30 mm diameter							
	287	54		80		42.5	M M 1		Welded clinker, clinker clasts are gray (2.5Y 5/1) with reddish brown (5YR 5/3) matrix, moderately weathered, weak to medium strong, traces of clay, larger clinker clasts							
-108	288						2 3 4		**BASALT Massive a'a** Gray (2.5Y 3/1), moderate to slightly weathered, medium strong, 5-10% elongate irregular vesicles, 1-10 mm, clay infills/seams (weathered to clay) pale brown (2.5Y 8/2) 1. 0, J, VN, clay, Sp, Wa, S 2. 75, J, VN, clay, Sp+Su, P, S 3. 0, J, VN, clay, Sp+Su, P, S 4. 15, J, VN, clay, Sp+Su, Wa, S 5. 5, J, VN, Fe, Mn, Su, Wa, S 6. 30, J, VN, No, No, Wa, SR							
	289						5 6									
-110	290						1		At 288.8 ft grades to slightly weathered, strong (no clay veins) 1. 5, J, VN, Mn, Fe, Su+Sp, Wa, SR					0.0	[23]	
	291						2 3		2. 85, J, VN, No, No, P, S 3. 65, J, VN, No, No, P, S 4. 75, J, VN, Mn, Sp, Wa, S 5. 10, J, VN, No, No, Wa, S 6. 90, J, VN, Mn, Sp, P, S 7. 10, J, VN, Mn, Sp, P, S 8. 20, J, VN, Mn, Cl, Sp, P, S 9. 20, J, VN, Mn, Sp, P, S 10. 75, J, VN, Mn, Su, P, S 11. 10, J, VN, Mn, Sp+Su, Cl, Sp, Wa, S							Grayish brown water return
	292	55		100		96	4 5									
-112	293						6 7									
							8									
	294						9 10									
-114							11									Boring paused at 295 ft on 2/21/19 for maintenance
	295						1							0.0	[25]	Boring resumed on 2/22/19 at 07:21, DTW = 143.15 ft btoc
	296								**BASALT a'a clinker** Black (7.5YR 2.5/1) welded clasts with dark reddish brown matrix (5YR 3/3), moderately weathered, weak							
-116									becomes loose, 20-80 mm diameters with very pale brown (10YR 8/3) clay infills 1. 15, J, VN							Grayish brown water return, water loss ~135 gal
	297	56		66		67										
	298								no recovery							
-118							M		**BASALT Pahoehoe** Reddish brown (5YR 4/3), moderately weathered, weak, 20% vesicles, rounded, <1 mm							
	299						M		At 298.2 ft heat alteration reddish yellow (7.5YR 7/6), 10 mm wider, No, No, Wa, R At 298.5 ft becomes dark reddish brown (5YR 3/2), moderately weathered, weak, 15% vesicles, <1 mm rounded, partially infilled with clay							
	300		54						At 298.9 ft some clay infilled veins very pale brown (10YR 8/3) clay					0.0	[45]	
-120									heat alteration, 50 mm wide, yellowish red (5YR 5/6)							Grayish brown water return
	301															

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Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	301						M		black (5YR 2.5/1), slightly weathered, hard, strong, 25% vesicles, 1-6 mm, rounded							Cored 4.5 ft, recovered 5.5 ft, extra 1 ft was from previous run which dropped
-122	302	57		122		84	1 2		dark gray (10YR 4/1), moderately weathered, medium strong, 5% vesicles, 1-5 mm 1. 90, J, VN, No, No, P, SR 2. 0, J, VN, No, No, P, SR 3. 5, 90, J, VN, No, No, Wa, SR							
	303						3 IF									Water loss ~135 gal
-124	304		55						black (5YR 2.5/1), slightly weathered, hard, strong, 15% vesicles, 1-8 mm						[41.3]	At 304.5 ft core barrel was full, run stopped short
	305						IF		dark brown (2.5YR 3/1), slightly weathered, medium strong to strong, 30% vesicles <2 mm							
-126	306						M		becomes moderately weathered, moderate strength, 15% vesicles 1-8 mm							
	307	58		100		51	1 2		307.2-307.5 ft 5% vesicles <1 mm, partially infilled with clay, very pale brown (10YR 8/3) clay							Grayish brown water return, water loss ~ 135 gal
	308						3 M		307.5-308.1 ft becomes 20% vesicles, rounded, 1-2 mm heat alteration reddish yellow (7.5YR 6/6)							
-128							4		308.2-308.5 ft becomes dark reddish brown (5YR 3/2), 25% vesicles <2 mm							
	309						5		At 308.4 ft black (5YR 2.5/1), moderate to slightly weathered, medium strong to strong, 1% vesicles, irregular rounded, 2-8 mm, partially infilled with very pale brown (10YR 8/3) clay 1. 0, J, VN, Mn, Cl, Sp, P, R 2. 0, J, VN, Mn, Sp, P, SR							
	310						6 7		3. 75, J, VN, Mn, Cl, Sp, Wa, R 4. 0, J, VN, Cl, Sp, P, R 5. 45, J, VN, Mn, Fe, Cl, Su, Wa, SR 6. 10, J, VN, Mn, Fe, Cl, Su, Wa, SR 7. 90, J, VN, Mn, Fe, Cl, Su, Wa, SR					0.0	[60]	
-130	311		57				1		At 310 ft black (5YR 2.5/1), slightly weathered, strong							Grayish brown water return, water loss ~ 135 gal
	312						2		becomes dark reddish brown (5YR 3/1), 35% vesicles, rounded <2 mm, yellow (10YR 8/6) clay vein							
-132		59		100		92			becomes dark gray (5YR 4/1) and gray (5YR 6/1), slightly weathered, medium strong to strong, 10-40% vesicles, rounded <0.5-8 mm 1. 50, J, VN, No, No, Wa, SR							
	313						3		2. 0, J, VN, Mn, Fe, Cl, Su, ST, SR 3. 75, J, VN, Cl, Sp, P, R 4. 75, J, VN, Mn, Fe, Su, P, S							
	314		58				4		becomes dark reddish brown (5YR 2.5/2), moderately weathered, medium strong, 10% vesicles, rounded <0.5-4 mm							
-134							5 6		5. 0, J, VN, Mn, Fe, Su, P, R 6. 90, J, VN, Mn, Fe, Su, Wa, R							
	315						M		becomes very dark gray (5YR 3/1) , slightly weathered, medium strong, 10% vesicles, rounded, <2 mm					0.0	[33.3]	
	316						M		315.8-316 ft heat alteration red (2.5YR 4/6) and reddish yellow (7.5YR 6/8)							
-136							1		At 316 ft 15% vesicles, 1-5 mm, partially infilled with very pale brown (10YR 8/3) clay							Grayish brown water return, water loss ~ 135 gal
	317															

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Project Number: 60571032

Log of Boring RHMW14

Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	317								1. 65, J, VN, Cl, Sp, Wa, SR 2. 0, J, VN, Cl, Mn, Fe, Su+Sp, Wa, R 3. 65, J, VN, Cl, Mn, Fe, Su+Sp, Wa, SR 4. 0, J, VN, No, No, Wa, R 5. 90, J, VN , No, No,P, SR							
	318	60		100		88	2 3									
-138																
	319						M 4		dark gray (10YR 5/1), slightly weathered, strong to very strong, 25-40% vesicles, rounded/irregular, 1-20 mm							
							5		30-50% vesicles, rounded, <2 mm							
	320								1. possibly heated infilled, 65, 2. 15, J, VN, No, No, P, R 3. 75, J, VN, No, No, Wa, SR 4. 0, J, VN, No, No, Wa, R					0.0	[75]	
-140																
	321						1 M									
							2									Grayish brown water return, water loss ~ 135 gal
	322															
-142		61		96		72	3									
	323															
							4									
	324						IF		highly fractured, reddish brown (5YR 4/4), black (5YR 2.5/1), dark reddish gray (2.5YR 4/1), medium strong rock, remnant ropey pahoehoe texture							
-144																
	325								no recovery							
							IF		dark gray (5YR 4/1), slightly weathered, hard, 15-30% vesicles, irregularly rounded, 1-20 mm 1. 75, J, N, Mn, Sp, Wa, SR 2. 75, J, VN, Mn, Sp, P, SR 3. 0, J, VN, No, No, Wa, SR	⊗				0.0	[75]	
	326		61				1 2									
-146																
	327						IF									
		62		98		62	IF M									Grayish brown water return, water loss ~ 135 gal
	328															
-148																
							3		328.8-331.4 ft more elongate 5-20% vesicles, 5-20 mm							
	329						M									
			62													
	330													0.0	[37.5]	
-150									45 mm vug							
	331															Grayish brown water return, water loss ~ 135 gal
							IF		331.4-332.4 ft becomes IF, red (2.5YR 4/6), reddish brown (2.5YR 4/4), moderate to slightly weathered, hard, 15% vesicles, irregular to rounded, <4 mm, Mn infills, very pale brown (10YR 8/2) clay infills							
	332															
-152		63		106		34	IF		becomes very dark gray (10YR 3/1), moderately weathered, medium strong to strong, 5-15% vesicles, rounded to irregular, <5 mm, partially clay infilled							
	333															

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Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	333						F		1. 0, J, VN, Cl, Sp, P, SR 2. 0, J, VN, Mn, Cl, Sp, Wa, SR 3. 75, J, VN, Mn, Cl, So, Na, SR							
-154	334		63				1 2 3		334-334.6 ft dip of 75 degrees, heat alteration zone, 30 mm wide, dark reddish brown (2.5YR 3/3) and reddish yellow (7.5YR 6/8)							
	335						F		black (5YR 2.5/1), slightly weathered, strong, 30% vesicles, rounded <2 mm					0.0	[60]	
-156	336						F		335.4-335.7 ft very pale brown (10YR 8/3) clay staining on fractures pieces very dark gray (10YR 3/1), slightly weathered, strong 335.8-336.4 ft 10-20% vesicles, rounded, 2-5 mm 336.4-336.8 ft 50% rounded vesicles, <2 mm							Grayish brown water return, water loss ~ 135 gal
	337	64		98		66	1 2 3		337-337.2 ft yellow (10YR 8/8) clay infills and staining 337.4-338 ft 20% vesicles, rounded, 28 mm							
-158	338						4		becomes 30% vesicles, rounded, <2 mm 1. 0, J, VN, No, No, Wa, SR 2. 0, J, VN, Cl, Sp, ST, R 3. 0, J, VN, Cl, Sp, ST, R 4. 5, J, VN, Cl, Sp+Su, Wa, R 5. 0, J, VN, Fe, Cl, Sp, Wa, SR 6. 0, J, VN, Mn, Fe, Cl, Sp, Wa, R 7. 0, J, VN, Cl, Sp, Wa, R							
	339						5 6 7									
-160	340		65				F 1		IF pieces yellowish red (5YR 4/6), black (5YR 2.5/1) with clay staining yellow (10YR 8/8) and very pale brown (8/3), Mn staining, slightly weathered, strong, 10% vesicles rounded <4 mm At 340 ft very dark gray (10YR 3/1), slightly weathered, strong, 30% vesicles, rounded <2 mm					0.0	[75]	
	341								heat alteration brownish yellow (10YR 6/6) becomes black (5YR 2.5/1), slightly weathered, strong, 10-20% vesicles, rounded/irregular, 1-5 mm 341.4-341.6 ft 50% vesicles, rounded/irregular, 5 mm							Grayish brown water return, water loss ~ 135 gal
-162	342	65		102		74	2 3		1. 0, J, VN, Mn, Fe, Cl, Su+Sp, Wa, R 342-342.4 ft 50% vesicles, rounded, 1-2 mm 2. 10, J, VN, No, No, Wa, SR 3. 5, J, VN, Mn, Fe, Cl, Sp, Wa, R IF pieces reddish brown (5YR 4/3) staining, Mn infills, 25% vesicles rounded, <0.5 mm							
	343						4 F									
-164	344						5 6		black (5YR 2.5/1), slightly weathered, strong, 25-40% vesicles, rounded, <3 mm 4. 0, J, VN, Mn, Fe, clay, Sp, Wa, R 5. 15, J, VN, No, No, Wa, R 6. 5, J, VN, No, No, Wa, R 7. 20, J, VN, No, No, Wa, R							
	345						7							0.0	[100]	
-166	346						1									Grayish brown water return, water loss ~ 135 gal
	347	66		106		44	F		IF pieces red (2.5YR 4/6) staining 1. 0, J, VN, No, No, P, R 2. 90, J, VN, Cl, Su+Sp, P, SR							
-168	348		68													
	349															

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	349						IF		IF pieces have yellow (2.5Y 8/6) and pale brown (2.5Y 8/3) staining							
-170	350						2		becomes dark gray (10YR 4/1), moderately weathered, hard/strong, 5% vesicles, irregular, <4 mm, partially clay infilled					0.0	[33.3]	
							1									
	351						2		At 350.5 ft becomes 20% vesicles, rounded/irregular, 1-10 mm, slightly weathered, strong							
-172	352	67		88		36			becomes gray (10YR 5/1), slightly weathered, 10% vesicles, irregular/rounded, 2-10 mm 1. 0, J, VN, Cl, Sp, Wa, R 2. 5, J, VN, No, No, P, SR 3. 0, J, VN, No, No, Wa, R							At 353 ft lost circulation. Per driller, drill rods fell 352-353 ft. No water return for rest of boring unless otherwise noted. DTW = 164.63 ft btoc at 10:53 drilled to 355 ft
	353						IF		no recovery							
	354								becomes dark gray (10YR 4/1), slightly weathered, strong, 40% vesicles, rounded, <2 mm							
-174							3									
	355													0.0	[150]	
	356						IF									
-176							1		1. 30, J, VN, No, No, P, S 2. 0, B, VN, Mn, Su, P, S 3. 0, B, VN, No, No, P, S							
	357						2									
		68		100		32	IF		possible flow boundary, red (2.5YR 4/6), reddish black (2.5YR 2.5/1) and light brown (7.5YR 6/4), 30-40% vesicles, rounded, <1 mm, slightly weathered, strong							Water loss ~ 125 gal
-178	358						3		very dusky red (2.5YR 2.5/2), slightly weathered, hard, 10% vesicles completely infilled with clay pale brown (2.5Y 8/2)							
									At 358.1 ft dark reddish brown (2.5YR 3/2) and reddish brown (2.5YR 4/4), moderately weathered, strong, 50% vesicles, rounded, <2 mm. Possible flow boundary							
	359						IF		becomes slightly to moderately weathered							
-180	360						1		1. 35, J, VN, No, No, Wa, SR (includes clay vein yellow 10YR 8/8) 2. 65, J, VN, Mn, Sp, clay Su, Wa, SR					0.0	[60]	
							2									
	361								clay staining and infills very pale brown (10YR 8/3) and Mn infills on IF pieces							
	362								becomes reddish black (2.5YR 2.5/1), slightly weathered, strong, 15-25% vesicles, <1 mm, partly infilled with clay pale brown (2.5Y 8/2), irregular pieces have clay, Su+Mn spoting							
-182		69		100		10										Water loss ~ 125 gal
	363						IF									
	364								increase in clay Su coating of irregular pieces							
-184			72													
									becomes brown (10YR 4/3)							
	365															

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Elevation, feet	Depth, feet	Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES Type	SAMPLES Number	SAMPLES Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	365						IF							0.0	[100]	
-186	366						1		becomes black (5YR 2.5/1) and dark reddish brown (5YR 3/4) slightly weathered, strong, 30% vesicles, round, 1-2 mm, partially infilled with clay white (10YR 8/1)							
	367	70		106		36	2		becomes dark reddish brown (5YR 3/2), moderately weathered, medium strong to strong, 15% vesicles completely infilled with clay, white (10YR 8/1) becomes reddish brown (5YR 4/3), slightly weathered, strong, 20-30% vesicles, rounded, 1-10 mm, partly infilled with clay very pale brown (10YR 8/3) 1. 0, J, VN, Mn, Fe, clay, Su, P, S 2. 0, J, VN, clay, Sp, Wa, R 3. 0, J, VN, Mn, clay, Sp, P, R 4. 45, J, VN, clay, Sp, Wa, SR						No water return, water loss ~ 125 gal
-188	368						3									
	369						IF		369.2-369.4 ft 2% vesicles, <0.5 mm becomes dark reddish gray (2.5YR 3/1), slightly weathered, hard, 5-15% vesicles, rounded, <2 mm							
-190	370						M							0.0	[100]	
	371	71		100		18	1 2		370.4-370.5 ft red (2.5YR 4/6), slightly weathered, medium strong to strong, 40% vesicles, <1 mm 371-371.2 ft red (2.5YR 4/6), slightly weathered, medium strong to strong, 40% vesicles, <1 mm At 371.2 ft becomes dark reddish gray (2.5YR 3/1), slightly weathered, strong, 10-30% vesicles, rounded, 1-4 mm						Water loss ~ 125 gal
-192	372						3 4									
	373						IF M		IF pieces have clay surface staining and partial vesicle infills, white (10YR 8/1) and yellow (10YR 8/6) 1. 0, J, VN, Mn, Cl, SP, Wa, R 2. 55, J, VN, Mn, Cl, SP, Wa, R 3. 0, J, VN, Mn, Cl, SP, Wa, R 4. 5, J, VN, Mn, Cl, SP, Wa, R						
-194	374															
	375								375.2-375.4 ft 5% vesicles, <0.5 mm, mostly infilled with clay					0.0	[100]	
	376		75				IF		halloysite mineral partially infilled fracture, 15 mm wide, white (2.5Y 8/1)							
-196	377	72		100		62	1		becomes dark gray (10YR 4/1), slightly weathered, strong, 10-40% vesicles, <0.5 to 10 mm, rounded 1. 90, J, VN, Mn, Cl, Sp, Wa, P 2. 0, J, VN, Mn, Cl, Sp, ST, SR 3. 5, J, VN, Cl, Sp, Wa, R 4. 0, J, VN, No, No, Wa, R						Water loss ~ 125 gal
-198	378						2 3									
	379		76				4									
-200	380													0.0	[100]	
	381						1 IF		At 380.9 ft IF pieces become partly dark reddish brown (2.5YR 3/4), slightly weathered, strong, 40% vesicles, rounded, <1 mm							Water loss ~ 125 gal

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	381						F							
-202	382	73		100		56	2		becomes black (5YR 2.5/1), slightly weathered, strong, 30% vesicles, round, 1-8 mm 1. 0, J, VN, No, No, Wa, R 2. 0, J, VN, No, No, Wa, R					
	383						3		Becomes 50% vesicles, rounded, <2 mm 3. 0, J, VN, No, No, ST, R					
-204	384						4		4. 90, J, VN, No, No, Wa, R 5. 5, J, VN, No, No, Wa, R					
	385						5 6		6. 85, J, VN, No, No, Wa, R			0.0	[150]	
							1		1. 0, J, VN, No, No, Wa, R 2. 16, VN, No, No, Wa, R 3. 5, J, VN, No, No, Wa, R					
-206	386						F							
	387								386.8-387.4 ft becomes 40% vesicles, rounded, <1 mm					
		74		102		86	F							Water loss ~ 125 gal
-208	388								becomes 30% vesicles, rounded, 1-4 mm					
	389						2		389-389.4 ft becomes 25% vesicles, rounded, 1-8 mm					Boring paused at 390 ft on 2/22/19, DTW=164.57 ft at 11:21
							3		becomes 30% vesicles, rounded/irregular, <4 mm					
-210	390		79						greenish gray (5/10Y), possible flow contact			0.0	[100]	Boring resumed at 390 ft on 2/25/19 at 07:11, DTW=163.48 ft
							1		black (5YR 2.5/1), sligthly weathered, strong, 10% vesicles, rounded, <3 mm					
	391						2 3 4		At 390.5 ft becomes dark reddish gray (2.5YR 3/1), slightly weathered, hard, 5% vesicles, rounded, slightly elongate, 2-12 mm, partially infilled with halloysite					
							M		becomes 15% vesicles, rounded, <2 mm					
-212	392								becomes 1% vesicles, rounded and elongate <5 mm					
		75		96		58			becomes black (5YR 2.5/1), slightly weathered, strong, 20% vesicles, rounded, <4 mm					
	393						5		At 392.3 ft greenish gray (5/10Y), 2% vesicles, <0.5 mm, possible flow contact At 392.5 ft becomes dark reddish gray (2.5YR 3/1), slightly weathered, strong, 20% vesicles, rounded, <1 mm					Water loss ~ 160 gal
									At 393 ft becomes 30% vesicles, rounded, 1-5 mm					
-214	394						6		becomes 15% vesicles, rounded/elongate, 2-10 mm					
							7 8		1. 85, J, N, halloysite, Sp, Wa, SR 2. 5, J, VN, halloysite, Sp, Wa, SR 3. 0, J, VN, halloysite, Sp, Wa, SR					
	395								4. 0, J, VN, halloysite, Sp, Wa, SR			0.0	[100]	
							1		5. 5, J, VN, No, No, Wa, R 6. 5, J, VN, No, No, Wa, R 7. 0, J, VN, Cl, Sp, Wa, R					
	396		81				2		8. 90, J, VN, No, No, Wa, R					
-216														Water loss ~ 160 gal
							F		At 394.9 ft becomes 30% vesicles, rounded, 1-5 mm					
	397								At 395.6 ft possible flow boundary, dark grayish					

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type / Number / Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	397								brown (10YR 4/2)					
		76		104		72	IF		396.2-396.5 ft becomes 10% vesicles, rounded/elongate, 1-10 mm					
-218	398						3		becomes black (10YR 2/1) and reddish brown (2.5YR 4/4), slightly weathered, medium strong to strong, 40% vesicles, rounded, <1 mm 1. 0, J, VN, No, No, Wa, R 2. 0, J, VN, No, No, Wa, SR 3. 5, J, VN, Mn, Sp, St, SR					Water loss ~ 160 gal
	399						IF		Sp to Wa with hallocite, Mn, Fe, yellow (10YR 8/8) clay					
	400								becomes black (5YR 2.5/1), slightly weathered, strong, 30% vesicles, rounded, <2 mm			0.0	[100]	Drilling paused at 07:32 due to rain 0747
-220							1							
			82				2		becomes 5% vesicles, elongate, 1-10 mm 1. 0, J, VN, No, No, Wa, R 2. 0, J, VN, No, No, ST, R 3. 5, J, VN, Mn, Cl, Sp, Pl, SR 4. 0, J, VN, No, No, Wa, SR					
	401						3							
	402						4		possible flow contact/heat alteration, black (2.5/N), red (2.5Y 4/6), dark reddish brown (2.5YR 3/3), yellowish brown (10YR 5/8), some halloysite					
-222							5							
		77		100		66	6		At 402 ft becomes reddish brown (2.5YR 4/2), slightly weathered, strong, 15% vesicles, rounded, <2 mm					Water loss ~ 160 gal
	403													
							7		403.5-403.7 ft heat alteration dark reddish brown (2.5YR 3/3), black (2.5N), red (2.5Y 4/6)					
	404								At 403.8 ft becomes 10% vesicles, rounded/irregular, 1-10 mm 5. 15, J, VN, Mn, Cl, Sp, Wa, R 6. 15, J, T, No, No, Wa, R 7. 0, J, VN, Mn, Cl, Sp, Wa, R					
-224							IF							
			83											
	405											0.0	[75]	
							IF		becomes 20% vesicles, rounded, 1-3 mm					
	406						1							
-226							2		becomes very dark gray (5YR 3/1), slightly weathered, hard, 10-25% vesicles, rounded/irregular, some elongate, 1-8 mm, vesicles infilled with clay					
							3							
	407						4		possible flow contact/heat alteration greenish gray (5/10Y) 1. 0, J, VN, No, No, Pl, R 2. 0, J, VN, Cl, Sp, Wa, R 3. 75, J, VN, Cl, Mn, Fe, Sp, Pl, SR 4. 0, J, VN, Cl, Sp, Pl, R 5. 0, J, VN, No, No, Wa, S 6. 45, J, VN, Cl, N, Fe, Su, Pl, S 7. 5, J, VN, No, No, Wa, SR 8. 0, J, VN, No, No, Wa, SR					Water loss ~ 160 gal
		78		104		84								
	408						5							
-228							6							
	409						7							
							8							
	410											0.0	[60]	
-230							IF							
	411								becomes very dark gray (10YR 3/1), slightly weathered, strong, 10-20% vesicles, rounded, 1-5 mm, some clay veins white (10YR 8/1) and very pale brown (10YR 8/3) 1. 90, J, VN, Cl, Mn, Sp+Su, Pl, S 2. 0, J, VN, No, No, Wa, SR 3. 0, J, VN, No, No, Wa, SR 4. 25, J, VN, Mn, Fe, Cl, Su+Sp, Pl, S 5. 0, J, VN, No, No, ST, SR					Water loss ~ 160 gal
	412						1							
-232							2							
		79		100		48								
	413						3							

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	413						4							
							5		becomes black (5YR 2.5/1) and dark reddish brown (10YR 3/3), slightly weathered, strong, 40% vesicles, rounded, <1 mm					
-234	414		86				IF		At 414 ft possible flow contact/heat alteration black (2.5/N), red (2.5Y 4/6), yellowish brown (10YR 5/8)					
									At 414.3 ft becomes dark reddish brown (2.5YR 3/4), slightly weathered, medium strong to strong, 30% vesicles, rounded/irregular, <0.5-2 mm	⊗		0.0	[150]	
	415						1		becomes dark reddish gray (2.5YR 3/1), 15% vesicles, elongate, 1-5 mm, partially infilled with halloysite					
-236	416						IF		fractures Su+Sp, Mn, clay, halloysite 1. 0, J, VN, Cl, Sp, Wa, SR					
	417						M							
							M							Water loss ~ 160 gal
		80		100		36	M		becomes reddish black (2.5/N), yellow (10YR 8/8), slightly weathered, strong, 30% vesicles, rounded, <2 mm					
-238	418													
	419						IF							
	420											0.0	[100]	
-240														
	421						1		becomes black (5YR 2.5/1), slightly weathered, strong, 20% vesicles, rounded, 1-5 mm 1. 5, J, VN, Cl, Sp, Pl, SR 2. 0, J, VN, No, No, Pl, R 3. 90, J, VN, No, No, Wa, SR 4. 0, J, VN, No, No, Wa, SR					
	422													
-242														
		81		100		54	2		becomes 30% vesicles, rounded, <1 mm					Water loss ~ 160 gal
	423								becomes dark reddish brown (2.5YR 3/3) and black (YR 2.5/1), slightly weathered, strong, 40% vesicles, rounded, <1 mm					
							IF							
	424								becomes black (5YR 2.5/1), slightly weathered, strong, 15% vesicles, rounded/irregular, 1-5 mm					
-244							3							
							4		becomes 30% vesicles, rounded, 1-5 mm, 5% weathered olivine phenocrysts 2-4 mm					
	425											0.0	[150]	
			89											
	426								becomes 10% vesicles, irregular, 1-10 mm					
-246							1		At 425.9 ft becomes very dark gray (10YR 3/1), slightly weathered, strong, 10% vesicles, rounded, irregular, <1 mm					
							2							
	427						3		At 426 ft becomes black (2.55/N), slightly weathered, strong, 10-25% vesicles, rounded, 1-8 mm 1. 0, J, VN, No, No, ST, SR 2. 45,J, VN, Mn, Fe, Cl, Su, Pl, VS 3. 0, J, VN, No, No, Wa, SR 4. 10, J, VN, No, No, ST, S 5. 10, J, VN, Mn, Cl, Su, ST, S					Water loss ~ 160 gal
		82		104		62								
-248	428						4							
							IF							
	429													

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	429													
			90				5		heat alteration/possible flow boundary black (2.5/N), dark red (2.5YR 3/6), light red (2.5YR 7/8), yellow (10YR 8/8). At 429.2 ft becomes reddish brown (2.5YR 4/4) and dark reddish gray (2.5YR 3/1) and yellow (10YR 8/8), olive brown (2.5Y 4/4), slightly weathered, strong, 40% vesicles, rounded, <1 mm. At 430 ft becomes 10-40% vesicles, rounded, 1-5 mm, Mn infills, and staining.					
-250	430						IF					0.0	[60]	
	431						IF							Water loss ~ 160 gal
-252	432	83		100		16	M		becomes very dark gray (10YR 3/1), slightly weathered, strong, 10% vesicles, rounded, 1-10 mm					
	433						IF							
-254	434						M		becomes very dark gray (10YR 3/1), olive brown (2.5Y 4/4), reddish brown (2.5YR 4/4), 15-30% vesicles, rounded, <1 mm IF, -Mn, Sp+Su					
	435						IF					0.0	[100]	
							1		becomes dark gray (2.5Y 4/1), slightly weathered, strong, 10% vesicles, rounded, <4 mm					
-256	436		92				2		heat alteration/potential flow boundary, black (2.5/N), olive brown (2.5Y 4/4) and yellow (10YR 8/8) At 436.1 ft becomes dark grayish brown (10YR 4/2), slightly weathered, strong, 20% vesicles, rounded, 1-4 mm 1. 85, J, VN, Mn, Cl, Sp, Wa, S 2. 90, J, VN, Mn, Cl, Sp+Su, Wa, SR 3. 0, J, VN, Mn, Sp, Wa, R 4. 80, J, VN, Mn, Sp, Wa, R 5. 0, J, VN, Mn, Sp, ST, R					
	437	84		100		42	IF							
-258	438													Water loss ~ 160 gal
	439		93				3							
							4							
							5		becomes reddish black (2.5/1), slightly weathered, strong, 30% vesicles, rounded, <2 mm IF some reddish brown (2.5YR 4/4), Mn spoting and staining 1. 25, J, VN, Mn, Sp, Wa, R 2. 25, J, VN, Mn, Sp, Wa, R 3. 15, J, VN, Mn, Sp, Wa, SR 4. 15, J, VN, Mn, Sp, Wa, SR					
-260	440											0.0	[150]	
	441						IF							
	442													Water loss ~ 160 gal
-262		85		108		40								
	443						1							
							2							
-264	444						3							
							4		At 444.8 ft becomes black (5YR 2.5/1), slightly weathered to no weathering, strong to very strong, 30% vesicles, rounded, <1 mm					
	445													

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Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	445											0.0	[75]	
									becomes 15% vesicles, rounded, <0.5-2 mm					
-266	446								becomes 5% vesicles, rounded/elongate, 5 mm becomes 10% vesicles, rounded, <0.5 mm					
	447								becomes 30% vesicles, rounded/irregular, 1-4 mm					
		86		96		88			becomes 10% vesicles, rounded/irregular, 2-10 mm					Water loss ~ 160 gal
-268	448						1		becomes 30% vesicles, rounded, 4-10 mm becomes 20% vesicles, rounded, <2 mm 1. 0, J, VN, No, No, Wa, SR 2. 10, J, VN, Mn, Sp, Wa, SR 3. 0, J, VN, Mn, Sp, Wa, R					
	449						2							
							3							
	450		96									0.0	[60]	
-270							1		1. 75, J, VN, No, No, Wa, SR 2. 0, J, VN, Mn, Cl, Sp+Su, Wa, SR 3. 0, J, VN, No, No, ST, SR 4. 0, J, VN, Fe, Su, Wa, SR					
	451						2							
							3							
	452						4							
-272							M							
		87		104		50								
	453													Water loss ~ 160 gal
							M							
	454								5. 10, J, VN, Mn, Sp, Wa, SR					
-274							5		**BASALT a'a Clinker** Red (2.5YR 4/6) and light red (2.5YR 6/8) with dark gray (2.5Y 4/1) slightly weathered, strong clasts, loose					
	455											0.0	[75]	
									At 454.2 ft becomes reddish brown (2.5YR 4/3) and reddish black (2.5YR 2.5/1), red (2.5YR 4/6)					
									455.5-456.7 ft becomes welded a'a clinker, very dark gray (10YR 3/1) with reddish brown (2.5YR 4/3)					
	456						M							
-276							F			⊗				
							M							
	457													Water loss ~ 160 gal
		88		60		8								
	458													
-278														
	459								no recovery					
	460												[50]	
-280									**BASALT Massive a'a** Gray (5/N), slightly weathered, strong to very strong, 10% vesicles, very elongate/stretched, 2-30 mm					
	461						1 2							

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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

Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	461						3		1. 10, J, VN, Mn, Sp, Wa, SR 2. 10, J, VN, Mn, Fe, Sp+Su, Wa, S 3. 10, J, VN, No, No, Wa, SR 4. 25, J, VN, No, No, Wa, SR 5. 25, J, VN, No, No, Wa, SR					
-282	462	89		100		60	M							
	463						M M 4							Water loss ~ 160 gal
							5 M							
-284	464						M							
	465								1. 45, J, VN, Mn, Sp, Wa, S 2. 0, J, VN, Mn, Sp, Wa, S			0.0	[50]	
	466						1							
-286							2							
	467						M							
		90		100		94	M M M							Water loss ~ 160 gal
	468						M							
-288							M M M M							
	469						M							
							IF M		becomes gray (6/N), slightly weathered, very strong, 2% vesicles, rounded/irregular, <1 mm					
	470								1. 20, J, VN, Mn, Sp, Cl, Su+Sp, ST, S 2. 0, J, VN, Mn, Cl, Sp, Wa, S 3. 75, J, VN, Mn, Cl, Sp, Wa, S 4. 80, J, T, Wa-sealed			0.0	[42.9]	
-290							1 M							
	471		101				2							
							3							
							4							Water loss ~ 500 gal
	472								**BASALT a'a Clinker** Black (10YR 2/1) and reddish brown (2.5YR 4/3), moderately weathered, strong, loose					
-292		91		74		28								
	473													~473-474 ft high water pressure
	474													
-294									no recovery					
	475		102									0.0	[60]	
							1		**BASALT Pahoehoe** Reddish black (2.5YR 2.5/1), slightly weathered, strong to very strong, 20% vesicles, rounded/irregular, 1-5 mm					
	476						2		At 475.2 ft roppy pahoehoe texture					
-296							3		1. 15, J, VN, No, No, Wa, SR 2. 5, J, VN, No, No, Wa, R 3. 0, J, VN, Mn, Sp, Wa, R 4. 0, J, VN, No, No, Wa, SR					Water loss ~ 500 gal
	477						4							

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Log of Boring RHMW14

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	477													
		92	102	104		62			5. 0, J, VN, Mn, Wa, SR becomes dark reddish brown (5YR 3/3), slightly weathered, strong to very strong, 40% vesicles, rounded, <0.5-4 mm					
-298	478							IF	becomes black (10YR 2/1), slightly weathered, strong to very strong, 30% vesicles, round, 1-2 mm, 1% weathered olivine phenocrysts, 2 mm					
	479		103					IF M						
	480							1 IF				0.0	[75]	
-300	481							2	becomes black (10YR 2/1), slightly weathered, very strong, 20% vesicles, irregular, 1-15 mm					
	482							IF	becomes 10% vesicles, irregular, 1-10 mm					
-302		93		100		32			becomes reddish brown (2.5YR 4/3) and yellow (10YR 7/8), slightly weathered, very strong, 20% vesicles, round, 1-2 mm					Water loss ~ 500 gal
	483							IF						
	484							3 4 5	becomes black (5YR 2.5/1), slightly weathered, very strong, 20% vesicles, rounded, 1-4 mm 1. 15, J, VN, No, No, ST, R 2. 0, J, VN, Mn, Sp, ST, SR 3. 0, J, VN, Mn, Sp, Wa, S 4. 45, J, VN, No, No, Pl, S 5. 45, J, VN, clay, Su, Wa, SR					
-304	485							1 2				0.0	[60]	
	486								IF stained with yellowish red (5YR 5/6) 1. 40, J, VN, No, Pl, SR 2. 40, J, VN, No, Pl, SR 3. 10, J, VN, Cl, Su, Wa, SR 4. 0, J, VN, No, No, Wa, SR					
-306	487							IF M	5. 45, J, VN, No, No, Wa, SR 6. 45, J, VN, Mn, Fe, Sp, Wa, SR					Water loss ~ 500 gal
		94		100		22			becomes black (10YR 2/1), slightly weathered, very strong, 25% vesicles, rounded, 1-3 mm					
	488							IF						
-308	489							3 4 5 6	becomes 15% vesicles, rounded/irregular, 1-10 mm					
	490								**BASALT a'a Clinker** Loose, reddish brown (2.5YR 5/4), dusky red (2.5YR 3/2), dark reddish brown (2.5YR 3/3), clay veins and staining yellow (10YR 8/8) and very pale brown (10YR 8/3), slightly to moderately weathered, medium strong to strong			0.0	[42.9]	
-310	491													
	492													Water loss ~ 500 gal
-312		95		54		0			no recovery					
	493													

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Log of Boring RHMW14

Elevation, feet	Depth, feet	ROCK CORE: Run No.	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: Fractures per Foot	ROCK CORE: R Q D, %	ROCK CORE: Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number	SAMPLES: Blows per foot	SAMPLES: PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	493														
	494		106						no recovery						End boring at 14:45 at 495 ft on 2/25/19. DTW=163.31 btoc
-314	495								Boring complete at 495 ft bgs						2/26/19 DTW= 163.53 btoc (159.78 ft bgs)
	496								Used a total of approximately 9,875 gallons of circulation water and two 50 lb bags of max gel bentonite powder. Airknife from 0-3 ft bgs. Drill with 24"0D auger core bucket from 3 ft bgs to 45 ft bgs. Installed 20" steel casing to 45 ft bgs. Drill with 10"0D HSA from 45 ft bgs to 56 ft bgs. HQ core from 56 ft bgs to 89 ft bgs. Ream borehole with 17.5" tricone to 89 ft bgs. Install 10" steel casing to 88 ft bgs. HQ core from 89 ft bgs to 134 ft bgs. Borehole reamed to 135 ft bgs with 9 7/8" tricone. 5" steel casing installed to 135 ft bgs. PQ core from 135 ft bgs to 495 ft bgs. Installed westbay MP38 multi-level well with 8 isolated sampling zones.						
-316	497														
	498														
-318	499														
	500														
-320	501														
	502														
-322	503														
	504														
-324	505														
	506														
-326	507														
	508														
-328	509														

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/17/2019 RHMW14

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Log of Boring RHTB01

Date(s) Drilled	**03/06/19 - 3/22/19**	Logged By	**M. Higley, B. Mintz**	Checked By (Date)	**J. Kronen**
Drilling Method	**Hand auger, HSA, HQ core, PQ core**	Drill Bit Size/Type	**8" OD HSA, HQ/PQ core diamond bit**	Total Depth of Borehole	**281.0 feet**
Drill Rig Type	**Mobile B-59/ Mobile B-90**	Drilling Contractor	**Valley Well Drilling**	Approximate Surface Elevation	**224.84**
Groundwater Level	**El. ~20.17' (3/22/19)**	Location	**Halawa Correctional Facility**	Inclination from Horizontal/Bearing	**90°**
Borehole Completion	**Nested set of four grouted in vibrating wire piezometers**	**#**	**Zone Identifier**	Hammer Data	**140 lbs/30-inch drop**

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
224	0								**FILL** Gray, well-graded GRAVEL (GW), gravel drill pad (FILL)							Hand auger to 5 ft bgs
	1								Moist, dark reddish brown (2.5YR 2.5/4) to (2.5YR 3/3) Sandy Fat CLAY (CH) with gravel, basaltic, fine to coarse, angular to subrounded, 15% gravel, 25% sand, 60% fines (FILL)							
	2															
222	3															
	4															
220	5								becomes dark brown (7.5YR 3/4), moist, less gravel Sandy Fat CLAY (CH), 5% gravel, 25% sand, 70% fines							Begin drilling with 8"0D HSA at 5 ft bgs
	6															
218	7															
	8								grades with more gravel, probable slightly weathered basalt boulder, angular, dark greenish gray (10Y 4/1)							Augers grinding at 8 - 9.5 ft bgs
216	9															
	10								very dark greenish gray (10Y 3/1), fragmented, slightly weathered basalt boulder			1		0.0		
214	11								Moist, dark brown (10YR 3/3) with strong brown (7.5YR 4/6) mottles and dark greenish gray (10YR 4/1), Clayey GRAVEL with Sand (GC), hard, 40% basalt gravel, 15% sand, 45% fines, angular basaltic (FILL).							Augers grinding hard at 10.33 ft to 12 ft. Softer at 12 ft
	12								**ALLUVIUM** Dark brown (10YR 3/3) Sandy Fat CLAY (CH), rounded to subrounded, moderate to highly weathered, fine to coarse, basaltic (Alluvium), 30%			2		0.0		
212	13															

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Log of Boring RHTB01

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	13								sand, 70% fines							
	14															
210	15								very dark greenish gray (10Y 2/1) basalt boulder, slightly to moderately weathered, intensely fractured					0.0	[75]	HSA to 15 ft bgs Begin coring with HQ core at 15 ft on 3/09/19
	16								dark gray (N4) to dark brown (10YR 3/3) matrix Clayey GRAVEL (GC) with sand. Sand and gravel are highly weathered, rounded to subrounded, dark yellowish brown (10YR 3/6), fine to coarse, with some highly to completely weathered basalt cobbles, high plasticity, 35% gravel, 20% sand, 45% fines							
208	17	1		100		0										Brown water return, no water loss
	18															
	19								grades with less clay							
206	20								grades with more cobbles, slightly to highly weathered, strong to very weak					0.0	[50]	
	21															
204	22	2		100		0										Brown water return
	23															
202	24															
	25													0.0	[75]	
200	26								very dark gray (N3), basalt boulder, slightly weathered, very hard							
	27								dark yellowish brown (10YR 3/6), strong brown (7.5YR 4/6) and very dark greenish gray (10Y 3/5) Clayey GRAVEL (GC) with sand, basaltic, rounded to subangular, highly to slightly weathered, fine to coarse, with some cobbles, 40% gravel, 30% sand, 30% fines							
198	28	3		70		13										
	29															
196																

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Log of Boring RHTB01

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	29								no recovery							
	30								loose basalt gravel and cobbles, clay matrix likely washed away, rounded to subangular					0.0	[100]	
194	31															Brown water return, no water loss
	32	4		60		0			dark olive gray (5Y 3/2) basalt pahoehoe boulder, moderately weathered, weak, 30-40% vesicles							
192	33															
	34								no recovery							
190	35								Very dark greenish gray (10Y 3/1) with strong brown (7.5YR 5/8) veins and staining, massive a'a basalt boulders and cobbles, moderately to slightly weathered, intensely fractured with thick Mn+Fe surface coating on fractures					0.0	[60]	
	36															Brown water return, no water loss
188	37	5		80		0										
	38								dark yellowish brown (10YR 3/4) matrix with very dark greenish gray (10Y 3/1) gravel, Clayey GRAVEL with Sand (GC), angular, moderately weathered, fine to coarse with cobbles (highly to completely weathered basalt boulder), 50% gravel, 25% sand, 25% fines							
186	39								no recovery							
	40								dark yellowish brown (10YR 4/6) to very dark greenish gray (10Y 3/1), loose basalt GRAVEL (GC) mostly rounded with some subangular, and cobbles, moderate to highly weathered, weak to strong, traces of clay but most washed away					0.0	[37.5]	
184	41															Brown water return, water loss ~300 gal. Driller thinks upper hole is squeezing preventing full water return
	42	6		60		0			more angular, less weathered, likely basalt boulder fragmented by drilling, some clay							
182	43															
	44								no recovery							
180	45															

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Log of Boring RHTB01

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	45													0.0	[42.9]	
	46								Dark gray (N4), dark brown (10YR 3/3) and yellowish brown (10YR 5/8), Fat CLAY (CH) with sand, coarse, rounded, highly weathered and friable, fine to coarse, 5% gravel, 25% sand, 70% fines							Brown water return, water loss ~300 gal
178	47	7		60		0			Grades with more GRAVEL and cobbles (GC), subrounded to subangular, moderately weathered, 40% gravel, 20% sand, 40% fines							
	48															
176	49															After run 7, driller tried to flush hole by pumping water, very high back pressure suggesting hole is squeezing
	50								very dark greenish gray (10Y 3/1) basalt GRAVEL (GC) to boulders, rounded to subangular, mostly rounded, moderately weathered					0.1	[33.3]	
174	51															Full brown water return, no water loss
	52	8		96		0			Dark brown (10YR 3/3) with very dark gray (N4) and yellowish brown (10YR 5/8) mottling, Sandy Fat CLAY with Gravel (SC), rounded, highly to moderately weathered, fine to coarse, 20% gravel, 25% sand, 55% fines							After run is complete and core barrel is retrieved, water continues to flow out of drill pipe and annulus for ~10 min. Driller suspects it is his drill water that pressurized the formation and is now depressurizing. Water loss fell from 10.55 ft btoc to 10.75 ft btoc in 35 min. Stick up is 3.75 ft. Hard slow drilling.
172	53															
	54															
170	55								very dark greenish gray (10Y 3/1), basalt cobbles, slightly to moderately weathered, Fe+Mn staining on fractures					0.0	[37.5]	
	56								dark brown (10YR 3/3) with very dark gray (N4) and yellowish brown (10YR 5/8) mottling, Sandy Fat CLAY (CH), fine to coarse, highly weathered sand, 30% sand, 5% gravel, 65% fines							
168	57	9		66		0			Very dark greenish gray (10Y 3/1), basalt boulder, moderately weathered, hard, intensely fractured with Fe+Mn staining on fractures, traces of clay							Brown water return, water loss ~200 gal
	58															At 58 ft fast drilling ~30sec/ft. Increased water loss
166	59								no recovery							
	60								dark yellowish brown (10YR 4/6) to very dark greenish gray, Clayey GRAVEL (GC), moderately to highly weathered, fine to coarse, rounded to subangular, with moderately to highly weathered basalt cobbles					0.0	[21.4]	
164	61															

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Log of Boring RHTB01

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
162	61															
	62	10		34		0										Brown water return, water loss ~100 gal
	63								no recovery							Driller says water pump is on lowest setting ~0.75 psi
	64															
160	65								same as above, clay matrix likely washing away					0.0	[100]	
	66															Brown water return, water loss ~50 gal Water flows out of hole annulus and casing (HQ) for ~10 min after extracting core barrel. This was observed on runs 8 through 11. Volume per run ~15-30 gallons
158	67	11		34		0										
	68								no recovery							
156	69															Driller says formation is soft with hard zones
	70													0.0	[100]	Water fell from 0 ft to 2.25 ft in 55 min
154	71															
	72	12		34												Brown water return, water loss ~100 gal
152	73								no recovery							
	74															
150	75								grades with less clay and cobbles, more gravel size fragments					0.0	[37.5]	
	76															
148	77															

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Log of Boring RHTB01

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	77															
	78	13		34					no recovery							
146	79															Boring paused at 80 ft bgs on 3/7/19 at 1318 Water level at 20.21
	80								dark brown (10YR 3/3), very dark greenish gray (10Y 3/1) and yellowish brown (10YR 5/8) Clayey GRAVEL (GC) with cobbles, basaltic, moderately to highly weathered, rounded to angular, mixture of pahoehoe and massive a'a					0.0	[75]	Water level on 3/8/19 at 23.88 ft. Resume drilling on 3/8/19. Bailed water to check for recharge, see field log book 8 pgs 139-140
144	81															
	82								dark brown (10YR 3/3) and yellowish brown (10YR 5/8) gravelly Fat CLAY with Sand (CH), basaltic, highly weathered, angular to rounded							
		14		50		0										
142	83															Brown water return, no water loss
	84								no recovery							
140	85								dark yellowish brown (10YR 3/4), yellowish brown (10YR 5/8) and very dark greenish gray (10Y 3/1), Clayey GRAVEL (GC), rounded to subangular, moderately to highly weathered, mix of pahoehoe and a'a					0.0	[60]	
	86															Brown water return, no water loss
138	87								no recovery							
		15		44		0										
	88															
136	89								**SAPROLITE** Very dark greenish gray (10Y 3/1), basalt cobbles and boulders, moderate to highly weathered, weak to very weak with layers of Clayey GRAVEL (GC) to Gravelly Fat CLAY with Sand (CH), very weak, friable, highly weathered, angular to rounded							
	90													0.0	[42.9]	
134	91								At 89.2 ft dark brown (10YR 3/3) Clayey GRAVEL with Sand (GC), basaltic, angular, highly weathered, fine to coarse, 40% gravel, 20% sand, 40% fines							Brown water return, no water loss
	92								At 89.7 ft very dark greenish gray (10Y 3/1) with yellowish brown (10YR 4/6) oxidation in vesicles, basalt a'a cobble, very weak, highly weathered, intensely fractured with Fe+Mn on fractures							
		16		60					At 91 ft dark yellowish brown (10YR 3/4) to dark greenish gray (10Y 3/1) Clayey GRAVEL with Sand (GC), rounded to angular, fine to coarse, basaltic, highly weathered, weak							
132	93															

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Log of Boring RHTB01

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	93								At 91.8 ft grades wih highly weathered, very weak, massive a'a basalt cobbles with Fe+Mn on fractures At 92.3 ft less clay, more gravel, gravel moderately weathered with strong brown (7.5YR 5/8) oxidation no recovery							
	94															
130	95													0.0	[42.9]	
	96								no recovery							Brown water return, no water loss
128	97	17		70		8			very dark greenish gray (10Y 3/1), massive a'a basalt boulder, highly to moderately weathered, very weak, intensely fractured with Fe+Mn partially filling, ~10% vesicles, 2-15 mm, some filled with clay (probably from coring), ~8% weathered olivine phenocrysts							
	98															Boring paused at 100 ft bgs on 3/8/19 at 0858. Hole reamed to 17.5" diameter. Prepare for installing 10" steel casing.
126	99															
	100								no recovery					0.0	[30]	10" steel casing installed to 100 ft bgs. Begin PQ coring on 3/19/19 at 1245 from 100 ft
		18		80		0										
124	101								no recovery Strong brown (7.5YR 4/6) with very dark gray (N3), basalt completely weathered, very weak to extremely weak, weathered to Clayey SAND with Gravel (SC), rounded core stones visible; vesicles 0.1-1.5 mm					0.0	[100]	
	102															
122	103															No water return, 100-101 and 101-106
		19		48		0										
	104															
120	105								no recovery							
	106								strong brown (7.5YR 4/3) to brown (7.5YR 4/2) Clayey SAND with Gravel (SC), basaltic subangular to angular, highly to completely weathered, friable, weak to extremely weak with highly weathered basalt cobbles					0.0	[75]	
118	107								highly weathered basalt cobble (107.2-107.7 ft)							Light brown water return
	108															
		20		84		0										
116	109															

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
114	109													
	110													
	111								dark gray (10YR 4/1) GRAVEL (GC), subrounded to subangular, Fe, Mn			0.0	[23.1]	
	112								Dark gray (10YR 4/1) massive a'a basalt boulder, moderately weathered, intensely fractured with Fe and Mn on surfaces (111.7-112.5 ft)					Light brown water return
112	113	21	10	100		0			Strong brown (7.5YR 4/3) to brown (7.5YR 4/2) Clayey GRAVEL with Sand (GC), subrounded to angular gravel, friable, weak to extremely weak, Mn, Fe on surfaces, highly to completely weathered basalt					
	114													
110	115													End drilling at 116 ft bgs, 3/19/19
	116											0.0	[75]	Resume drilling at 116 ft bgs 3/20/19. Water level is 0 ft bgs at 0800
108	117		11						dark greenish gray (4/5 GY), massive a'a basalt boulders, highly to moderately weathered, extremely weak, no vesicles					
	118								completely weathered basalt, Clayey SAND with Gravel (SC), fines 50%, sand 30%, gravel 20%, yellowish brown (10YR 5/4), angular gravel					Light brown water return, no water loss
106	119	22		88		0			intensely fractured, Fe+Mn staining	4				
	120													
104	121		12				NR		no recovery			0.0	[23.1]	
	122						IF		Massive a'a basalt boulder, intensely fractured, greenish black (2.5/10GY), moderate to highly weathered, very weak, no vesicles. IF. J, VN, Mn, Fe, Su, Wa, S					Hard slow drilling at 122-124 ft
102	123	23	13	100		0								Light brown water return, no water loss
	124								At 124.4 ft Clayey GRAVEL with Sand (GC), dark yellowish brown (10YR 5/4), angular gravel, basaltic, highly weathered, some cobbles, fines 50%, sand 20%, gravel 30%					
100	125													

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	125								124.6-124.8 ft increase in angular gravel and cobbles					
	126								very dark gray (2.5Y 3/1), massive a'a basalt boulder, very weathered, Fe Mn Su stains			0.0	[100]	
98	127								intensely fractured, pahoehoe basalt boulder, very dark gray (10YR 3/1), highly weathered, extremely weak, 15% rounded vesicles, <2 mm, infilled with Mn+Fe, clay matrix washed out, loose					Light brown water return, no water loss
									grayish brown (2.5Y 5/2), massive a'a basalt boulder, intensely fractured, Mn+Fe surface stains					
	128								At 127.5 ft Clayey GRAVEL with Sand (GC), dark yellowish brown (10YR 5/4), Mn staining, fines 45%, sand 15%, gravel 40%					
		24	14	94		0								
96	129								massive a'a basalt boulder, yellowish red (5YR 4/6), completely to highly weathered, very weak, 15% vesicles, 1-5 mm, irregular-elongate, Mn infilled					
	130								Dark yellowish brown (10YR 5/4), black (10YR 2/1), gray (5Y 5/1) Clayey SAND with Gravel (SC), relic structures still evident, fines 50%, sand 35%, gravel 15%, vesicles and fractures preserved, highly weathered basalt, extremely weak, Mn staining					
94	131						NR		no recovery			0.0	[300]	Faster drilling extremely easy, rods falling for whole run
	132													
							NR							
92	133													
		25	15	28		0								
	134								no recovery					Light brown water return, no water loss
90	135													
	136								same as above, mechanical fractures.			0.0	[300]	Faster drilling, rods dropping
									MM					
									MM					
88	137								relic vesicles 10%, rounded-irregular, 1-5 mm, infilled with Mn					
	138													Light brown water return, no water loss
		26	16	80		0								
86	139								reddish brown (5YR 4/4) with prominent infilled relic fractures and relic vesicles infilled with Mn					
	140													Per driller "3 in dropped down hole when core barrel was retrieved"
84	141													

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	141													0.0	[300]	Light brown water return, no water loss
	142															
82	143	27	17	120		0										Fast drilling, rods dropping quick. Extra foot recovered from run 27 was likely from run 26 and was added to that run
	144															
80	145															
	146									3				0.0	[300]	
78	147															Light brown water return, no water loss
	148								relic massive a'a basalt boulder, dark grayish brown (2.5YR 4/2), heavily weathered, very weak							Fast drilling, rods dropping
76	149	28	18	100		0										
	150															
74	151		19						same as above but contains relic massive a'a boulders/cobbles in clay matrix, olive gray (5Y 5/2), highly weathered, very weak, relic structures (fractures)					0.0	[75]	
	152															Light brown water return, no water loss
72	153															
	154	29	20	100		0			becomes light brown (7.5YR 6/4) with olive gray (5Y 5/2), relic massive a'a basalt, highly weathered basalt, irregular-angular cobbles, relic structures, extremely weak, fines 40%, sand 45%, gravel 15%							
70	155															
	156								becomes dark brown (10YR 3/3), Sandy Lean CLAY with Gravel (SC), fines 60%, sand 20%, gravel 20%, highly weathered basalt, rounded gravel, relic structures present					0.0	[75]	
68	157								relic massive a'a basalt boulder, olive gray (5Y 5/2), highly weathered, in clay matrix, extremely weak							

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type	Number	Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	157								At 156.6 ft becomes dark yellowish brown (10YR 5/2), brown (10YR 4/3), dark reddish gray (10YR 4/2), highly weathered, relic structures-fractures and vesicles infilled with Mn, rounded-irregular gravel size clasts in clay matrix, extremely weak							Light brown water return, no water loss
	158	30		100		0										
66	159															
	160								subrounded-angular cobbles/gravels							
64	161													0.0	[300]	Fast drilling, rods dropping
	162															
62	163	31		106		0										Light brown water return, no water loss
	164															Bagged 9" of core for possible geotech sample
60	165															
	166		23											0.0	[60]	Light brown water return, no water loss
58	167								dark reddish brown (5YR 3/4), relic massive a'a basalt, highly weathered, extremely weak, elongate vesicles 1-8 mm, irregular, infilled with Mn, Fe, white secondary mineralization (possibly calcite), subrounded to angular gravel size clasts in a clay matrix							
	168	32		94		0										
56	169															
	170															
54	171													0.0	[37.5]	Light brown water return, no water loss
	172															
52	173								At 172.6 ft intensely fractured and mechanically fractured basalt, massive a'a boulder, very dark greenish gray (10Y 3/1), highly weathered, very weak, Mn+Fe staining							

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	173								Very dark grayish brown (10YR 3/2) and yellowish red (10YR 5/6) Clayey GRAVEL with Sand (GC), highly weathered, extremely weak, basaltic, subrounded gravel, fines 50%, sand 20%, gravel 30%					
	174	33	25	100		0								
-50	175						IF		massive a'a basalt boulder, intensely fractured, weak, highly weathered, Mn+Fe staining, dark greenish gray (10Y 4/1) IF. J, VN, Mn, Fe, Su, Pl, S					
	176											0.0	[50]	First hard drilling, then easy, then hard
-48	177								dark greenish gray (10Y 4/1) and strong brown (5.5YR 4/6), completely weathered massive a'a basalt, weathers to Clayey Gravel (GC), subangular to angular gravel with cobbles, friable					
	178													Light brown water return, no water loss
		34	26	88		0								
-46	179								Dark greenish gray (10Y 4/1) and strong brown (5.5YR 4/6) Clayey SAND with Gravel (SC), completely weathered basalt					
	180								grades with more gravel, highly weathered, friable, strong brown (7.5YR 5/6) and dark gray (7.5YR 4/1), completely to highly weathered basalt, weathers to Clayey SAND with Gravel (SC), gravel is highly weathered, friable					
-44	181						NR		no recovery			0.0	[75]	
	182									2				
-42	183								grades with highly weathered basalt cobbles, fines 50%, sand 30%, gravel 20%					
		35		100		0								
	184													
-40	185													Boring paused at 185 ft on 3/20/19
	186											0.0	[60]	Resume drilling at 0645 on 3/21/19. Water level equals 63.08 ft btoc
-38	187								187.4-187.8 ft massive a'a basalt boulder, dark greenish gray (10Y 4/1), moderate to highly weathered, extremely weak, Mn+Fe staining					
	188													Light brown water return, no water loss
		36	28	94		0								
-36	189								Dark yellowish brown (10YR 4/5) Clayey GRAVEL					

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type / Number / Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	189								with Sand (GC), clay matrix, highly weathered, weak, basalt gravel pieces dark greenish gray (5GY 4/1), angular, weak, moderate to highly weathered, Mn+Fe staining, large gravel/cobbles, possible boulder in clay matrix, fines 40%, sand 20%, gravel 40%					
	190						MIF		massive basalt a'a boulder, black (10YR 2/1), mechanically intensely fractured, moderate to highly weathered, extremely weak					
34	191								no recovery					
									At 190.4 ft becomes Clayey SAND with Gravel (SC), dark yellowish brown (10YR 4/6) and yellowish brown (10YR 5/6), highly to completely weathered, extremely weak, angular gravel, fines 50%, sand 30%, gravel 20%			0.0	[50]	Light brown water return, no water loss
	192													Difficult drilling
32	193								At 191.2 ft massive a'a basalt boulder, yellowish brown (10YR 5/4), highly weathered, weak, 0% vesicles, irregular and subrounded, <1 mm, partially infilled with Mn+Fe, secondary mineralization possibly calcite					
		37	29	72		0			At 192 ft Clayey GRAVEL with SAND (GC), dark yellowish brown (10YR 4/6) and yellowish brown (10YR 5/6), highly weathered, extremely weak, subrounded to angular gravel, fines 50%, sand 25%, gravel 25%					
	194								no recovery					
30	195						M M M 1 2 3		massive a'a basalt boulder, dark greenish gray (10Y 4/1), highly weathered, very weak, rounded to subrounded At 195 ft gravel sized pieces 1. 10, J, VN, Mn, Fe, Su, Wa, SR 2. 0, J, VN, Mn, Fe, Su, Wa, S 3. 0, J, VN, Mn, Fe, Su, Wa, SR					
	196						M M M		small scale fractures throughout			0.0	[60]	
28	197													Light brown water return, no water loss Difficult drilling
									Strong brown (7.5YR 4/6) Clayey SAND with Gravel (SC), highly weathered, extremely weak, relic structures preserved, highly weathered dark greenish gray (10Y 4/1) basaltic gravel with Mn+Fe staining, subrounded to angular gravel, fines 40%, sand 40%, gravel 20%					
	198													
		38	30	72					massive a'a basalt boulder, very dark gray (10YR 3/2), moderate to highly weathered, very weak, intensely and mechanically fractured, 1% olivine phenocryst, 5% vesicles, irregular, 1-6 mm, some Mn+Fe staining, secondary mineralization (possibly calcite)					
26	199													
	200								no recovery					
24	201								massive a'a basalt, dark greenish gray (10Y 4/1), moderate to highly weathered, very weak, intensely fractured, fractures have Mn+Fe surface staining, smooth			0.0	[100]	
	202													Light brown water return, no water loss
22	203						IF							Difficult drilling
		39	31	80		0								
	204		32						becomes more broken up and fractured, Mn+Fe+clay staining on fractures (surface and spotting), intensely fractured, some mechanical fractures towards the end of the run					
20	205													

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Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type Number Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	205								no recovery					
	206								brown (10YR 4/3) Clayey GRAVEL with Sand (GC), moderate to highly weathered, extremely weak, gravel sized/cobble sized basalt fragments, fines 40%, sand 25%, gravel 35%			0.0	[27.3]	Light brown water return, no water loss Difficult drilling
18	207													
	208	40	32	66		0			massive a'a basalt, dark greenish gray (10Y 4/1), 3% vesicles, <1 mm, partially infilled with Mn, moderate to highly weathered, very weak At 208.1 ft becomes intensely fractured massive a'a basalt, dark greenish gray (10Y 4/1) and black (2.5/N), highly weathered, very weak, rounded to subanguler cobbles, Mn+Fe+clay staining spotting					Dropped core, could not latch inner barrel. Trip out PQ casing to recover core. While tripping out casing, inner barrel latched. Core likely fell down hole
16	209													
	210								no recovery					
14	211											0.0	[50]	
	212						M M		brown (10YR 4/3) Clayey GRAVEL with Sand (GC), moderate to highly weathered, extremely weak, gravel/cobble sized basalt fragments, some Mn+Fe+secondary minerals (calcite?) staining on gravel fragments, fines 40%, sand 25%, gravel 35%					Light brown water return, no water loss
12	213						M IF		At 212.1 ft basalt pahoehoe boulder, very dark grayish brown (10YR 3/2), moderate to highly weathered, weak, mechanically fractured, 15% vesicles, rounded, <3 mm, partially infilled with clay, Mn, Fe					Faster drilling for middle ~2 ft
	214	41	33	100		0	M IF		At 212.4 ft massive a'a basalt boulder, brown (7.5YR 5/4), moderate to highly weathered, weak, 10% vesicles, irregular/subrounded, 1-20 mm, partially infilled with Mn+Fe, intensely fractured, fractures have Mn staining, some mechanical fractures					
10	215								Brown (10YR 4/3) Clayey SAND with Gravel (SC), highly to completely weathered, extremely weak, some secondary mineral staining (calcite?), fines 50%, sand 35%, gravel 15%					
	216		34						At 214 ft becomes more fractured and broken up, more intensely fractured massive a'a basalt, dark greenish gray (4/10Y), moderately weathered, weak, Mn+Fe staining			0.0	[42.9]	
8	217								Brown (10YR 4/3) Lean CLAY with Gravel (CL), moderate to highly weathered, very weak, gravel pieces are dark greenish gray (10Y 4/1) a'a and very dark grayish brown (10YR 3/2) pahoehoe with secondary calcite mineralization, reddish brown (5YR 5/3) basalt, fines 55%, sand 15%, gravel 30%					Light brown water return, no water loss
	218						M M M M M M IF		massive a'a basalt, dark greenish gray (10Y 4/1), highly weathered, weak, intensely fractured and mechanically fractured, Mn+Fe+clay staining on fracture surfaces					
6	219	42	35						becomes more intensely fractured and more broken up					
	220								Lean CLAY with Gravel (CL) as above At 220.3 ft pahoehoe basalt boulder, very dark gray (10YR 3/1), moderately weathered, weak, 5% vesicles, rounded to subrounded, 1-5 mm, partially infilled with clay					
4	221						1							

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	221								1. 0, J, VN, Cl, Sp, Wa, SR			0.0	[30]	
									At 220.6 ft Lean CLAY with Gravel (CL) as above					
	222													Light brown water return, no water loss
-2	223						1		massive a'a basalt, dark greenish gray (10Y 4/1), moderately weathered, weak					
									Lean CLAY with Gravel (CL) as above					
		43	36	100		30			1. 50, J, VN, Mn, Su, Pl, VS					
	224						2		massive a'a, greenish gray (5GY 6/1), moderately weathered, weak to medium strong, 5% vesicles, subrounded irregular and elongate, 1-25 mm, partially infilled with clay					
							3		2. 10, J, VN, Mn, Cl, Sp, Wa, SR					
							4		3. 20, J, VN, Mn, Sp, ST, SR					
-0	225						5		4. 20, J, VN, Mn, Sp, ST, SR					
									5. 5, J, VN, Mn, Sp, Wa, SR					
							M		For Run Number 44:					
							IF		1. 0, J, VN, Mn, Fe, Su+Sp, Wa, SR					
	226						M		2. 45, J, VN, Mn, Fe, Su+Sp, Wa, SR			0.0	[33.3]	
							1		3. 5, J, VN, calcite, Sp, Wa, R					
							M		4. 90, J, VN, Mn, Su, Cl, Sp, Wa, SR					
-2									5. 0, J, VN, Mn, Fe, Cl, Sp, Wa, SR					
	227		37				2		6. 0, J, VN, Cl, Sp, Wa, SR					
							IF		7. 0, J, VN, Cl, Sp, Wa, SR					Light brown water return, no water loss
							M							
							M		brown (10YR 4/3), Lean CLAY with Sand (CL) (completely weathered pahoehoe), fines 60%, sand 25%, gravel 15%, includes relic pahoehoe basalt, very dark gray (10YR 3/1), completely weathered, extremely weak, <2 mm rounded vesicles partially infilled with secondary mineral (calcite?)					
	228													
		44		80		28								
-4							3		Pahoehoe basalt, very dark gray (10YR 3/1), moderate to highly weathered, medium strong to weak, 5% vesicles, rounded, <2 mm, partially infilled with clay					
	229						4							
							5							
							6							
							7		becomes 20% vesicles, subrounded to subangular, 2-8 mm, partially infilled with clay					
	230						IF		At 229.8 ft becomes 25% vesicles, rounded, 5 mm, uniform, partially infilled with clay					
-6									no recovery 230'-231' bgs					
	231		38				M		5% vesicles, rounded to subrounded, 1-4 mm			0.0	[50]	
							M							
							M							
							M							
	232						M		becomes brown (10YR 5/3), moderate to highly weathered, medium strong to weak, 30% vesicles, rounded, 1 mm, infilled with clay pinkish white (10YR 8/3)					Light brown water return, no water loss
							M							
							M							
							M							
-8							IF							
	233						M							
							M		becomes very dark gray (10YR 3/1), moderate to highly weathered, medium strong to weak, 20% vesicles subrounded, <2 mm, infilled with clay pinkish white (10YR 8/3)					Intermittent hard and soft drilling
		45	39	100		20	M							
							M							
	234						M							
							M							
							M		possible flow contact, heat alteration, yellowish red (5YR 5/6), ~30 mm wide					
-10							IF							
	235						M		At 234.8 ft becomes reddish brown (5YR 4/3), highly weathered, weak, 10% vesicles, <1 mm, partially infilled with Mn and clay pinkish white (10YR 8/3)					
							M							
							IF							
	236						M		At 236.2 ft becomes gray (10YR 5/1), moderately weathered, medium strong, 5% vesicles, <1 mm, partially infilled with clay			0.0	[75]	
							M							
							M							
							M		At 236.4 ft becomes very dark gray (10YR 3/1), 20% vesicles, rounded, <4 mm, infilled with clay					
-12	237						1		1. 0, J, Vn, Cl, Sp, Wa, SR					

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	237						M		becomes reddish brown (5YR 4/3), possible flow contact/alteration					
							M							
	238						IF							
		46	40	102		42			becomes black (10YR 2/1), moderately weathered, medium strong, 20% vesicles, rounded, 1-5 mm, partially infilled with clay					
-14	239						M		2. 0, J, VN, Mn, Cl, Sp, Wa, SR 3. 45, J, VN, Mn, Sp, Wa, SR					
							IF		includes heat alteration, strong brown (7.5YR 5/5)					
	240						2							
							3		heat alteration, strong brown (7.5YR 5/6)					
-16							M		becomes strong brown (7.5YR 5/6), highly weathered, very weak, 10% vesicles, irregular, <1 mm, partially infilled with clay and Mn					
	241											0.0	[42.9]	
							M							
							M							
							1		1. 0, J, VN, Mn, Fe, Cl, Sp, Wa, SR					
	242						2		**BASALT Pahoehoe** Greenish gray (5Y 6/1), moderately weathered, medium strong, 5% vesicles, subrounded, 5-25 mm, Mn spotting in some vesicles, partially clay filled vesicles, grading to no clay in vesicles					Water loss ~50 gal
							IF							
-18							3		2. 5, J, VN, Mn, Fe, Cl, Sp, Wa, SR					
	243						4		3. 5, J, VN, No, No, Wa, SR 4. 0, J, VN, Mn, Sp, Wa, SR					
		47	41	100		52								
							5		5. 15, J, VN, Mn, Sp, Wa, SR					
	244						6		6. 50, J, VN, Mn, Sp, Wa, SR 7. 0, J, VN, Mn, Sp, Cl, Su, Wa, SR vesicles infilled with yellow (10YR 8/6) clay					
							7		8. 0, J, VN, Mn, Fe, Cl, Sp, Wa, R					
-20	245								vesicles infilled with yellow (10YR 8/6) clay band of 30% vesicles, subrounded, <1 mm 15% vesicles, subrounded, <2 mm					
							8							
	246		42						becomes black (10YR 2/1), moderate to slightly weathered, medium strong to strong, 5-20% vesicles, rounded, 1-4 mm			0.0	[42.9]	
-22							1							
	247						2							
							3		heat alteration (possible contact), red (2.5YR 5/6)					
							4		becomes reddish brown (5YR 4/3), highly weathered, weak, 10% vesicles, irregular, <2 mm, partially infilled with clay					
	248						IF		At 248 ft becomes moderate to highly weathered, medium strong to strong, no vesicles					Water loss ~50 gal
		48	43	100		78	5							
-24	249						6		5% vesicles, 2-10 mm, subrounded 20% vesicles, 1-2 mm, rounded to subrounded					
	250						7		becomes very dark gray (7.5YR 3/1), moderately weathered, medium strong, 10% vesicles, subrounded, partially infilled with clay 1. 0, J, VN, Mn, Fe, Sp, Wa, SR 2. 45, J, VN, Mn, Fe, Sp, Wa, SR					
-26														
	251						IF		3. 5, J, VN, Mn, Sp, Wa, SR 4. 0, J, VN, Mn, Sp, Wa, R 5. 0, J, VN, Mn, Sp, Wa, SR 6. 5, J, VN, Mn, Sp, Wa, SR 7. 0, J, VN, Mn, Sp, Wa, SR			0.0	[60]	
							IF							
	252						1		At 252 ft becomes gray (5Y 6/1), slightly weathered, medium strong to strong rock, 5% vesicles, 3-15 mm, subangular, partially infilled with clay					Water loss ~100 gal
			44				2							
-28	253													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/6/2019 RHTB01

Project: CTO1830126 - Red Hill Bulk Fuel Storage Facilty
Project Location: CTO18F0126
Project Number: 60371042

Log of Boring RHTB01

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type / Number / Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	253								becomes 15% vesicles, subrounded, 1-3 mm 1. 10, J, T, filled with brownish yellow (10YR 6/6) clay 2. 20, J, VN, Mn, Sp, Wa, SR					
		49	44	100		64			becomes very dark gray (10YR 3/1), slightly weathered, medium strong to strong with 20% vesicles, rounded, 1-5 mm					
	254							3 4 IF	becomes 25% vesicles, rounded, 1-5 mm 3. 0, J, VN, No, No, Wa, SR 4. 45, J, VN, Mn, Fe, Su, Wa, SR					
-30	255							5	5. 15, J, VN, Mn, Sp, Wa, SR					
	256											0.0	[42.9]	
								IF						
-32	257								becomes 15% vesicles, subrounded, 3-5 mm, infilled with clay					Water loss ~200 gal
								1	At 257.1 ft becomes 10% vesicles, rounded, <1 mm					
	258								At 257.4 ft heat alteration, possible flow contact, yellowish red (5YR 5/6), 25 mm thick					
		50	45	110		76		2	At 257.6 ft becomes dark reddish brown (5YR 3/3), highly weathered, weak, 3% vesicles, <1 mm, partially infilled with clay yellow (10YR 8/6)					
-34	259							3	At 258 ft becomes gray (10YR 5/1), moderately weathered, medium strong, 15% vesicles, subrounded, 2-6 mm, partially infilled with clay 1. 0, J, VN, Mn, Cl, Sp, Wa, R 2. 30, J, VN, Mn, Cl, Sp, Wa, SR					Lost water circulation at ~260 ft No water return for remainder of boring unless otherwise noted Boring paused on 3/21/19 at 261 ft
	260							4	3. 25, J, VN, Mn, Sp, Wa, R 4. 50, J, VN, Mn, Cl, Sp, Wa, SR					
-36	261		46					IF	At 260.4 ft becomes dark gray (10YR 4/1), slightly weathered, very strong, 20% vesicles, rounded, 1-5 mm 1. 10, J, VN, Mn, Sp, Wa, SR 2. 5, J, VN, Mn, Sp, Wa, SR			0.0	[20]	Resume coring on 3/22/19 at 0814. DTW = 207.54 ft btoc (204.67 ft bgs)
	262							1 2 M	becomes 10% vesicles, rounded to subrounded, 2-12 mm	1				
									evidence of core grinding					High water pressure causing the pressure relief value on GAC filter to activate
-38	263							3	becomes very dark gray (7.5YR 3/1), slightly weathered, very strong, 25% vesicles, rounded, 2 mm					
		51	47	84		52		IF						
	264							M	no recovery					
									evidence of core grinding. Becomes black (5YR 2.5/1), slightly weathered, strong to very strong, 10% vesicles, rounded, <2 mm					Drilling paused partway through to adjust pressure relief valve on GAC
-40	265							4 5	3. 60, J, VN, Mn, Fe, Cl, Sp, Wa, R 4. 0, J, VN, Mn, Sp, Fe, Su, Wa, R 5. 25, J, VN, Mn, Sp, Wa, R					
								M	becomes 25% vesicles, rounded to subrounded, 1-5 mm					
	266											0.0	[100]	Top 0.5 ft from run 52 likely dropped from run 51
								1 IF	becomes red (2.5YR 4/8), possible heat alteration? slightly weathered, very strong, 30% vesicles, rounded, <2 mm					
-42	267							2	At 266.9 ft becomes black (2.5/N), slightly weathered, very strong, 30% vesicles, rounded, <2 mm					
								IF						
	268							3 4	becomes very dark gray (10YR 3/1), slightly weathered, very strong, 30% vesicles, rounded, 1-5 mm					
		52	48	110		50		5	1. 0, J, VN, No, No, Wa, R 2. 10, J, VN, Cl, Sp, ST, R					
-44	269													

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

Log of Boring RHTB01

Elevation, feet	Depth, feet	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per Foot	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	Well Schematic	SAMPLES: Type / Number / Blows per foot	PID (ppm)	Drill Time [Rate, ft/hr]	FIELD NOTES AND TEST RESULTS
	269								3. 45, J, VN, Mn, Cl, Sp, Fe, Su, Wa, SR 4. 5, J, VN, Mn, Cl, Sp, Wa, SR 5. 50, J, VN, Mn, Cl, Sp, Wa, SR 6. 0, J, VN, No, No, Sp, Wa, R 7. 5, J, VN, Mn, Cl, Sp, Wa, R					
	270													
-46	271		49									0.0	[60]	
	272								becomes 15% vesicles, subrounded, 1-5 mm					
-48	273	53		100		86			becomes 10% vesicles, subrounded, 1-15 mm 1. 35, J, VN, No, No, Wa, R 2. 0, J, VN, No, No, Wa, R 3. 10, J, VN, Cl, Sp, Wa, R 4. 0, J, VN, Mn, Fe, Sp, Wa, SR 5. 45, J, VN, Mn, Fe, Sp, Wa, SR 6. 0, J, VN, Mn, Fe, Sp, Wa, SR 7. 80, J, VN, Mn, Sp, Wa, SR 8. 0, J, VN, Fe, Sp, Wa, SR					
	274		50											
-50	275								At 273.9 ft becomes 25% vesicles, rounded to subrounded, 1-5 mm becomes 20% vesicles, rounded, 1-10 mm					
	276								At 277.1 ft becomes 25% vesicles, rounded to subrounded, 1-4 mm			0.0	[60]	
-52	277								At 277.7 ft becomes 10% vesicles, subrounded, <2 mm At 278.1 ft possible flow contact, becomes dark reddish brown (5YR 3/4), moderately weathered, medium strong to strong, 15% vesicles, subangled, infilled with clay very pale brown (10YR 8/4)					
	278	54		86		66			At 278.8 ft becomes reddish brown (5YR 5/3), moderate to slightly weathered, strong, 10% vesicles, irregular, subrounded to subangular, 1-5 mm, Mn spotting in vesicles					
-54	279								At 279.5 ft becomes 5% vesicles, subrounded, 3-25 mm, partially infilled with Mn+Sp, partially infilled with clay, very pale brown (10YR 8/4) (halloysite) 1. 50, J, VN, Mn, Cl, Sp, Wa, SR 2. 5, J, VN, Mn, Sp, Fe, Su, Wa, SR 3. 0, J, VN, Mn, Sp, Wa, SR 4. 0, J, VN, Mn, Sp, Wa, SR 5. 0, J, VN, Mn, Cl, Sp, Wa, SR					
	280		52						no recovery					Boring complete on 3/22/19 at 281 ft. 0.8 ft of core dropped downhole
-56	281								Bottom of boring total depth is 281 ft bgs.					
	282								Used a total of approximately 1,450 gallons of circulation water. Hand cleared from 0-5 ft bgs. Drill with 8" 0D HSA from 5-15 ft bgs. HQ core from 15-100 ft bgs. Hole reamed to 17.5". Install 10" steel casing to 100 ft bgs. PQ core from 100 ft to 281 ft bgs. Installed nested set of 4 vibrating wire piezometers and grouted in place.					
-58	283													
	284													
-60	285													

Report: CTO53 RED HILL WITH WELL AND PID; File: CTO18F0126 RED HILL CORE LOGS.GPJ; 6/6/2019 RHTB01

Appendix B: Hydrographs

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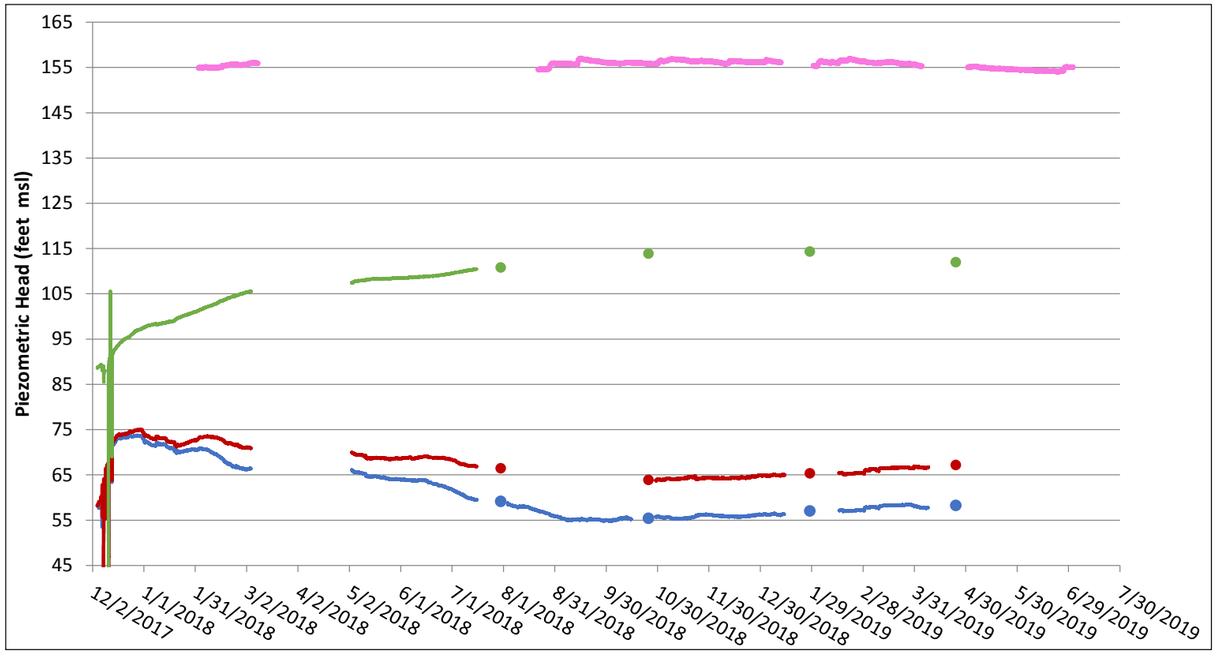

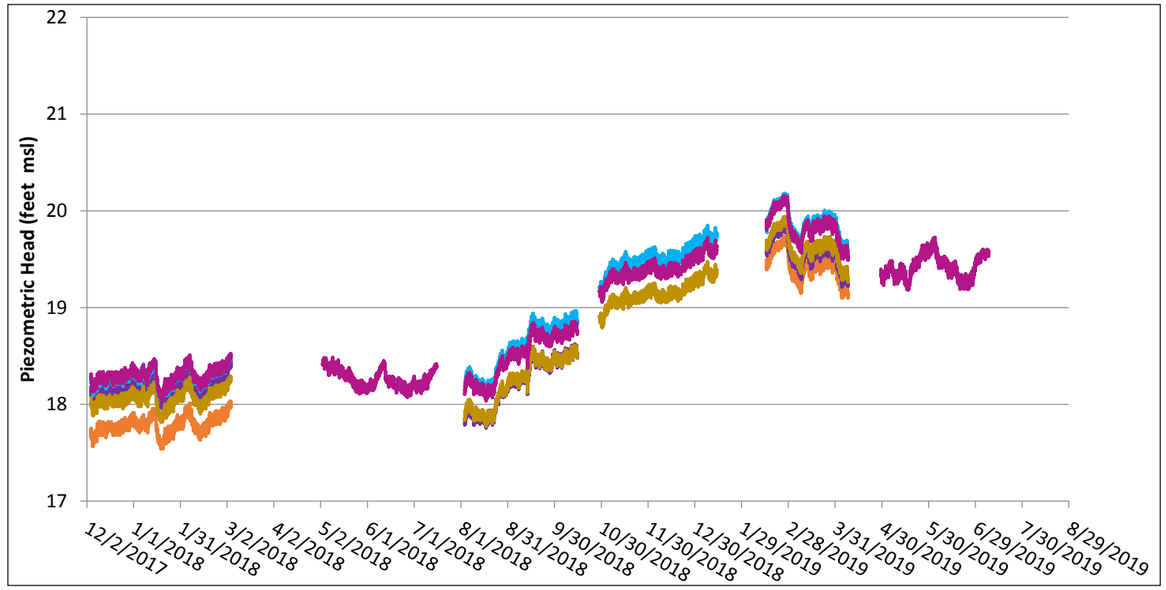

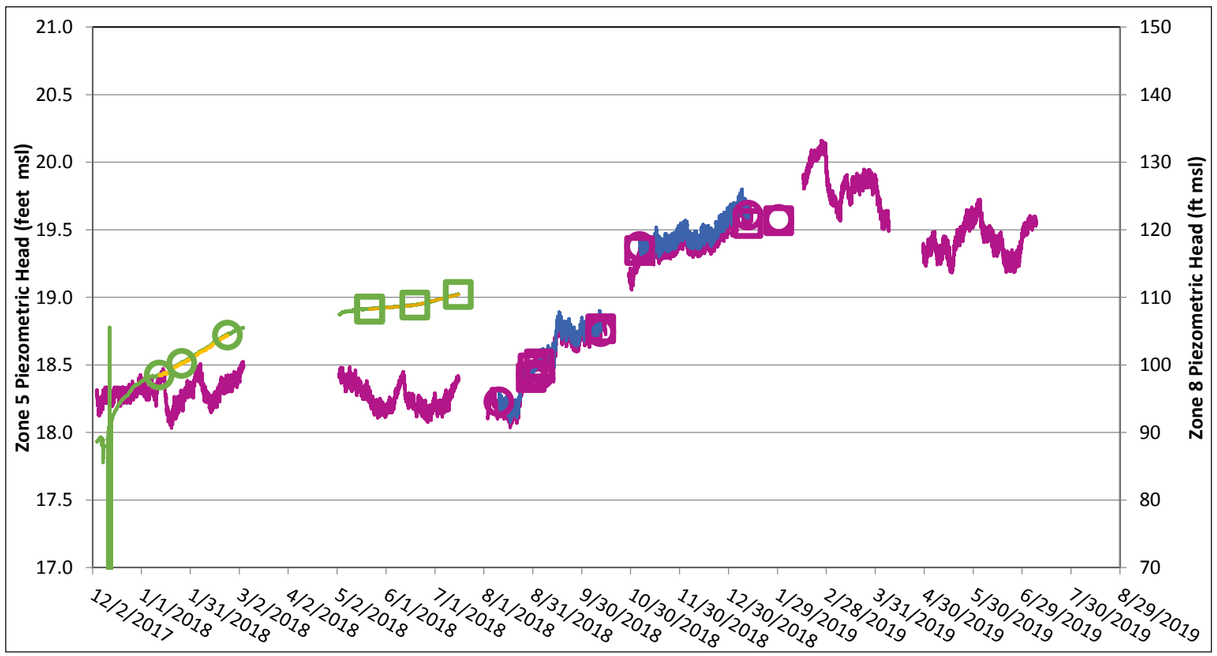

LEGEND	Generalized Geology	Zone Top (ft msl)	Zone Bottom (ft msl)
Zone 8 – MOSDAX Transducer	Saprolite	51.06	5.86
Zone 7- MOSDAX Transducer	Saprolite	0.56	-29.44
Zone 6 – MOSDAX Transducer	Saprolite	34.64	-45.14
Zone 5 – MOSDAX Transducer	Basalt	-66.94	-19.94
Zone 4- MOSDAX Transducer	Basalt	-120.14	-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 8 USGS Hand Measurements			
Zone 8 Navy Hand Measurements			
Zone 5 – 700H Vented Transducer			
Zone 5 USGS Hand Measurements			
Zone 5 Navy Hand Measurements			

Appendix B-1
RHMW11 and UMW-1 – Long-Term Piezometric Heads
Groundwater Flow Model Progress Report 08
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, Hawaiʻi

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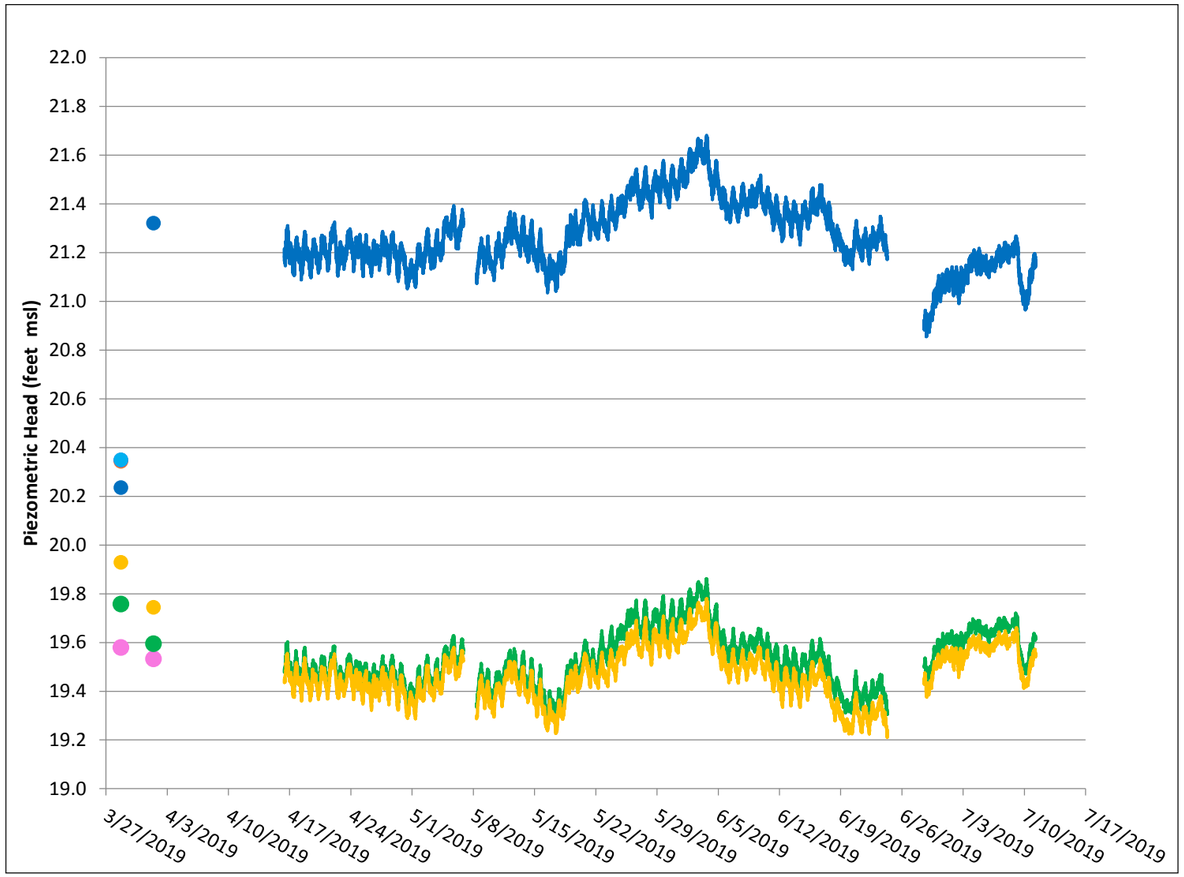
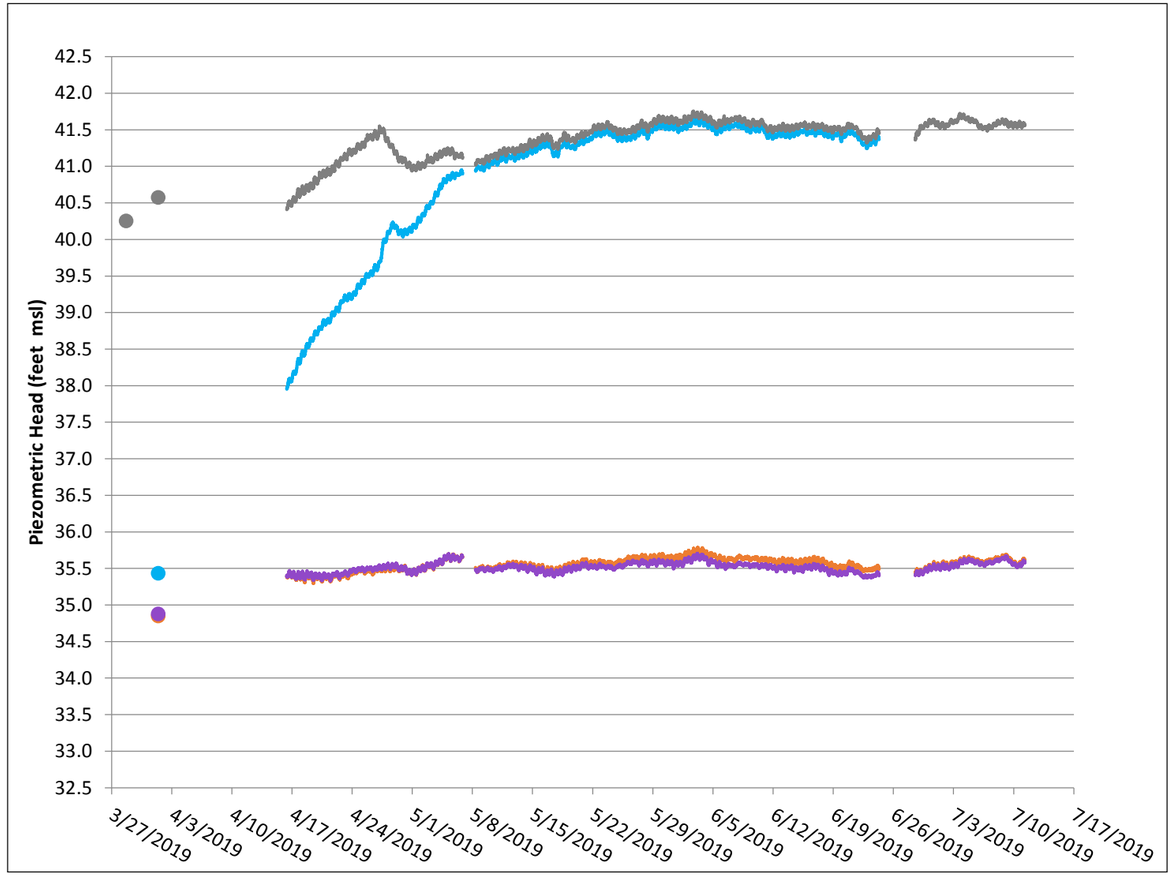


LEGEND	Generalized Geology	Zone Top (ft msl)	Zone Bottom (ft msl)
Zone 8 – MOSDAX Transducer	Weathered Basalt	49.8	30.8
Zone 7 – MOSDAX Transducer	Weathered Basalt	25.8	10.8
Zone 6 – MOSDAX Transducer	Weathered Basalt	32.8	-19.2
Zone 5- MOSDAX Transducer	Basalt	-24.2	-36.2
Zone 4 – MOSDAX Transducer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



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 B-2
RHMW14 – Long-Term Piezometric Heads
Groundwater Flow Model Progress Report 08
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, Hawaiʻi

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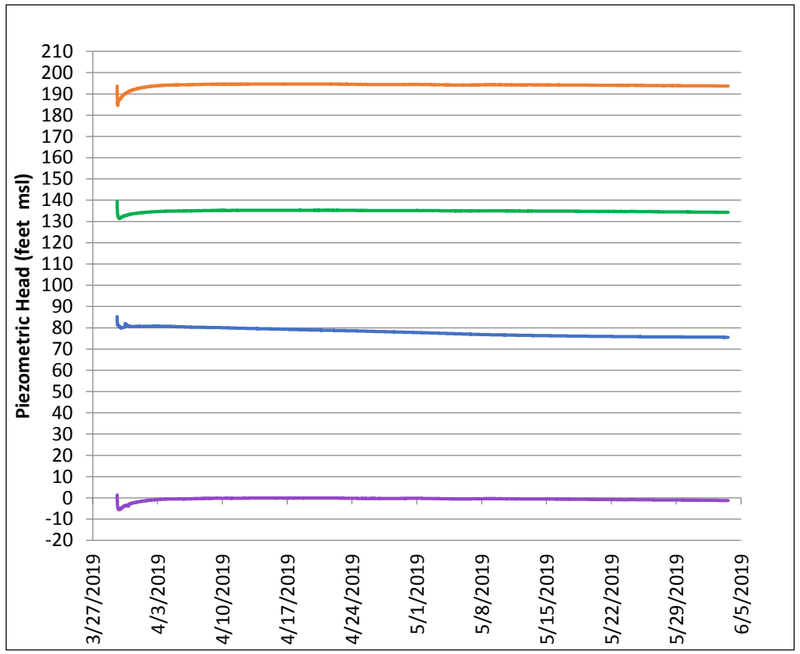

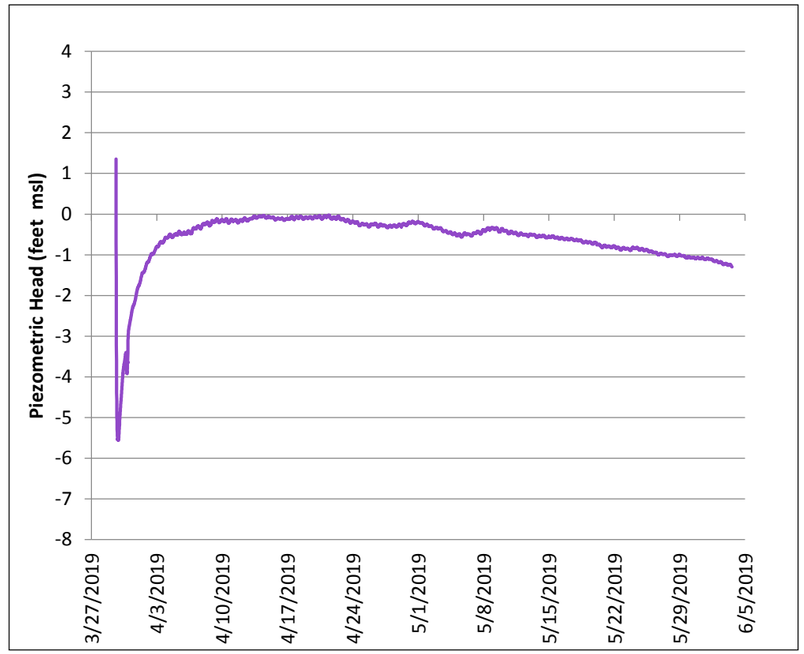

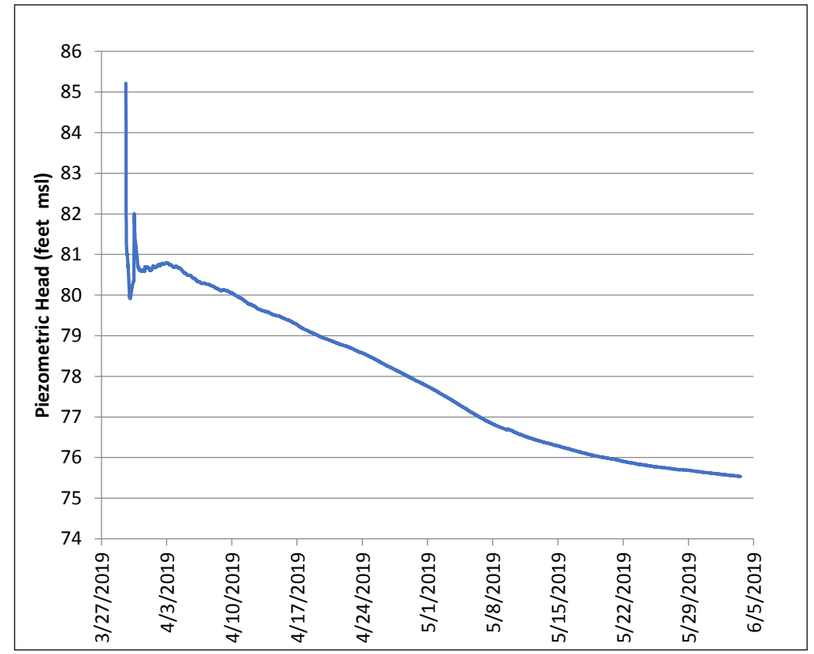

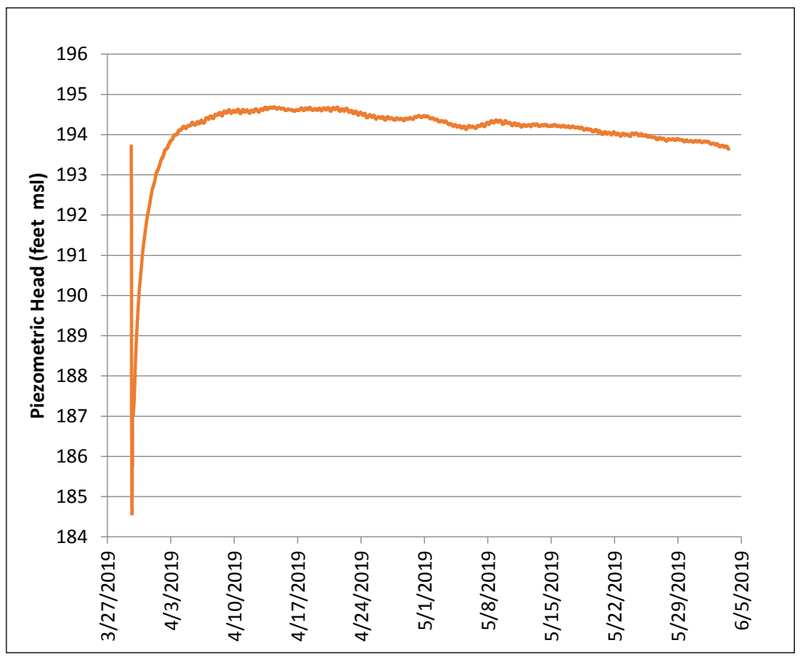

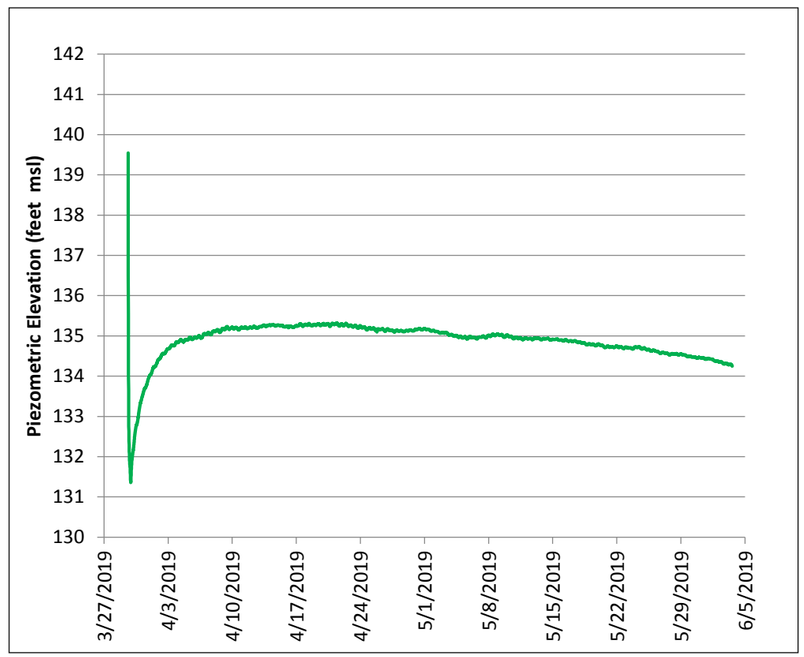

LEGEND	Generalized Geology	Probe Elevation (ft msl)
Zone 4	Saprolite	106
Zone 3	Saprolite	79
Zone 2	Saprolite	43
Zone 1	Basalt	-37

Appendix B-3
RHTB01 – Piezometric Heads
Groundwater Flow Model Progress Report 08
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

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