Final
Fourth Quarter 2015 - Quarterly Groundwater Monitoring Report Outside Tunnel Wells

Red Hill Bulk Fuel Storage Facility
Joint Base Pearl Harbor-Hickam, Oahu, Hawaii

DOH Facility ID No.: 9-102271
DOH Release ID No.: 990051, 010011, 020028, and 140010

January 2016

Department of the Navy
Naval Facilities Engineering Command, Hawaii
400 Marshall Road
JBPHH HI 96860-3139

Contract Number N62742-14-D-1884, CTO 0014

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ACRONYMS AND ABBREVIATIONS

ACRONYMS/ ABBREVIATIONS	DEFINITION/MEANING
CCV	Continuing Calibration Verification
COPC	Contaminant of Potential Concern
DLNR	State of Hawaii Department of Land and Natural Resources
DoD	Department of Defense
DOH	State of Hawaii Department of Health
DON	Department of the Navy
DQO	Decision Quality Objective
E2	Element Environmental, LLC
EAL	Environmental Action Level
EPA	Environmental Protection Agency
ESI	Environmental Science International, Inc.
F-76	Marine Diesel Fuel
ICAL	Initial Calibration
ID	Identification
JBPHH	Joint Base Pearl Harbor-Hickam
JP-5	Jet Fuel Propellant-5
JP-8	Jet Fuel Propellant-8
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection
LOQ	Limit of Quantitation
µg/L	micrograms per liter
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NAVFAC	Naval Facilities Engineering Command
NAVSUP FLC	Naval Supply Systems Command Fleet Logistics Center
N.D.	Not Detected
PAH	Polycyclic Aromatic Hydrocarbons
PARCCS	Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity
pH	hydrogen activity
QC	Quality Control
QSM	Quality Systems Manual
RHSF	Red Hill Bulk Fuel Storage Facility
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
TCE	Trichloroethylene
TEC	The Environmental Company, Inc.
TPH	Total Petroleum Hydrocarbons
TPH-d	Total Petroleum Hydrocarbons as diesel
TPH-g	Total Petroleum Hydrocarbons as gasoline
TPH-o	Total Petroleum Hydrocarbons as oil
U.S.	United States of America
UST	Underground Storage Tank
VOC	Volatile Organic Compound

WP	Work Plan

EXECUTIVE SUMMARY

This quarterly groundwater monitoring report presents the results of the fourth quarter 2015 groundwater sampling event, conducted on 19 October 2015, at the outside tunnel wells of the Red Hill Bulk Fuel Storage Facility [RHSF], Joint Base Pearl Harbor-Hickam [JBPHH], Hawaii. The RHSF is located in Halawa Heights on the Island of Oahu. There are 18 active and 2 inactive underground storage tanks [USTs] located at the RHSF. The State of Hawaii Department of Health [DOH] Facility Identification [ID] number is 9-102271. The DOH Release ID numbers are 990051, 010011, 020028, and 140010.

The groundwater sampling was conducted as part of the long-term groundwater and soil vapor monitoring program at the RHSF and concurrent with release response activities initiated at Tank 5 in January 2014, for Naval Supply Systems Command Fleet Logistics Center [NAVSUP FLC] Pearl Harbor (formerly Fleet and Industrial Supply Center), under Naval Facilities Engineering Command [NAVFAC] Contract Number N62742-14-D-1884. The sampling was conducted in accordance with the approved Work Plan [WP]/Sampling and Analysis Plan [SAP] prepared by Environmental Science International, Inc. [E2].

On 19 October 2015, E2 personnel collected groundwater samples from five outside tunnel monitoring wells (wells OWDFMW01, HDMW2253-03, RHMW04, RHMW06, and RHMW07). One primary and one duplicate groundwater sample were collected from well RHMW06. All groundwater samples were analyzed for petroleum constituents. Analytical results were compared to DOH Tier 1 Environmental Action Levels [EALs]. A summary of the analytical results is provided below.

- **OWDFMW01** – Concentrations of Total Petroleum Hydrocarbons as diesel (TPH-d) (680 micrograms per liter (µg/L)) and TPH as oil (TPH-o) (100 µg/L) were detected above and at their respective DOH Tier 1 EALs. Lead (0.033 µg/L) and several volatile organic compounds [VOCs] and polycyclic aromatic hydrocarbons [PAHs] were also detected; however, none of these detected concentrations exceeded their respective DOH Tier 1 EALs. Several of the detected PAHs and VOC methylene chloride were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as non-detect (ND) in the data summary tables within this report. Due to the consistent high hydrogen activity (pH) and presence of acetone in well OWDFMW01, contamination from another source may be impacting the well.
- **HDMW2253-03** – The only analytes detected in groundwater were TPH-d (21 µg/L), TPH as gasoline (TPH-g) (16 µg/L), VOC toluene (0.37 µg/L) and lead (0.032 µg/L). The concentrations did not exceed the DOH Tier 1 EALs. TPH-o and several PAHs were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. With the exception of one possibly erroneous result obtained during the event in April 2014, TPH-d concentrations have not exceeded the DOH Tier 1 EAL in well HDMW2253-03 since January 2013.

- **RHMW04** – The only analytes detected in groundwater were several PAHs and lead (0.044 µg/L). The concentrations did not exceed their respective DOH Tier 1 EALs. TPH-d, TPH-o and several PAHs were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.
- **RHMW06** – The only analytes detected in groundwater were TPH-d (17 and 15 µg/L), VOCs bromodichloromethane (0.00044 µg/L) (only in the primary sample), toluene (1.10 and 0.50 µg/L) and lead (0.012 and 0.016 µg/L). None of the detected concentrations exceeded their DOH Tier 1 EALs. TPH-o, several PAHs and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.
- **RHMW07** – The analytes detected in groundwater were TPH-d (26 µg/L), PAH 1-methylnaphthalene (0.0067 µg/L) , VOC toluene (0.64 µg/L) and lead (0.013 µg/L). The concentrations did not exceed their respective DOH Tier 1 EALs. TPH-o, several PAHs and VOC methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.

During the October 2015 sampling event, TPH-d and TPH-o were detected at concentrations above and at their respective DOH Tier 1 EALs in OWDFMW01. The majority of the TPH-d concentration reported for the samples from OWDFMW01 was caused by single peak. The compound or compound mixture represented by the single peak does not resemble a petroleum fuel. For both TPH-d and TPH-o in OWDFMW01, the total concentrations reported are likely inaccurate, because they were determined by comparison to a diesel and an oil standard, respectively. Additional scrutiny of the TPH-d concentrations in well OWDFMW01 is warranted. Based on an unnaturally high pH and the presence of acetone in well OWDFMW01, the associated sample data may not accurately represent the conditions of the groundwater at the site.

The groundwater contaminant concentrations in the other wells remained at low concentrations and did not change significantly since the previous sampling event (July 2015), or were not detected. No Contaminants of Potential Concern [COPCs] in wells HDMW2253-03, RHMW04, RHMW06 or RHMW07 were detected at concentrations above their respective DOH Tier 1 EALs.

Based on a suspected 2014 release at the RHSF and the results of the recent groundwater sampling and analysis, continued groundwater monitoring at the RHSF is recommended. If the TPH-d concentrations significantly increase, the monitoring frequency should be increased to monthly, even though wells RHMW04, RHMW06, RHMW07, HDMW2253-03, and OWDFMW01 are not included in the RHSF Groundwater Protection Plan.

An alternative means of collecting groundwater samples from the vicinity of well OWDFMW01 should be evaluated if TPH impacts continue to trend upwards and high pH conditions persist.

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SECTION 1 – INTRODUCTION

This quarterly groundwater monitoring report presents the results of the fourth quarter 2015 groundwater sampling event conducted on 19 October 2015, at the outside tunnel wells of the RHSF, JBPHH, Hawaii. The RHSF is located in Halawa Heights on the Island of Oahu. The purpose of the sampling is to (1) assess the condition of groundwater beneath and in the vicinity of the RHSF with respect to chemical constituents associated with jet fuel propellant and marine diesel fuel, and (2) to ensure the Navy remains in compliance with DOH UST release response requirements as described in Hawaii Administrative Rules 11-281 Subchapter 7, Release Response Action (DOH, 2013). The DOH Facility ID number for the RHSF is 9-102271. The DOH Release ID numbers are 990051, 010011, 020028, and 140010.

The groundwater sampling was conducted as part of the long-term groundwater and soil vapor monitoring program at the RHSF for NAVSUP FLC Pearl Harbor, under NAVFAC Contract Number N62742-14-D-1884. The sampling was conducted in accordance with the approved WP/SAP and WP/SAP Technical Addendum prepared by E2 (E2, 2015).

1.1 SITE DESCRIPTION

The RHSF is located on federal government land (zoned F1 - Military and Federal), located in Halawa Heights, approximately 2.5 miles northeast of Pearl Harbor. It is located on a low ridge on the western edge of the Koolau Mountain Range that divides Halawa Valley from Moanalua Valley. The RHSF is bordered on the north by Halawa Correctional Facility and private businesses, on the southwest by the United States of America [U.S.] Coast Guard reservation, on the south by residential neighborhoods, and on the east by Moanalua Valley. A quarry is located less than a quarter mile away to the northwest. The RHSF occupies 144 acres of land and the majority of the site is at an elevation of approximately 200 to 500 feet above mean sea level.

The RHSF contains 18 active and 2 inactive USTs, which are operated by NAVSUP FLC Pearl Harbor. Each UST has a capacity of approximately 12.5 million gallons. The RHSF is located approximately 100 feet above the basal aquifer. The USTs contain Jet Fuel Propellant-5 [JP-5], Jet Fuel Propellant-8 [JP-8], and Marine Diesel Fuel [F-76]. The current status of each of the USTs is summarized in Table 1.1.

Five groundwater monitoring wells (wells OWDFMW01, HDMW2253-03, RHMW04, RHMW06, and RHMW07) are located outside of the RHSF tunnel system. Well HDMW2253-03 is located at the Halawa Correctional Facility (outside the RHSF); well OWDFMW01 is located at the former Oily Waste Disposal Facility near Adit 3; and wells RHMW04, RHMW06, and RHMW07 are located on the north side of the RHSF along the road to the Navy Firing Range. Four groundwater monitoring wells (wells RHMW01, RHMW02, RHMW03, and RHMW05) are located within the RHSF lower access tunnel, and one sampling point (RHMW2254-01) is

located at Red Hill Shaft. Monitoring data for the four wells located inside the tunnel and one sampling point at Red Hill Shaft are included in a separate report.

As noted, monitoring wells RHMW01, RHMW02, RHMW03, and RHMW05 are located inside the underground tunnels. Sampling point RHMW2254-01 is located inside the infiltration gallery of the Department of the Navy [DON] drinking water supply Well 2254-01. DON Well 2254-01 is located approximately 2,400 feet down-gradient of the USTs and provides potable water to the JBPHH Water System, which serves approximately 65,200 military customers. NAVFAC Public Works Department operates the infiltration gallery and DON Well 2254-01.

TABLE 1.1
Current Status of the USTs
Red Hill Bulk Fuel Storage Facility

Tank Identification	Fuel Type	Status	Capacity
F-1	None	Inactive	12.5 million gallons
F-2	JP-8	Active	12.5 million gallons
F-3	JP-8	Active	12.5 million gallons
F-4	JP-8	Active	12.5 million gallons
F-5	JP-8	Active	12.5 million gallons
F-6	JP-8	Active	12.5 million gallons
F-7	JP-5	Active	12.5 million gallons
F-8	JP-5	Active	12.5 million gallons
F-9	JP-5	Active	12.5 million gallons
F-10	JP-5	Active	12.5 million gallons
F-11	JP-5	Active	12.5 million gallons
F-12	JP-5	Active	12.5 million gallons
F-13	F-76	Active	12.5 million gallons
F-14	F-76	Active	12.5 million gallons
F-15	F-76	Active	12.5 million gallons
F-16	F-76	Active	12.5 million gallons
F-17	JP-5	Active	12.5 million gallons
F-18	JP-5	Active	12.5 million gallons
F-19	None	Inactive	12.5 million gallons
F-20	JP-5	Active	12.5 million gallons

F-76 Marine Diesel Fuel
JP-5 Jet Fuel Propellant-5
JP-8 Jet Fuel Propellant-8

1.2 PHYSICAL SETTINGS

Climatological conditions in the area of the RHSF consist of warm to moderate temperatures and low to moderate rainfall. The RHSF is leeward of the prevailing northeasterly trade winds. The average annual precipitation is approximately 40 inches, which occurs mainly between November and April (State of Hawaii Department of Land and Natural Resources [DLNR], 1986). Annual pan evaporation is approximately 75 inches (DLNR, 1985). Average temperatures range from the low 60's to high 80's (degrees Fahrenheit) (Atlas of Hawaii, 1983).

Oahu consists of the eroded remnants of two shield volcanoes, Waianae and Koolau. The RHSF is located on the southwest flank of the Koolau volcanic shield. Lavas erupted during the shield-building phase of the volcano belong to the *Koolau Volcanic Series* (Stearns and Vaksvik, 1935). Following formation of the Koolau shield, a long period of volcanic quiescence occurred, during which the shield was deeply eroded. Following this erosional period, eruptive activity resumed. Lavas and pyroclastic material erupted during this period belong to the *Honolulu Volcanic Series* (Stearns and Vaksvik, 1935).

In the immediate area of the RHSF, Koolau Volcanic Series lavas dominate, although there are consolidated and unconsolidated non-calcareous deposits in the vicinity that consist of alluvium generated during erosion of the Koolau volcanic shield. South-southwest of the RHSF, and in isolated exposures to the west, are pyroclastic deposits formed during eruptions from three Honolulu Volcanic Series vents, Salt Lake, Aliamanu, and Makalapa (Stearns and Vaksvik, 1935). Based on established geology and records of wells drilled at the RHSF (Stearns and Vaksvik, 1938), the RHSF is underlain by Koolau Volcanic Series basalts. The area of the RHSF is classified as *Rock Land*, where 25 to 90% of the land surface is covered by exposed rock and there are only shallow soils (Foote, et al., 1972).

Groundwater in Hawaii exists in two principal aquifer types. The first and most important type, in terms of drinking water resources, is the basal aquifer. The basal aquifer exists as a lens of fresh water floating on and displacing seawater within the pore spaces, fractures, and voids of the basalt that forms the underlying mass of each Hawaiian island. In parts of Oahu, groundwater in the basal aquifer is confined by the overlying caprock and is under pressure. Waters that flow freely to the surface from wells that tap the basal aquifer are referred to as *artesian*.

The second type of aquifer is the caprock aquifer, which consists of various kinds of unconfined and semi-confined groundwater. Commonly, the caprock consists of a thick sequence of nearly impermeable clays, coral, and basalt that separates the caprock aquifer from the basal aquifer. The impermeable nature of these materials and the artesian nature of the basal aquifer severely restrict the downward migration of groundwater from the upper caprock aquifer. However, in the area of the RHSF, there is no discernible caprock.

Groundwater in the area of the RHSF is part of the *Waimalu Aquifer System* of the *Pearl Harbor Aquifer Sector.* The aquifer is classified as a basal, unconfined, flank-type; and is currently used as a drinking water source. The aquifer is considered fresh, with less than 250 milligrams per liter of chloride, and is considered an irreplaceable resource with a high vulnerability to contamination (Mink and Lau, 1990).

The nearest drinking water supply well is the Red Hill Shaft Well 2254-01, located in the infiltration gallery within the RHSF. The Well 2254-01 is located approximately 2,400 feet down-gradient of the USTs.

The nearest body of surface water is Halawa Stream, an ephemeral stream that is present along the north side of the RHSF. Except for the portion to the east of the Halawa Correctional Facility, the stream is contained by a concrete culvert. The stream is usually dry, but flows after periods of significant rainfall.

Wells OWDFMW01, HDMW2253-03, RHMW04, RHMW06, and RHMW07 are all located within 150 meters of a portion of Halawa stream. The distance of each well to Halawa Stream is presented in Table 1.2

TABLE 1.2
Distance of Wells to Halawa Stream
Red Hill Bulk Fuel Storage Facility

Well	Distance to Halawa Stream (meters)
HDMW2253-03	64.25
OWDFMW01	142.68
RHMW04	80.85
RHMW06	104.09
RHMW07	81.20

1.3 BACKGROUND

The RHSF was constructed by the U.S. Government in the early 1940s. Twenty USTs and a series of tunnels were constructed to supply fuel to the Navy. The USTs were constructed of steel and they currently contain JP-5, JP-8, and F-76. Several tanks in the past have stored DON special fuel oil, DON distillate, aviation gasoline, and motor gasoline (Environet, 2010). The fueling system is a self-contained underground unit that was installed into native rock comprised primarily of basalt with some interbedded tuffs and breccias (Environet, 2010). Each UST measures approximately 250 feet in height and 100 feet in diameter. The upper domes of the tanks lie at depths varying between 100 feet and 200 feet below ground surface.

In response to increasing concentrations of COPCs in the groundwater monitoring wells within the facility (specifically RHMW02) during the 2008 sampling events, quarterly groundwater monitoring was initiated in 2009 at the outside tunnel wells.

In 2009, groundwater samples were collected from wells RHMW04, OWDFMW01, and HDMW2253-03. Samples were collected in August and October 2009. None of the COPCs were detected at concentrations exceeding the current gross contamination or drinking water toxicity DOH EALs.

In 2010, groundwater samples were collected from wells RHMW04, OWDFMW01, and HDMW2253-03. Samples were collected from well RHMW04 in January and April 2010. Samples were collected from well OWDFMW01 in January, April, and October 2010. Samples were collected from well HDMW2253-03 in January, April, July and October 2010. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **HDMW2253-03** – TPH-d was detected at a concentration above the DOH EALs for gross contamination and drinking water toxicity in January 2010 (The Environmental Company, Inc. [TEC], 2010a).
- **OWDFMW01** – TPH-d was detected at a concentration above the DOH EALs for gross contamination and drinking water toxicity in January and April 2010 (TEC, 2010a; TEC, 2010b).

In 2011, groundwater samples were collected from wells OWDFMW01 and HDMW2253-03. Samples were collected in January, April, July, and October 2011. None of the COPCs were detected at concentrations exceeding the current DOH EALs for gross contamination or drinking water toxicity. In Fall 2011, the DOH EALs were revised. The drinking water toxicity EAL for TPH-d decreased from 210 to 190 µg/L.

In 2012, groundwater samples were collected from wells OWDFMW01 and HDMW2253-03. Samples were collected in January, April, July, and November 2012. TPH-d was detected at a concentration above the DOH EALs in samples collected from wells HDMW2253-03 and OWDFMW01 (Environet, 2012; ESI, 2013a). The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **HDMW2253-03** – TPH-d was detected at concentrations above the DOH EALs for gross contamination and drinking water toxicity in April and November 2012.
- **OWDFMW01** – TPH-d was detected at a concentration above the DOH EALs for gross contamination and drinking water toxicity in April 2012.

In 2013, groundwater samples were collected from wells OWDFMW01 and HDMW2253-03. Samples were collected in January, April, July, and October 2013. TPH-d was detected at a concentration above the DOH EALs in samples collected from wells HDMW2253-03 and OWDFMW01 (ESI, 2013b, 2013c, 2013d, and 2014a). The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **HDMW2253-03** – TPH-d was detected at a concentration above the DOH EALs for gross contamination and drinking water toxicity in January 2013.
- **OWDFMW01** – TPH-d was detected at concentrations above the DOH EALs for gross contamination and drinking water toxicity in all four quarters during 2013.

In 2014, groundwater samples were collected from wells OWDFMW01 and HDMW2253-03. Samples were collected in January, April, July, and October 2014. Well RHMW04 was also sampled in July and October 2014. TPH-d was detected at concentrations above the DOH EALs in samples collected from well OWDFMW01 in January and April 2014. TPH-d was also detected at a concentration above the DOH EALs in a sample collected from well HDMW2253-03 in April 2014; however, this was likely an erroneous result due to a switched

sample (ESI, 2014c, 2014d, 2014e, and 2015a). The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **HDMW2253-03** – TPH-d was detected at a concentration above the DOH EALs for both gross contamination and drinking water toxicity in April 2014. However, as discussed above, this was likely an erroneous result.
- **OWDFMW01** – TPH-d was detected at concentrations above the DOH EALs for gross contamination and drinking water toxicity in April 2014 and above only the EAL for gross contamination in January 2014.

In January 2014, an additional groundwater sampling was conducted at HDMW2253-03 in response to a suspected release from Tank 5. None of the COPC concentrations exceeded the current DOH EALs (ESI, 2014b).

Between August and October 2014, wells RHMW06 and RHMW07 were installed at the RHSF in order to develop a more robust groundwater monitoring network at the site (Battelle, 2015a). Both wells were sampled in October 2014. The PAH 2-methylnaphthalene was detected in the sample collected from well RHMW06. TPH-d, 2-methylnaphthalene, and acetone were detected in the sample collected from well RHMW07. None of the COPC concentrations exceeded the current DOH EALs for gross contamination or drinking water toxicity. In the well installation report, it was speculated that these detections may have been related to the drilling foam used during the installation of the wells.

In January 2015, groundwater samples were collected from wells OWDFMW01, HDMW2253-03, and RHMW04 (ESI, 2015b), and from wells RHMW06, and RHMW07 (Battelle, 2015b). None of the COPC concentrations exceeded the current DOH EALs for drinking water toxicity or gross contamination.

In April 2015, groundwater samples were collected from wells OWDFMW01, HDMW2253-03, RHMW04, RHMW06, and RHMW07. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **OWDFMW01** – TPH-d and TPH-o were detected at concentrations above their respective DOH EALs.

in July 2015, groundwater samples were collected from wells OWDFMW01, HDMW2253-03, RHMW04, RHMW06, and RHMW07. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **OWDFMW01** – TPH-d and TPH-o were detected above their respective DOH Tier 1 EALs.

1.3.1 Previous Reports

The following groundwater monitoring reports for wells located outside the RHSF tunnel system were previously submitted to DOH:

1. Groundwater Monitoring Report, August 2009 (submitted September 2009).
2. Groundwater Monitoring Report, October 2009 (submitted December 2009).
3. Groundwater Monitoring Report, January, 2010 (submitted April 2010).
4. Groundwater Monitoring Report, April 2010 (submitted May 2010).
5. Groundwater Monitoring Report, July 2010 (submitted August 2010).
6. Groundwater Monitoring Report, October 2010 (submitted December 2010).
7. Groundwater Monitoring Report, January 2011 (submitted March 2011).
8. Groundwater Monitoring Report, April 2011 (submitted June 2011).
9. Groundwater Monitoring Report, July 2011 (submitted September 2011).
10. Groundwater Monitoring Report, October 2011 (submitted December 2011).
11. Groundwater Monitoring Report, January 2012 (submitted March 2012).
12. Groundwater Monitoring Report, April 2012 (submitted July 2012).
13. Groundwater Monitoring Report, July 2012 (submitted August 2012).
14. Groundwater Monitoring Report, November 2012 (submitted January 2013).
15. Groundwater Monitoring Report, January 2013 (submitted April 2013).
16. Groundwater Monitoring Report, April 2013 (submitted July 2013).
17. Groundwater Monitoring Report, July 2013 (submitted September 2013).
18. Groundwater Monitoring Report, October 2013 (submitted January 2014).
19. Groundwater Monitoring Report for Additional Sampling of HDMW2253-03, January 2014 (submitted February 2014).
20. Groundwater Monitoring Report, January 2014 (submitted April 2014).
21. Groundwater Monitoring Report, April 2014 (submitted June 2014).
22. Groundwater Monitoring Report, July 2014 (submitted September 2014).
23. Groundwater Monitoring Report, October 2014 (submitted January 2015).
24. Groundwater Monitoring Report, January 2015 (submitted March 2015).
25. Draft Monitoring Well Installation Report for RHMW06 and RHMW07, March 2015 (submitted March 2015).
26. Draft Technical Memorandum, Groundwater Sampling Event for RHMW06 and RHMW07, April 2015 (submitted April 2015).

27. Groundwater Monitoring Report, April 2015 (submitted August 2015).

28. Groundwater Monitoring Report, July 2015 (submitted November 2015).

SECTION 2 – GROUNDWATER SAMPLING

On 19 October 2015, E2 personnel collected groundwater samples from five monitoring wells (wells OWDFMW01, HDMW2253-03, RHMW04, RHMW06, and RHMW07). A primary and duplicate groundwater sample were collected from well RHMW06.

The samples were collected in accordance with the 2015 WP/SAP. The WP/SAP is consistent with DOH UST release response requirements (DOH, 2000); DON Procedure I-C-3, *Monitoring Well Sampling* (DON, 2007); and the Interim Update, Final RHSF Groundwater Protection Plan (TEC, 2014). Prior to purging and sampling, the depth to groundwater and the depth to the bottom of the wells were measured by E2 using a Solinst oil/water interface probe. The measurements are included in the groundwater sampling logs. No measurable product, sheen, or petroleum hydrocarbon odor was observed in any of the wells.

2.1 GROUNDWATER SAMPLING

Prior to collecting groundwater samples, the monitoring wells were purged of standing water in the well casings. Wells OWDFMW01 and HDMW2253-03 were purged using disposable bailers. Wells RHMW04, RHMW06, and RHMW07 contain dedicated bladder pumps which were used to purge the wells and to collect samples. The monitoring wells were purged at rates of 0.21 to 0.94 liters per minute.

Water quality parameters were monitored on a periodic basis during well purging. The water quality parameters that were measured included pH, temperature, conductivity, dissolved oxygen, and oxidation-reduction potential. The water quality parameters were evaluated to demonstrate that the natural characteristics of the aquifer formation water were present within the monitoring well before collecting the sample. At least four readings were collected during the purging process. Purging was considered complete when at least three consecutive water quality measurements stabilized within approximately 10%. The readings were recorded on groundwater monitoring logs which are included in Appendix A. The field notes are included in Appendix B.

When the water quality parameters stabilized, groundwater samples were collected from the wells. The disposable bailers or dedicated bladder pump were used to collect the groundwater samples from the monitoring wells. For each monitoring well, the groundwater samples were collected no more than two hours after purging was completed to prevent groundwater interaction with the monitoring well casing and atmosphere. Samples collected for dissolved lead were filtered in the field using new 0.45-micron filters.

All samples were labeled and logged on the Sample Inventory Log, placed in Ziploc™ bags and sealed, custody sealed, sealed with tape, placed in a cooler with wet ice, and logged onto the Chain-of-Custody form. The samples were labeled and logged in accordance with DON Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures* (DON,

2007). All samples were shipped under Chain-of-Custody to the analytical laboratory and analyzed for the COPCs as described in Section 2.2.

2.2 ANALYTICAL RESULTS

The samples were analyzed for TPH-g, TPH-d, and TPH-o using EPA Method 8015M; VOCs using EPA Methods 8260C, 8260C-SIM, and 8011; PAHs using EPA Method 8270C SIM; and dissolved lead using EPA Method 6020. Analytical results were compared to DOH Tier 1 EALs where groundwater is a current source of drinking water and surface water is less than 150 meters from the site. The analytical results are described below and summarized in Table 2.1. A copy of the laboratory report is included as Appendix C.

For ease of reading, only analytical results for chemicals that have been detected since 2010 are presented in Table 2.1. A description of laboratory data qualifiers, definitions of the terms Method Detection Limit [MDL], Limit of Detection [LOD], and Limit of Quantitation [LOQ], and basic concepts of those terms are presented as Appendix D.

- **OWDFMW01** – Concentrations of TPH-d (680 µg/L) and TPH-o (100 µg/L) were detected above and at their respective DOH Tier 1 EALs. Lead (0.033 µg/L), VOCs and PAHs were also detected; however, none of these detected concentrations exceeded their respective DOH Tier 1 EALs. Several PAHs and VOC methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. Due to the consistent high pH and presence of acetone in well OWDFMW01, contamination from another source may be impacting the well.
- **HDMW2253-03** – The only analytes detected in groundwater were TPH-d (21 µg/L), TPH-g (16 µg/L), VOC toluene (0.37 µg/L) and lead (0.032 µg/L). The concentrations did not exceed the DOH Tier 1 EALs. TPH-o and several PAHs were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. With the exception of one possibly erroneous result obtained during the event in April 2014, TPH-d concentrations have not exceeded the DOH Tier 1 EAL in well HDMW2253-03 since January 2013.
- **RHMW04** – The only analytes detected in groundwater were several PAHs and lead (0.044 µg/L). The concentrations did not exceed their respective DOH Tier 1 EALs. TPH-d, TPH-o and several PAHs were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.
- **RHMW06** – The only analytes detected in groundwater were TPH-d (17 and 15 µg/L), VOCs bromodichloromethane (0.00044 µg/L) (only in the primary sample), toluene (1.10 and 0.50 µg/L) and lead (0.012 and 0.016 µg/L). None of the detected concentrations exceeded their DOH Tier 1 EALs. TPH-o, several PAHs and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely

resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.

- **RHMW07** – The analytes detected in groundwater were TPH-d (26 µg/L), PAH 1-methylnaphthalene (0.0067 µg/L) , VOC toluene (0.64 µg/L) and lead (0.013 µg/L). The concentrations did not exceed their respective DOH Tier 1 EALs. TPH-o, several PAHs and VOC methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.

2.2.1 Groundwater Contaminant Trends

The historical groundwater contaminant concentration trends for COPCs that exceeded the DOH Tier 1 EALs are illustrated in Appendix E. A summary of groundwater contaminant trends is provided below.

- **OWDFMW01** – TPH-d and TPH-o were detected in both samples from this well at concentrations exceeding and at their respective DOH Tier 1 EALs. Concentrations of all other COPCs detected during this round of quarterly sampling were consistent with historical data.
- **HDMW2253-03** – TPH-d was detected in this well at a concentration below the DOH Tier 1 EAL. With the exception of one possibly erroneous result obtained during the event in April 2014, TPH-d concentrations have not exceeded the DOH Tier 1 EAL in well HDMW2253-03 since January 2013.
- **RHMW04** – Concentrations of TPH-d and TPH-o were detected in this well above the previous reported concentrations but remain below the respective DOH Tier 1 EALs. Concentrations of all other COPCs detected during this round of quarterly sampling were below the detection limits of the historical analytical results.
- **RHMW06** – This well was installed in September 2014 and first sampled in October 2014. To date, no COPCs have been detected at concentrations exceeding the DOH Tier 1 EALs.
- **RHMW07** – This well was installed and first sampled in October 2014. To date, no COPCs have been detected at concentrations exceeding the DOH Tier 1 EALs.

2.3 WASTE DISPOSAL

The purged groundwater and decontamination water generated during sampling of the wells were placed in two 55-gallon drums along with the purged water and decontamination water from the inside tunnel wells. The drums will be properly profiled and manifested following the next quarterly sampling event, or when they reach 90% full.

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TABLE 2.1
Analytical Results for Groundwater Sampling (19 October 2015)
Red Hill Bulk Storage Facility
October 2015 Quarterly Monitoring Report

Method	Chemical	DOH EAL	OWDFMW01 (ERH002) <150 meters from surface water					HDMW2253 (ERH001) <150 meters from surface water					RHMW04 (ERH006) <150 meters from surface water					RHMW06 (ERH004) <150 meters from surface water					RHMW07 (ERH003) <150 meters from surface water				
			Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL
EPA 8015C	TPH-g	100	ND	U	50	25	13	16	J	50	25	13	ND	U	50	25	13	ND	U	50	25	13	ND	U	50	25	13
	TPH-d	100	680	B,Z	53	21	12	21	B,J	56	23	13	ND	B,U,	53	22	12	17	B,J	53	21	12	26	B,J	59	24	13
	TPH-o	100	100	B,J	110	53	20	ND	B,U	120	56	22	ND	B,U	110	53	21	ND	B,U	110	53	20	ND	B,U	120	59	23
EPA 8270D SIM	Acenaphthene	20	ND	U	0.020	0.0050	0.0044	ND	U	0.019	0.0050	0.0044	ND	U	0.020	0.0050	0.0044	ND	U	0.019	0.0050	0.0044	ND	U	0.020	0.0050	0.0044
	Acenaphthylene	30	0.0082	J	0.020	0.0050	0.0034	ND	U	0.019	0.0050	0.0034	ND	U	0.020	0.0050	0.0034	ND	U	0.019	0.0050	0.0034	ND	U	0.020	0.0050	0.0034
	Benz(a)anthracene	0.27	ND	B,U	0.020	0.0050	0.0026	ND	B,U	0.019	0.0050	0.0026	ND	B,U	0.020	0.0050	0.0026	ND	B,U	0.019	0.0050	0.0026	ND	B,U	0.020	0.0050	0.0026
	Benzo(g,h,i)perylene	0.1	ND	B,U	0.020	0.0050	0.0029	ND	B,U	0.019	0.0050	0.0029	0.0076	B,J	0.020	0.0050	0.0029	ND	B,U	0.019	0.0050	0.0029	ND	B,U	0.020	0.0050	0.0029
	Dibenz(a,h)anthracene	0.0092	ND	B,U	0.020	0.0050	0.0026	ND	B,U	0.019	0.0050	0.0026	0.011	B,J	0.020	0.0050	0.0029	ND	B,U	0.019	0.0050	0.0026	ND	B,U	0.020	0.0050	0.0026
	Fluoranthene	8	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010
	Fluorene	3.9	ND	U	0.020	0.0050	0.0038	ND	U	0.019	0.0050	0.0038	ND	U	0.020	0.0050	0.0038	ND	U	0.019	0.0050	0.0038	ND	U	0.020	0.0050	0.0038
	1-Methylnaphthalene	2.1	0.019	J	0.020	0.0050	0.0035	ND	U	0.019	0.0050	0.0035	0.0043	J	0.020	0.0050	0.0035	ND	U	0.019	0.0050	0.0035	ND	U	0.020	0.0050	0.0035
	2-Methylnaphthalene	2.1	0.013	B,J	0.020	0.0050	0.0023	ND	B,U	0.019	0.0050	0.0023	0.0047	B,J	0.020	0.0050	0.0023	ND	B,U	0.019	0.0050	0.0023	0.010	B,J	0.020	0.0050	0.0023
	Naphthalene	17	0.025	B,J	0.020	0.0050	0.0038	0.0042	B,J	0.019	0.0050	0.0038	0.0051	B,J	0.020	0.0050	0.0038	ND	B,U	0.019	0.0050	0.0038	0.010	B,J	0.020	0.0050	0.0038
	Phenanthrene	4.6	0.0073	J	0.020	0.0050	0.0050	ND	U	0.019	0.0050	0.0050	ND	U	0.020	0.0050	0.0050	ND	U	0.019	0.0050	0.0050	ND	U	0.020	0.0050	0.0050
	Pyrene	2	ND	U	0.020	0.010	0.0053	ND	U	0.019	0.010	0.0053	ND	U	0.020	0.010	0.0053	ND	U	0.019	0.010	0.0053	ND	U	0.020	0.010	0.0053
EPA 8260C/ 8260-SIM/ 8011	1,1,1,2-Tetrachloroethane	0.067	ND	U	0.020	0.015	0.0087	ND	U	0.020	0.015	0.0087	ND	U	0.02	0.015	0.0087	ND	U	0.020	0.015	0.0087	ND	U	0.020	0.015	0.0087
	1,2,3-Trichloropropane	0.6	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20
	1,2-Dibromo 3-Chloropropane	0.04	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22
	1,2-Dibromoethane (EDB)	0.04	ND	U	0.010	0.004	0.003	ND	U	0.010	0.0040	0.0030	ND	U	0.010	0.0040	0.0030	ND	U	0.010	0.0040	0.0030	ND	U	0.010	0.0040	0.0030
	1,2-Dichloroethane	0.15	0.0009	J	0.020	0.015	0.0058	ND	U	0.020	0.015	0.0058	ND	U	0.020	0.015	0.0058	ND	U	0.020	0.015	0.0058	ND	U	0.020	0.015	0.0058
	Acetone	1500	56	*	20	10	3.3	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3
	Benzene	5	ND	U,*	0.50	0.10	0.062	ND	U,*	0.50	0.10	0.062	0.080	J,*	0.50	0.10	0.062	ND	U,*	0.50	0.10	0.062	ND	U,*	0.50	0.10	0.062
	Bromodichloromethane	0.12	ND	U	0.020	0.010	0.0034	ND	U	0.020	0.010	0.0034	ND	U	0.020	0.010	0.0034	0.00044	TB,J	0.020	0.010	0.0034	ND		0.020	0.010	0.0034
	Chloroform	70	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072
	Chloromethane	1.8	0.12	J,*	0.50	0.20	0.0068	ND	U,*	0.50	0.20	0.0068	ND	U,*	0.50	0.20	0.0068	ND	U,*	0.50	0.20	0.0068	ND	U,*	0.50	0.20	0.0068
	Ethylbenzene	30	ND	U,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050
	Methylene Chloride	4.8	ND	B,U,*	2.00	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10
	Toluene	40	0.40	J,*	0.50	0.10	0.054	0.37	J,*	0.50	0.10	0.054	0.42	J,*	0.50	0.10	0.054	1.1	*	0.50	0.10	0.054	0.64	*	0.50	0.10	0.054
	Trichloroethene (TCE)	5	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10
	Xylenes, Total	20	ND	U,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18
EPA 6020A	Lead, Dissolved	5.6	0.033		0.020	0.010	0.0040	0.032		0.020	0.010	0.0040	0.044		0.020	0.010	0.0040	0.012	J	0.020	0.010	0.0040	0.013	J	0.020	0.010	0.0040

Only chemicals that have been detected since 2010 are included in this table.
Data are reported in micrograms per liter (µg/L). Shaded values exceeded the DOH Tier 1 EALs.

B — B - Compound identified during validation in the blank. Result was changed to ND if the reported concentration was below the concentration detected in the blank. Results remain reported in the laboratory provided report.
D — The reported result is from a dilution.
DOH EAL — DOH Tier 1 Environmental Action Levels for groundwater *where groundwater* is a current drinking water source *and is located within* 150 meters from surface water (DOH, Fall 2011).
EPA — Environmental Protection Agency
* — Analyzed passed the EPA recommended holding time.
i — The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
J — The result is an estimated value.
L — The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
TB — Compound was identified in the trip blank at a concentration higher than detected in sample.

LOD — Limit of Detection
LOQ — Limit of Quantitation
ND — Not Detected
Q — Qualifiers
U — The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
Y — The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z — The chromatographic fingerprint does not resemble a petroleum product.

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SECTION 3 – DATA QUALITY ASSESSMENT

A data quality assessment, which consists of a review of the overall groundwater sample collection and analysis process, was performed in order to determine whether the analytical data generated met the decision quality objectives (DQOs) for the project and if the data is usable for the intended purpose. The data quality assessment was performed in accordance with the approved WP/SAP (E2, 2015). The field Quality Control program consisted of standardized sample collection and management procedures, and the collection of field duplicate samples, matrix spike [MS] samples, and trip blank samples. The laboratory quality assurance program consisted of the use of standard analytical methods and the preparation and analyses of MS/Matrix Spike Duplicate [MSD] samples, surrogate spikes, blanks, and Laboratory Control Samples [LCSs]/Laboratory Control Sample Duplicates [LCSDs].

3.1 DATA VALIDATION AND ASSESSMENT

The objective of data validation is to provide data of known quality for project decisions. Data quality is judged in terms of Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity [PARCCS]. A number of factors may affect the quality of data, including: sample collection methods, sample analysis methods, and adherence to established procedures for sample collection, preservation, management, shipment, and analysis.

Precision

Precision is defined as the reproducibility of replicate measurements. Precision is evaluated by Relative Percentage Difference [RPD] of field duplicate, LCS/LCSD, and MS/MSD results. Field duplicate and MS/MSD samples were collected at a rate of approximately 25% of project samples. Field duplicates were sent to the laboratory along with the primary samples.

The RPDs of detected analytes for the primary and field duplicate samples (ERH004 and ERH005) are provided in Table 3.1. An RPD of less than 50% for duplicate pairs is required by the DON *Project Procedures Manual* to be considered acceptable (DON, 2007). The RPDs for duplicate sample pairs for all analytes met acceptance criteria.

Accuracy

Accuracy is defined as the degree of conformity of a measurement to a standard or true value. Accuracy is evaluated through measurement of the percent recovery of an analyte in a reference standard or spiked sample. Accuracy limits for surrogates, laboratory control spike, MS, and MSD samples are either prescribed by the Department of Defense [DoD] or established by the individual laboratory. The acceptance criteria for accuracy are dependent on the analytical method and are based on historical laboratory or DoD data.

The fairly large error inherent to the analysis of diesel- and oil-range hydrocarbons by EPA Method 8015 should be considered when results are compared to each other, to action levels, and to results from previous sampling events. Any comparative analysis of the results should

take into consideration the fairly wide method acceptance limits as per DoD Quality Systems Manual [QSM] 5.0 (36-132%).

All MS and/or MSD recoveries met the control limit criteria, indicating that negative matrix effects were negligible with all analysis.

All surrogate spike recoveries met the control limit criteria indicating that Laboratory procedures were meeting method analyte recovery criteria.

The data accuracy for this monitoring event is considered acceptable.

Representativeness

Representativeness is the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness was achieved by conducting sampling in accordance with the sample collection procedures described in the project WP/SAP, including standardized sample collection methods (ESI, 2012).

Representativeness is also evaluated through the compliance with the standardized sample holding time and sample preservation methods, and through the analysis of blank samples, including method blank and trip blank samples.

Samples analyzed for volatile organic compounds by EPA 8260C were run passed the EPA recommended holding time of 14 days. Samples were preserved and kept chilled. The data appear to indicate that volatile concentrations do not demonstrate an overall low bias as seen by consistent concentrations of ethylbenzene and xylenes in RHMW02 as compared to past sampling rounds, however a low bias may exist.

For this sampling event, one trip blank was included with the cooler containing samples for VOC and TPH-g analysis to assess the potential for contamination during sample transport. Chloroform, methylene chloride and toluene were detected in the trip blank at concentrations below their respective LOQs.

Additionally, methylene chloride, toluene, TPH-d, TPH-o, benz(a)anthracene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene and naphthalene were detected in the method blank at concentrations below their respective LOQs. Presence of these compounds at comparable levels in project samples likely indicate positive interference from laboratory procedures (laboratory contamination). Subsequently, detections for compounds identified in the method blank were changed to ND in Tables 2-1 and 3-1.

The consistently high pH (10 to 13) observed over several sampling events in well OWDFMW01 is atypical for the groundwater in the area and suggests, along with the presence of acetone, that there may be a deficiency in the concrete or bentonite sealing materials used in the construction of the well, or some other localized condition in the vicinity of the well.

Consequently, the associated sample data (ERH002) may not accurately represent the conditions of the groundwater at the site.

With the exceptions noted above, the groundwater sample data are considered representative of the groundwater quality at the site. A summary of the trip blank results is provided in Table 3.1.

Completeness

Completeness is defined as the overall percentage of valid analytical results (including estimated results) compared to the total number of analytical results reported by the laboratory. No data were rejected for this project, and therefore the completeness goal for this project (90%) was successfully met.

Comparability

Comparability expresses the confidence with which one data set can be compared to another data set. Comparability can be related to accuracy and precision because these quantities are measures of data reliability. Data with acceptable precision and accuracy are considered comparable if collection techniques, analytical procedures, methods and reporting are equivalent. For this monitoring event, the samples were collected using approaches consistent with those in the previous events, and the same analytical methods/procedures were used to measure the concentration of COPCs. The field and laboratory personnel followed standard operating procedures. With the exceptions noted below, the results are considered comparable within this data set and with the data collected from previous sampling events.

All samples collected from wells OWDFMW01, HDMW2253-03, and RHMW04 from October 2010 to and including February 2015 were analyzed by Calscience Environmental Laboratories in Garden Grove, CA (now Eurofins Calscience). Samples collected from wells RHMW06 and RHMW07 in October 2014 and January 2015 were analyzed by APPL Laboratories, Inc. of Clovis, CA and EMAX Laboratories of Torrance, CA. Samples collected from all five wells in April, July, and October 2015 were analyzed by ALS Environmental in Kelso, WA. Analytical MDLs, LODs, and LOQs were lower for most analytes than they had been prior to April 2015, and several VOCs and PAHs have been detected since April 2015 at concentrations that would have been below previous LODs and therefore not detected. The method used to analyze 1,2-dichloroethane, bromodichloromethane, dibromochloromethane, and 1,1,2,2-tetrachloroethane was changed from EPA Method 8260 to EPA Method 8260-SIM to improve sensitivity. Correspondingly, analysis of 1,2-dibromo-3-chloropropane and 1,2-dibromoethane was changed from EPA Method 8260 to EPA Method 8011 for the same reason. The significantly improved reporting limits should be considered when results are compared to data from previous events.

Additionally, during the April 2015 event, TPH-o was added to the analyte list. There are very few previous TPH-o results to compare this data to.

Between August 2009 and July 2010, naphthalene was analyzed for by both EPA Methods 8260B and 8270C-SIM, and beginning in October 2010, only results using EPA Method 8270C-SIM were reported. Naphthalene was not detected in groundwater from either well HDMW2253-03 or OWDFMW01 until November 2012 and has never been detected in RHMW04; however, when both methods were used for samples collected from inside well RHMW02, concentrations of naphthalene detected by EPA Method 8260B were generally two to three times higher than those detected by EPA Method 8270C-SIM. We assume this is due to the better preservation of VOCs associated with the use of EPA Method 8260B. This suggests that the naphthalene results provided by EPA Method 8270C-SIM may be biased low. Naphthalene concentrations in samples collected beginning in October 2010 were analyzed using EPA Method 8270C-SIM and results may be biased low. However, naphthalene concentrations in project samples have been orders of magnitude below DOH EALs, and this potential low bias should not affect project decisions.

The TPH-g analysis of project samples through July 2010 was performed using EPA Method 8015. Between October 2010 and January 2015, EPA Method 8260B was used. Beginning with the April 2015 event, EPA Method 8015 was used again. There was no event where both methods were used; consequently, there is no way to directly compare the results obtained by the two methods and to assess potential bias. However, there is no reason to believe that using either method should bias the data, and the TPH-g data for all events should be comparable.

Other than the lower detection limits, the addition of TPH-o to the analyte list, and the naphthalene bias discussed above, no other issues with comparability were identified. The results are considered comparable within this data set and with the data collected from recent sampling events.

Sensitivity

The LOQs are established by the laboratory based on the LODs or instrument detection limits, historical data, and EPA limits established for the various methods. The LOQs and LODs for samples may require adjustment by the laboratory due to matrix interference or if high levels of target analytes necessitate dilution before analysis. Matrix interference and sample dilutions have the effect of decreasing sensitivity and increasing the LOQs/LODs.

All LODs were sufficiently low to satisfy project DQOs. The limits for several analytes were significantly lower than in historical sampling events. The impact on comparability of the data to historical data is described in the comparability section of this report. The laboratory, in several cases, indicated issues with relative response factors determined for initial calibrations or calibration verifications of certain VOCs. In every case, the laboratory verified that the sensitivity was sufficient to detect the affected compounds at their respective LOQs. All LOQs for the affected analytes were below the EALs, indicating that any potential impact on sensitivity was minor and irrelevant in terms of project decisions.

3.2 DATA ASSESSMENT AND USABILITY CONCLUSIONS

The PARCCS criteria were evaluated, and with some exceptions, all criteria were met. Results associated with QC data that failed acceptance criteria are discussed in detail in Section 3.1 of this report. Data quality issues that need to be taken into account for project decisions are summarized below.

Samples analyzed for volatile organic compounds by EPA 8260C were run passed the EPA recommended holding time of 14 days. Samples were preserved and kept chilled. The data appear to indicate that volatile concentrations do not demonstrate an overall low bias as seen by consistent concentrations of ethylbenzene and xylenes in RHMW02 as compared to past sampling rounds, however a low bias may exist.

The data assessment concludes that all data generated during this event are usable for the intended purpose, with the limitations described above.

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TABLE 3.1
Quality Control Results for Groundwater Sampling (19 October 2015)
Red Hill Bulk Storage Facility
October 2015 Quarterly Monitoring Report

Method	Chemical	DOH EAL	RHMW06 (ERH004) <150 meters from surface water					RHMW06 (ERH005) (DUP) <150 meters from surface water					RPD Duplicate %	Trip Blank				
			Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL		Result	Q	LOQ	LOD	DL
EPA 8015C	TPH-g	100	ND	U	50	25	13	ND	U	50	25	13	NA	ND	U	50	25	13
	TPH-d	100	17	B,J	53	21	12	ND	B,U	53	21	12	NA	-	-	-	-	-
	TPH-o	100	ND	B,U	110	53	20	ND	B,U	110	53	20	NA	-	-	-	-	-
EPA 8270D SIM	Acenaphthene	20	ND	U	0.019	0.0050	0.0044	ND	U	0.020	0.0050	0.0044	NA	-	-	-	-	-
	Acenaphthylene	30	ND	U	0.019	0.0050	0.0034	ND	U	0.020	0.0050	0.0034	NA	-	-	-	-	-
	Benz(a)anthracene	0.27	ND	B,U	0.019	0.0050	0.0026	ND	B,U	0.020	0.0050	0.0026	NA	-	-	-	-	-
	Benzo(g,h,i)perylene	0.1	ND	B,U	0.020	0.0050	0.0029	ND	B,U	0.019	0.0050	0.0029		-	-	-	-	-
	Fluoranthene	8	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	NA	-	-	-	-	-
	Fluorene	3.9	ND	U	0.019	0.0050	0.0038	ND	U	0.020	0.0050	0.0038	NA	-	-	-	-	-
	1-Methylnaphthalene	2.1	ND	U	0.019	0.0050	0.0035	ND	U	0.020	0.0050	0.0035	NA	-	-	-	-	-
	2-Methylnaphthalene	2.1	ND	B,U	0.019	0.0050	0.0023	ND	B,U	0.020	0.0050	0.0023	NA	-	-	-	-	-
	Naphthalene	17	ND	B,U	0.019	0.0050	0.0038	ND	B,U	0.020	0.0050	0.0038	NA	-	-	-	-	-
	Phenanthrene	4.6	ND	U	0.019	0.0050	0.0050	ND	U	0.020	0.0050	0.0050	NA	-	-	-	-	-
	Pyrene	2	ND	U	0.019	0.010	0.0053	ND	U	0.020	0.01	0.0053	NA	-	-	-	-	-
EPA 8260C/ 8260-SIM/ 8011	1,1,1,2-Tetrachloroethane	0.067	ND	U	0.020	0.015	0.0087	ND	U	20	15	8.7	NA	ND	U,*	0.020	0.015	0.0087
	1,2,3-Trichloropropane	0.6	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	NA	ND	U,*	0.50	0.50	0.20
	1,2-Dibromo 3-Chloropropane	0.04	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	NA	ND	U,*	2.0	0.80	0.22
	1,2-Dibromoethane (EDB)	0.04	ND	U	0.010	0.0040	0.0030	ND	U	0.010	0.0040	0.0030	NA	ND	U,*	2.0	0.20	0.10
	1,2-Dichloroethane	0.15	ND	U	0.020	0.015	0.0058	ND	U	20	15	5.8	NA	ND	U	0.020	0.015	0.0058
	Acetone	1500	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3	NA	ND	U,*	20	10	3.3
	Benzene	5	ND	U,*	0.50	0.10	0.062	ND	U,*	0.50	0.10	0.062	NA	ND	U,*	0.50	0.10	0.062
	Bromodichloromethane	0.12	ND	B,J	0.020	0.010	0.0034	ND	B,J	0.020	0.010	0.0034	NA	ND	B,J	0.020	0.010	0.0034
	Chloroform	70	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	NA	0.09	J,*	0.50	0.20	0.072
	Chloromethane	1.8	ND	U,*	0.50	0.20	0.0068	ND	U,*	0.50	0.20	0.0068	NA	ND	U,*	0.50	0.20	0.0068
	Ethylbenzene	30	ND	U,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050	NA	ND	U,*	0.50	0.10	0.05
	Methylene Chloride	4.8	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	NA	0.16	J,*	2.0	0.20	0.10
	Toluene	40	1.1	*	0.50	0.10	0.054	0.5	*	0.50	0.10	0.054	18.8%	0.89	*	0.50	0.10	0.054
	Trichloroethene (TCE)	5	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	NA	ND	U,*	0.50	0.10	0.10
	Xylenes, Total	20	ND	U,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18	NA	ND	U,*	1.0	0.20	0.18
EPA 6020A	Lead, Dissolved	5.6	0.012	J	0.020	0.010	0.0040	0.016	J	0.020	0.010	0.0040	7.1%	-	-	-	-	-

Only chemicals that have been detected since 2010 are included in this table.
Data are reported in micrograms per liter (µg/L).

B — B - Compound identified during validation in the blank. Result was changed to ND if the reported concentration was below the concentration blank. Results remain reported in the laboratory provided report.
D — The reported result is from a dilution.
DOH EAL — DOH Tier 1 Environmental Action Levels for groundwater where groundwater is a current drinking water source and is located within 150 meters from surface water (DOH, Fall 2011).
EPA — Environmental Protection Agency
* — Analyzed passed the EPA recommended holding time
i — The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
J — The result is an estimated value.
L — The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.

LOD — Limit of Detection
LOQ — Limit of Quantitation
ND — Not Detected
Q — Qualifiers
U — The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.

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SECTION 4 – SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This quarterly monitoring report presents the results of groundwater sampling conducted on 19 October 2015, at the RHSF, JBPHH, Hawaii. The RHSF is located in Halawa Heights on the Island of Oahu. The DOH Facility ID number for the RHSF is 9-102271. The DOH Release ID numbers are 990051, 010011, 020028, and 140010.

The groundwater sampling was conducted as part of the long-term groundwater and soil vapor monitoring program at the RHSF for NAVSUP FLC Pearl Harbor, under NAVFAC Contract Number N62742-14-D-1884. The sampling was conducted in accordance with the approved WP/SAP and Technical Addendum prepared by E2.

E2 personnel collected groundwater samples from five monitoring wells (wells HDMW2253-03, OWDFMW01, RHMW04, RHMW06, and RHMW07). One primary sample and one duplicate sample were collected from well RHMW06. A summary of the analytical results is provided below.

- **OWDFMW01** – Concentrations of TPH-d (680 µg/L) and TPH-o (100 µg/L) were detected above and at their respective DOH Tier 1 EALs. Lead (0.033 µg/L) and several VOCs and PAHs were also detected; however, none of these detected concentrations exceeded their respective DOH Tier 1 EALs. Several PAHs and VOC methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. Due to the consistent high hydrogen activity (pH) and presence of acetone in well OWDFMW01, contamination from another source may be impacting the well.
- **HDMW2253-03** – The only analytes detected in groundwater were TPH-d (21 µg/L), TPH-g (16 µg/L), VOC toluene (0.37 µg/L) and lead (0.032 µg/L). The concentrations did not exceed the DOH Tier 1 EALs. TPH-o and several PAHs were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. With the exception of one possibly erroneous result obtained during the event in April 2014, TPH-d concentrations have not exceeded the DOH Tier 1 EAL in well HDMW2253-03 since January 2013.
- **RHMW04** – The only analytes detected in groundwater were several PAHs and lead (0.044 µg/L). The concentrations did not exceed their respective DOH Tier 1 EALs. TPH-d, TPH-o and several PAHs were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.
- **RHMW06** – The only analytes detected in groundwater were TPH-d (17 and 15 µg/L), VOCs bromodichloromethane (0.00044 µg/L) (only in the primary sample), toluene (1.10 and 0.50 µg/L) and lead (0.012 and 0.016 µg/L). None of the detected concentrations

exceeded their DOH Tier 1 EALs. TPH-o, several PAHs and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.

- **RHMW07** – The analytes detected in groundwater were TPH-d (26 µg/L), PAH 1-methylnaphthalene (0.0067 µg/L) , VOC toluene (0.64 µg/L) and lead (0.013 µg/L). The concentrations did not exceed their respective DOH Tier 1 EALs. TPH-o, several PAHs and VOC methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report.

Groundwater Contaminant Trends

Historical groundwater contaminant concentration trends of COPCs that exceeded the DOH EALs are presented in Appendix E. A summary of groundwater contaminant trends for the five monitoring wells is provided below.

- **OWDFMW01** – TPH-d and TPH-o were detected in both samples from this well at concentrations exceeding and at their respective DOH Tier 1 EALs. Concentrations of all other COPCs detected during this round of quarterly sampling were consistent with historical data.
- **HDMW2253-03** – TPH-d was detected in this well at a concentration below the DOH Tier 1 EAL. With the exception of one possibly erroneous result obtained during the event in April 2014, TPH-d concentrations have not exceeded the DOH Tier 1 EAL in well HDMW2253-03 since January 2013.
- **RHMW04** – Concentrations of TPH-d and TPH-o were detected in this well above the previous reported concentrations but remain below the respective DOH Tier 1 EALs. Concentrations of all other COPCs detected during this round of quarterly sampling were below the detection limits of the historical analytical results.
- **RHMW06** – This well was installed in September 2014 and first sampled in October 2014. To date, no COPCs have been detected at concentrations exceeding the DOH Tier 1 EALs.
- **RHMW07** – This well was installed and first sampled in October 2014. To date, no COPCs have been detected at concentrations exceeding the DOH Tier 1 EALs.

Conclusions and Recommendations

During the October 2015 sampling event, TPH-d and TPH-o were detected at concentrations above and at their respective DOH Tier 1 EALs in OWDFMW01. The majority of the TPH-d concentration reported for the samples from OWDFMW01 was caused by one single peak. The compound or compound mixture represented by the single peak did not resemble a petroleum fuel. For both TPH-d and TPH-o in OWDFMW01, the total concentrations reported are likely inaccurate, because they were determined by comparison to a diesel and an oil standard, respectively. Additional scrutiny of the TPH-d concentrations in well OWDFMW01 is warranted.

Acetone has been detected in well OWDFMW01 at low concentrations occasionally since October 2010 and then in every groundwater sampling event since April 2013. The well also has an unnaturally high pH in the range of 10 to 13. As discussed in Section 3, these conditions are likely unrelated to a release from the USTs at RHSF and may be a result of a deficiency in the well sealing material or another condition isolated to the immediate area of the well. This suggests that the associated sample data may not accurately represent the conditions of the groundwater at the site.

The groundwater contaminant concentrations in wells HDMW2253-03, RHMW04, RHMW06 and RHMW07 remained low and did not change significantly since the previous sampling event (July 2015), or were not detected. No COPCs were detected at concentrations above their respective DOH Tier 1 EALs in these four wells.

Detections of TPH-d, TPH-o and PAHs below the LOQ were likely a result of low level laboratory contamination as seen in the laboratory method blank.

Based on a suspected 2014 release at the RHSF and the results of the recent groundwater sampling and analysis, continued groundwater monitoring at the RHSF is recommended. If the TPH-d concentrations significantly increase, the monitoring frequency should be increased to monthly, even though wells OWDFMW01, HDMW2253-03, RHMW04, RHMW06, and RHMW07 are not included in the RHSF Groundwater Protection Plan.

An alternative means of collecting groundwater samples from the vicinity of well OWDFMW01 should be evaluated if TPH impacts continue to trend upwards and high pH conditions persist.

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SECTION 5 – FUTURE WORK

Future work includes the first quarter 2016 groundwater monitoring, which is tentatively scheduled for January 2016. A quarterly groundwater monitoring report will be prepared to document the sampling.

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APPENDIX A

Groundwater Sampling Logs

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Figure 1-C-3-1
Groundwater Sampling Log

Project Number: 150037 Date: 10-19-2015

Location: RHFS Time: 11:35

Well Number: OWDFMW01 Climatic Conditions: Sunny, partly cloud, light NE wind

Initial Measurements: Static Water Level: 120.88 @ 11:50
Total Depth:

Well Purging: Length of Saturated Zone: _____ linear feet
Volume of Water to be Evacuated: _____ gals./linear ft. x
Linear feet of Saturation x Casing Volumes* = _____ gallons
Method of Removal: Bladder Pump
Pumping Rate: _____ gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/19/15 1158	0.3	11.22	33.41	1.64	-69.8	7.1
10/19/15 1202	0.6	11.33	33.62	2.45	-49.8	8.8
10/19/15 1206	0.9	11.34	33.68	2.41	-34.1	9.4
10/19/15 1209	1.2	11.12	32.76	2.03	-33.2	11.7
10/19/15 1212	1.5	11.33	33.48	2.15	-33.3	7.7

Sample Withdrawal Method: Bladder Pump
Appearance of Sample:
Color Clear
Turbidity
Sediment None
Other

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly with (HNO3); (6) 40-mL VOA vials with HCl; and (1) 40-mL VOA vial with Na2S2O3

Sample Identification Number(s): ERH002

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals; well head PID 1140, 0 ppm

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete
Samples delivered to:
Date/Time:
Transporters:

* Capacity of casing (gallons/linear foot): 2”-0.16, 4”-0.65, 6”-1.47, 8”-2.61, 10”-4.08, 12”-5.87

Figure 1-C-3-1
Groundwater Sampling Log

Project Number: 150037 Date: 10-19-2015

Location: Halawa Time: 08:55

Well Number: HDMW2253-03 Climatic Conditions: Sunny, partly cloudy, light NE wind

Initial Measurements: Static Water Level: 208.40 @ 10:19
Total Depth: 1575

Well Purging: Length of Saturated Zone: _____ linear feet
Volume of Water to be Evacuated: _____ gals./linear ft. x
Linear feet of Saturation x Casing Volumes* = _____ gallons
Method of Removal: Bailer
Pumping Rate: _____ gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/19/15 1027	0.3	6.95	502	1.42	-95.0	55.3
10/19/15 1032	0.4	6.33	493.7	2.57	-77.5	52.0
10/19/15 1039	0.7	6.73	490.1	3.75	-46.8	122.0
10/19/15 1042	0.9	6.71	493.8	3.64	-59.1	58.2

Sample Withdrawal Method: Bailer/Teflon
Appearance of Sample:
Color Clear
Turbidity
Sediment None
Other Floating Algae/Organics

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO (none); TPH-GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); Total Lead (HNO3); and EDB (none)
Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (1) 500-mL Amber glass jars (HCl); (2) 500-mL Amber glass jars; (7) 40-mL VOA vials
Sample Identification Number(s): RH-MW2253-GW415/ERH001

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete
Samples delivered to: _____
Date/Time: _____
Transporters: _____

* Capacity of casing (gallons/linear foot): 2”-0.16, 4”-0.65, 6”-1.47, 8”-2.61, 10”-4.08, 12”-5.87

Figure 1-C-3-1
Groundwater Sampling Log

Project Number: 150037 Date: 10-19-2015

Location: RHFS Time: 11:35

Well Number: RHMW04 Climatic Conditions: Sunny, partly cloudy, light NE wind

Initial Measurements: Static Water Level: 294.61 @ 15:15
Total Depth:

Well Purging: Length of Saturated Zone: _____ linear feet
Volume of Water to be Evacuated: _____ gals./linear ft. x
Linear feet of Saturation x Casing Volumes* = _____ gallons
Method of Removal: Bladder Pump
Pumping Rate: _____ gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/19/15 1544	0.1	7.69	473.3	7.10	-6.4	4.3
10/19/15 1548	0.25	6.72	454.9	7.09	69.2	2.5
10/19/15 1550	0.5	5.92	451.5	7.30	165.9	1.9
10/19/15 1555	1.25	5.69	452.7	7.28	19.09	1.7
10/19/15 1558	1.5	5.63	452.5	7.25	203.5	1.7
10/19/15 1601	1.60	5.60	452.8	7.22	216.3	1.8

Sample Withdrawal Method: Bladder Pump
Appearance of Sample:
Color Clear
Turbidity
Sediment None
Other Sulfur odor

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly with (HNO3); (6) 40-mL VOA vials (HCl); and (1) 40-mL VOA vial (Na2S2O3)

Sample Identification Number(s):

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete
Samples delivered to:
Date/Time:
Transporters:

* Capacity of casing (gallons/linear foot): 2”-0.16, 4”-0.65, 6”-1.47, 8”-2.61, 10”-4.08, 12”-5.87

Figure 1-C-3-1
Groundwater Sampling Log

Project Number: 150037 Date: 10-19-2015

Location: RHFS Time: 13:46

Well Number: RHMW06 Climatic Conditions: Sunny, partial clouds, light NE wind

Initial Measurements: Static Water Level: 2410.69 @ 14:00
Total Depth:

Well Purging: Length of Saturated Zone: _____ linear feet
Volume of Water to be Evacuated: _____ gals./linear ft. x
Linear feet of Saturation x Casing Volumes* = _____ gallons
Method of Removal: Dedicated Submersible Bladder Pump
Pumping Rate: 0.25 L/min gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/19/15 1407	0.25	7.60	1584	7.70	90.4	2.1
10/19/15 1412	1.0	7.02	1686	6.34	92.7	5.1
10/19/15 1416	2.0	6.88	1718	6.20	73.5	3.4
10/19/15 1420	2.5	6.86	1722	6.19	68.8	2.8
10/19/15 1425	3.0	6.85	1722	6.13	74.5	2.8

Sample Withdrawal Method: Dedicated Submersible Bladder Pump
Appearance of Sample:
Color Clear
Turbidity
Sediment None
Other No odor

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly (HNO3); (6) 40-mL VOA vials (HCl); and (1) 40-mL VOA vial (Na2S2O3)

Sample Identification Number(s): ERH004@1435, Sample Duplicate ERH005@1455

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals; well head PID 1355; 264 ppb

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete
Samples delivered to:
Date/Time:
Transporters:

* Capacity of casing (gallons/linear foot): 2”-0.16, 4”-0.65, 6”-1.47, 8”-2.61, 10”-4.08, 12”-5.87

Figure 1-C-3-1
Groundwater Sampling Log

Project Number: 150037 Date: 10-19-2015

Location: RHFS Time: 12:41

Well Number: RHMW07 Climatic Conditions: Sunny, partial clouds, light NE wind

Initial Measurements: Static Water Level: 198.88 @ 12:56
Total Depth:

Well Purging: Length of Saturated Zone: _____ linear feet
Volume of Water to be Evacuated: _____ gals./linear ft. x
Linear feet of Saturation x Casing Volumes* = _____ gallons
Method of Removal: Bladder Pump
Pumping Rate: 0.5 L/min gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/19/15 1306	1.0	7.47	1708	2.68	116.0	1.4
10/19/15 1309	2.0	7.28	1796	1.64	109.8	1.3
10/19/15 1312	2.5	7.23	1793	1.56	97.0	1.2
10/19/15 1315	3.0	7.21	1793	1.48	86.0	1.3
10/19/15 1319	3.5	7.18	1788	1.50	81.1	1.3
10/19/15 1321	4.0	7.17	1779	1.40	77.1	1.5

Sample Withdrawal Method: Dedicated Submersible Bladder Pump
Appearance of Sample:
Color Clear
Turbidity
Sediment Light/None
Other No observable odor

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly with (HNO3); (6) 40-mL VOA vials with HCl; and (1) 40-mL VOA vial with Na2S2O3

Sample Identification Number(s): ERH003

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete
Samples delivered to:
Date/Time:
Transporters:

* Capacity of casing (gallons/linear foot): 2”-0.16, 4”-0.65, 6”-1.47, 8”-2.61, 10”-4.08, 12”-5.87

APPENDIX B

Field Notes

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10/19/15
Activity: Quarterly GW sampling
Team: E2: M.H, M.N, J.T NAVFAC: D. Uchima DLNR: Bob Chenoy
PPE: Level D
Weather: Clear, light trades
Refs: WP/SAP, PDM

0850- Tailgate mtg
0855- Proceed w/ setup @ well HDMW2253-03
(H. Correctional Facility).
0910- Calibrate YSI using:

pH	10.0	C359085
pH	7.0	SAB556
pH	4.0	SAA223
EC	1413	SAA927

} Lot #s

10:27 BEGIN PURGE
10:42 END PURGE
10:45 BEGAN SAMPLING. SAMPLE TIME
11:20 LEFT SITE.

11:35 ARRIVED AT SITE OWDFMW01

11:40 TOOK PID READING
11:58-12:12 ~~AUGH~~ BEGIN/END PURGE
12:18 BEGAN SAMPLING — SAMPLE TIME
12:35 LEFT SITE

12:41 ARRIVED ONSITE @ ~~RHMW2254-01~~ RHMW07
12:46 PID MEASUREMENT, = READING = 0.
13:06 BEGAN PURGE

* Pump Controller Settings:
① Pressure: 110 psi (gauge)
② Fill Time 50 seconds
③ Discharge Time 30 seconds

* CO_2 Tank Settings:
① 160 psi

10/19/15

SAMPLE LOG:

SAMPLED BY: MH, MN, JT

ARRIVED: 9:05 AM

EPA ID:	SAMPLE ID	~~TIME~~ DATE	TIME
ERH001	RH-MW2253-GW415	10/19/15	10:45
ERH002	RH-OWDFMW01-GW415	10/19/15	12:10
ERH003	RH-MW07-GW415	10/19/15	~~13:00~~ 13:25
ERH004	RH-MW06-GW415	10/19/15	~~13:40~~ 14:35
ERH005	RH-MW06-GW415	10/19/15	DUPLICATE 14:55
ERH006	RH-MW04-GW415	10/19/15	16:20
ERH007	~~MS~~ MS	10/19/15	16:20
ERH008	MSD	10/19/15	16:20

Rite in the Rain

1325 Collect GW sample from RHMW07 - ERH003

1335 Complete sample collection - clean up.

13:44 LEFT SITE

13:46 ARRIVED AT SITE @ RHMW06

13:56 PID READING TAKEN.

14:00 Begin purge

1435 Sample Time RHMW06 ERH004
1455 Blind Duplicate Sample Time ERH005

1510 - leave well, proceed to next well.

1515 - Setup @ well RHMW04

1520 Begin purge RHMW04

~~1620~~

Pump Controller settings - RHMW04:

1. pressure 160 psi
2. Fill time 60-70 seconds
3. Discharge time 50 wells

1620: Sample time ERH006 (primary) ERH007 MS, ERH008 MSD

1645 leave site - proceed to IDW drum to drop buckets - label drum.

1710 - leave RHSF.

10-19-15

APPENDIX C

Laboratory Reports
(included on attached CD)

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APPENDIX D
Fact Sheet, Quantitation & Detection

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Fact Sheet: Detection and Quantitation — What Project Managers and Data Users Need to Know

As a Project Manager or decision-maker, you may use environmental data to accomplish one or more of the following tasks:

- Determine whether a chemical substance is present in an environmental sample at or above some threshold value or action level;
- Verify that a pollutant concentration remains below a permit limit;
- Evaluate potential risks to human health or the environment;
- Monitor changes in concentrations of contaminants; or
- Determine the effectiveness of remediation activities.

Making correct decisions in these cases often depends on the ability of an analytical method to detect and measure extremely low concentrations of a substance.

This fact sheet has been prepared to: 1) provide Project Managers and data users with basic information about detection and quantitation concepts; and 2) acquaint the reader with detection and quantitation terminology and requirements contained in the *DoD Quality Systems Manual for Environmental Laboratories (DoD QSM)*, Version 4.1. This information should help clarify the uncertainty associated with reporting low-concentration data. It should also help project teams understand the importance of selecting analytical methods that are sensitive enough for their intended uses, i.e., capable of generating reliable data (data of known precision and bias) at the project-specific decision levels.

Measures of Sensitivity — Basic Concepts

The following terms are used to describe the routine sensitivity of analytical procedures:

- DL – Detection Limit
- LOD – Limit of Detection
- LOQ – Limit of Quantitation

All measures of sensitivity are specific to the analyte, sample matrix, test method, instrumentation, and analyst/laboratory performance. Therefore, analytical performance must be demonstrated for each variable (e.g., it is possible that two "identical" instruments from the same manufacturer may exhibit different sensitivities).

The Detection Limit (DL) is the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. In other words, if a substance is detected at or above the DL, it can be reliably stated (with 99% confidence) that the analyte is present (there is a 1% chance that the analyte is not present (a false positive)). Note that for reporting purposes, any result at or above the DL must also meet qualitative identification criteria required by the test method. Although a result at or above the DL indicates that the analyte is present, the absence of a result at or above the DL is inconclusive (i.e., one cannot confidently state whether the analyte is present or absent), because the false negative rate at the DL is 50%.

The Limit of Detection (LOD) is the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a 99% confidence level. In other words, if a sample has a true concentration at the LOD, there is a minimum probability of 99% of reporting a "detection" (a measured value $\geq$ DL) and a 1% chance of reporting a non-detect (a false negative).

The failure to obtain a "detection" should be reported as "<LOD," because the false negative rate at the LOD is 1%. Reporting the sample result as "<DL" is inappropriate because, as stated above, the false negative rate at the DL is 50%.

The Limit of Quantitation (LOQ) is the lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias. The LOQ is typically larger than the LOD (but may be equal to the LOD, depending upon the acceptance limits for precision and bias); therefore, the following is true:

$$DL < LOD \leq LOQ$$

Quantitative results can only be achieved at or above the LOQ. Measurements between the DL and the LOQ assure the *presence* of the analyte with confidence, but their numeric values are estimates.

Types of Procedures for Estimating Sensitivity

Numerical estimates of the DL, LOD, or LOQ for a specific analyte, matrix, and method can be calculated using various statistical procedures, which involve spiking reagent water or other specific matrix with low concentrations of the analyte of interest. At this time, unfortunately, universally accepted statistical procedures do not exist.

The estimator that has been most commonly used by environmental laboratories is the EPA Method Detection Limit (MDL), which is an approximation of the DL. EPA has defined the MDL as the "minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, and is determined from analysis of a sample in a given matrix containing the analyte."[1] Calculating the MDL at 99% confidence means there is a 1% probability that a sample having a result at or above the MDL is a false positive. The EPA MDL was designed to protect against false positives.

Uses and Limitations of the MDL

When performed correctly and consistently, MDLs determined using the EPA procedure can be useful for comparing different laboratories' performance using the same methods, or the performance of different methods within the same laboratory. Laboratories typically determine the MDL in reagent water, resulting in a "best-case" MDL, which provides limited information about method performance on real-world samples.

The EPA MDL procedure has been criticized as a poor estimator of the DL for the following reasons:

1. It is a single laboratory, short-term estimator that fails to account for analytical bias, changing instrument conditions, or analyst skill.
2. It assumes uniform variance across all possible spike concentrations, failing to account for the fact that variance increases at higher concentrations.
3. It assumes that measured values at the spike concentration are normally distributed. By using this procedure and spiking at very low concentrations, laboratories have been able to calculate MDLs that cannot be achieved in practice.

DoD QSM Requirements

For the reasons discussed in the previous paragraph, the DoD QSM requires that laboratories verify measures of method sensitivity, in terms of the LOD and LOQ, at least quarterly. Requirements for the LOD and the LOQ are contained in DoD QSM Boxes D-13 and D-14, respectively, which follow:

[1] 40 Code of Federal Regulations (CFR) Part 136, Appendix B, rev. 1.11.

Box D-13

Limit of Detection (LOD): Determination and Verification (Requirement)

A laboratory shall establish a detection limit (DL) using a scientifically valid and documented procedure for each suite of analyte-matrix-method, including surrogates. The detection limit shall be used to determine the LOD for each analyte and matrix as well as for all preparatory and cleanup methods routinely used on samples, as follows:

After each detection limit determination, the laboratory must immediately establish the LOD by spiking a quality system matrix at approximately two to three times the detection limit (for a single-analyte standard) or one to four times the detection limit (for a multi-analyte standard). This spike concentration establishes the LOD. It is specific to each combination of analyte, matrix, method (including sample preparation), and instrument configuration. The LOD must be verified quarterly. The following requirements apply to the initial detection limit/LOD determinations and to the quarterly LOD verifications.

- The apparent signal to noise ratio at the LOD must be at least three and the results must meet all method requirements for analyte identification (e.g., ion abundance, second-column confirmation, or pattern recognition.) For data systems that do not provide a measure of noise, the signal produced by the verification sample must produce a result that is at least three standard deviations greater than the mean method blank concentrations.
- If a laboratory uses multiple instruments for a given method the LOD must be verified on each.
- If the LOD verification fails, then the laboratory must repeat the detection limit determination and LOD verification at a higher concentration or perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration.
- The laboratory shall maintain documentation for all detection limit determinations and LOD verifications.

Box D-14

Limit of Quantitation (LOQ): Establishment and Verification of LOQ (Requirement)

For DoD projects, the LOQ must be set within the calibration range prior to sample analysis. At a minimum, the LOQ must be verified quarterly.

The laboratory procedure for establishing the LOQ must empirically demonstrate precision and bias at the LOQ. The LOQ and associated precision and bias must meet client requirements and must be reported. If the method is modified, precision and bias at the new LOQ must be demonstrated and reported.

Establishing Project-Specific Requirements for Method Sensitivity

Project teams should establish their project-specific requirements for method sensitivity in terms of a Reporting Limit (RL) for each analyte and matrix. As defined in the DoD QSM, the RL is the lowest concentration value specified by the client that meets project requirements for reporting quantitative data with known precision and bias for a specific analyte in a specific matrix. The LOQ cannot be greater than the RL, if precision and bias of the RL and LOQ are the same. If the LOQ for a particular analytical method or laboratory cannot meet the RL, then a project team has three options:

1. Improve analyst performance or modify the method to achieve a lower LOQ.
2. Select a different method with an LOQ less than or equal to the RL.
3. Raise the RL.

Please note that precision and bias must be taken into consideration when assessing the LOQ versus the RL. Also note that data below the RL can be reported; however they are estimated values if less than the LOQ.

Reporting and Flagging Analytical Data

Although data reporting and flagging requirements are project-specific, all reported LOD and LOQ shall be adjusted for the size of sample aliquots, concentration/dilution factors, and percent solids. In addition, the following example (based on Box 47 of DoD QSM Version 4.1) illustrates the proper use of the "U" and "J" data qualifier flags for non-detect and estimated analytical results, respectively.

U – Analyte was not detected and is reported as less than the LOD or as defined by the client. The LOD has been adjusted for any dilution or concentration of the sample (* see Example, below).

J – The reported result is an estimated value (e.g., matrix interference was observed or the analyte was detected at a concentration outside the quantitation range, see Box 33).

Example: DL = 2, LOD = 4, LOQ = 20, and RL = 30 with the precision and bias of the LOQ meeting those of the RL and all samples are undiluted.

Sample #1:	Analytical result: Non-detect	Reported result: <4 U
Sample #2:	Analytical result: 3	Reported result: 3 J
Sample #3:	Analytical result: 10	Reported result: 10 J
Sample #4:	Analytical result: 20	Reported result: 20
Sample #5:	Analytical result: 30	Reported result: 30

Understanding and Documenting Uncertainty for Low-Concentration Data

As mentioned above, detection and quantitation limits are laboratory specific. Following are some steps Project Managers can take to document measurement uncertainty for low concentration data.

- As part of the laboratory selection process, provide the laboratory with project-specific RLs, including precision and bias, for each analyte and matrix. Ask the laboratory to provide its DL, LOD, and LOQ with associated precision and bias for each target analyte, in each matrix of concern (e.g., reagent water, clean sand, etc.), and verify that these values meet project-specific RLs. Request laboratory SOPs for establishing the DL and for establishing and verifying the LOD and LOQ.
- Ask the laboratory to verify the LOD by processing an LOD verification check sample with each batch of samples. This is a quality control sample that is spiked at a concentration at or slightly above the LOD to evaluate whether the analyte of interest is in fact "detectable" in the matrix of interest. To confidently report non-detects, set the reporting for non-detects to less than the LOD.
- If the project involves the collection of unusual or difficult matrices, or if the project-specific RL is near the LOQ, ask the laboratory to verify the LOQ in the project-specific matrix by analyzing a minimum of four replicate samples with known concentrations at the LOQ.
- Review the raw data (e.g., chromatograms) for low-concentration data. If a result is reported above the DL, make sure that the signal-to-noise ratio is at least 3.
- Compare sample results with blank results. If sample results (including chromatograms) cannot be distinguished from blank results, then they are not meaningful.

APPENDIX E

Historical Groundwater Exceedance Trends

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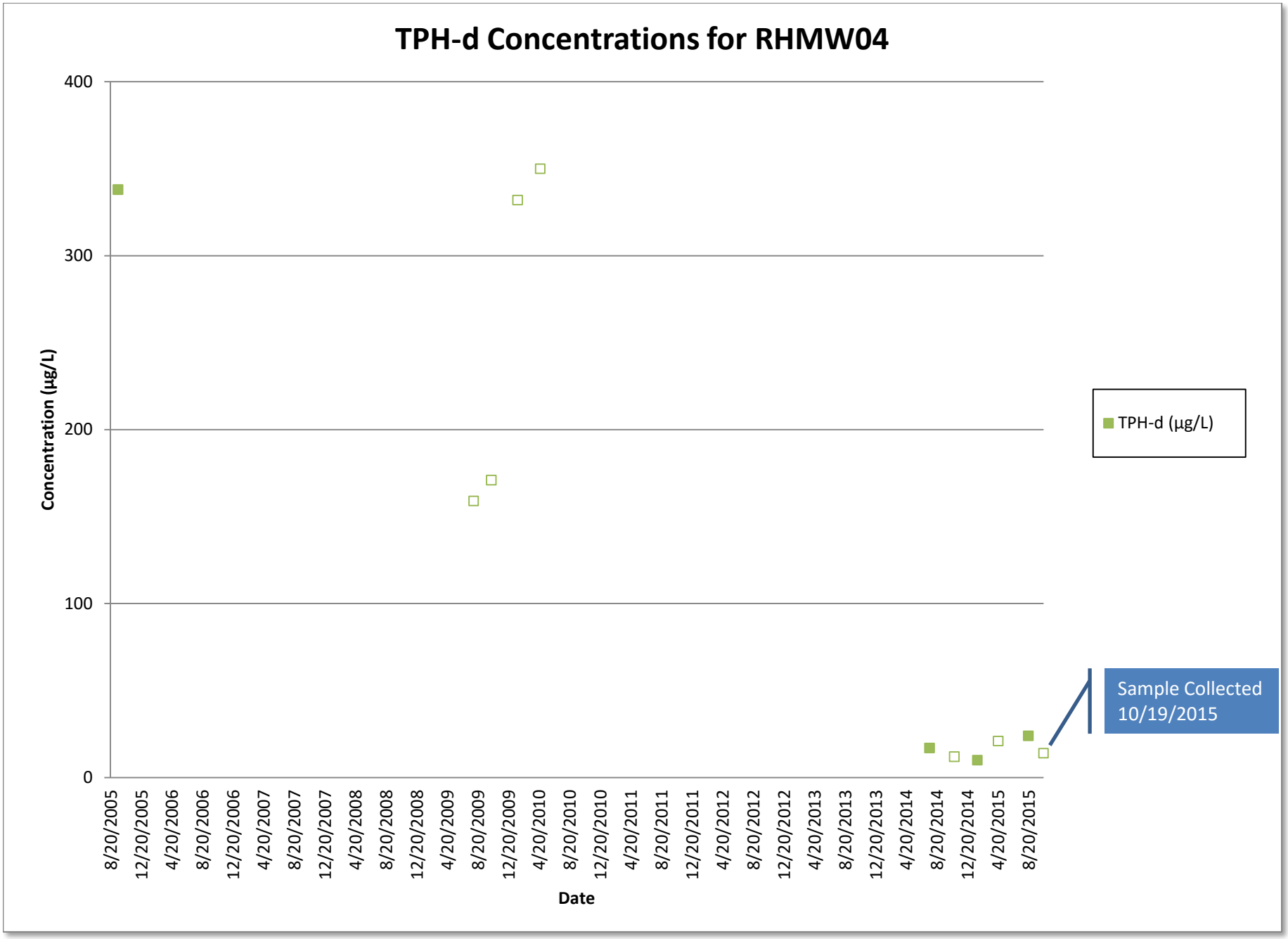
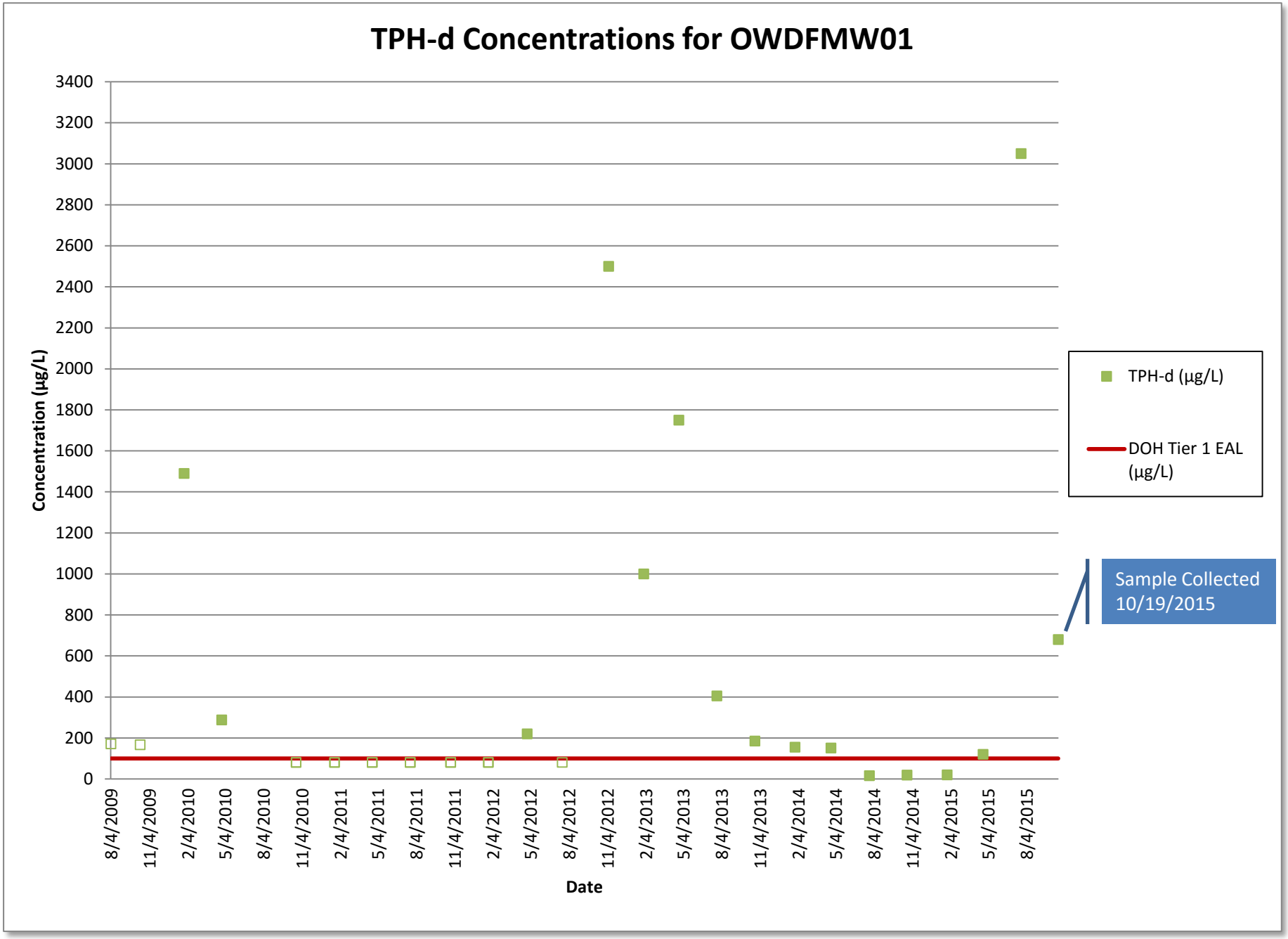
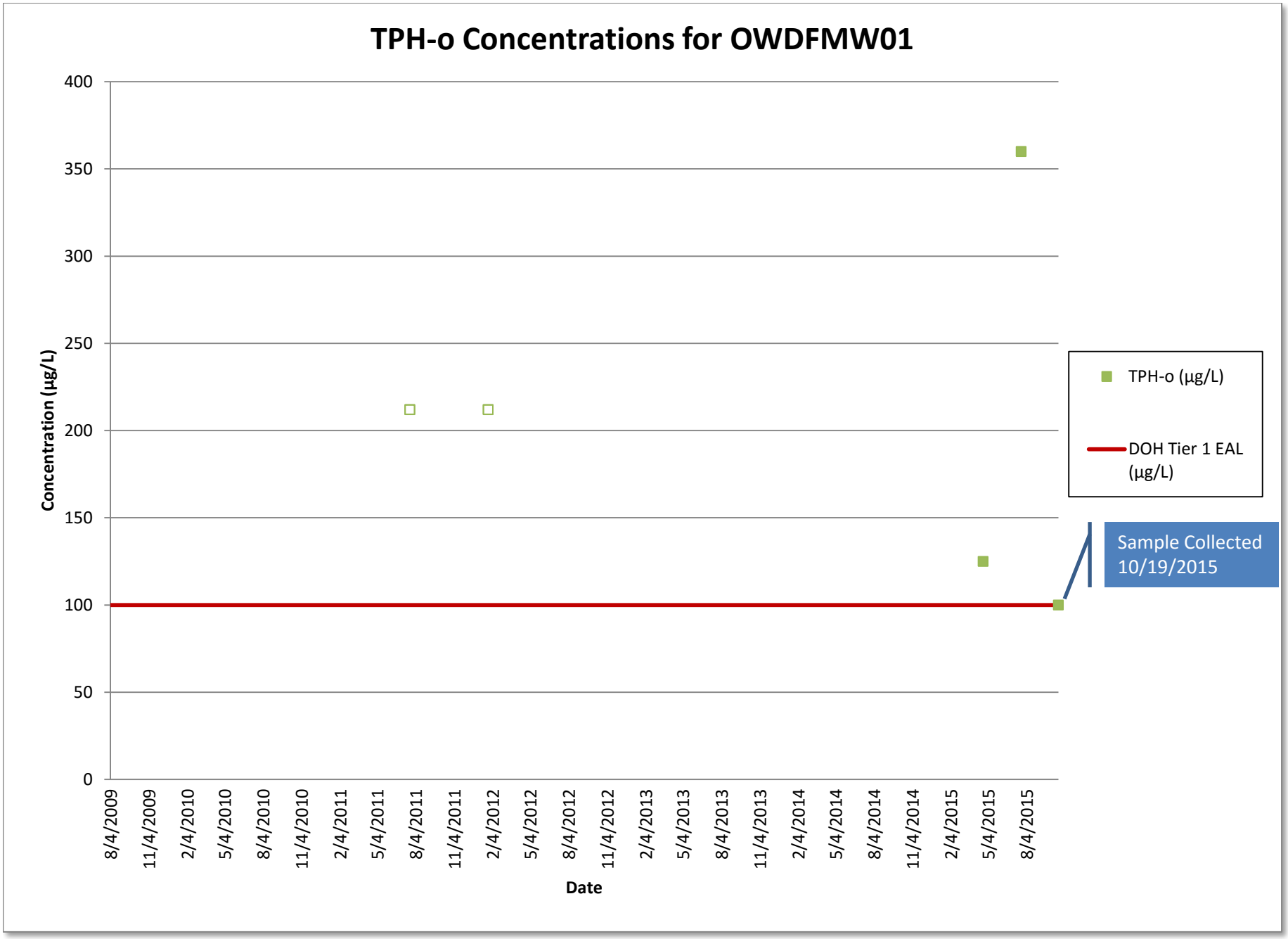
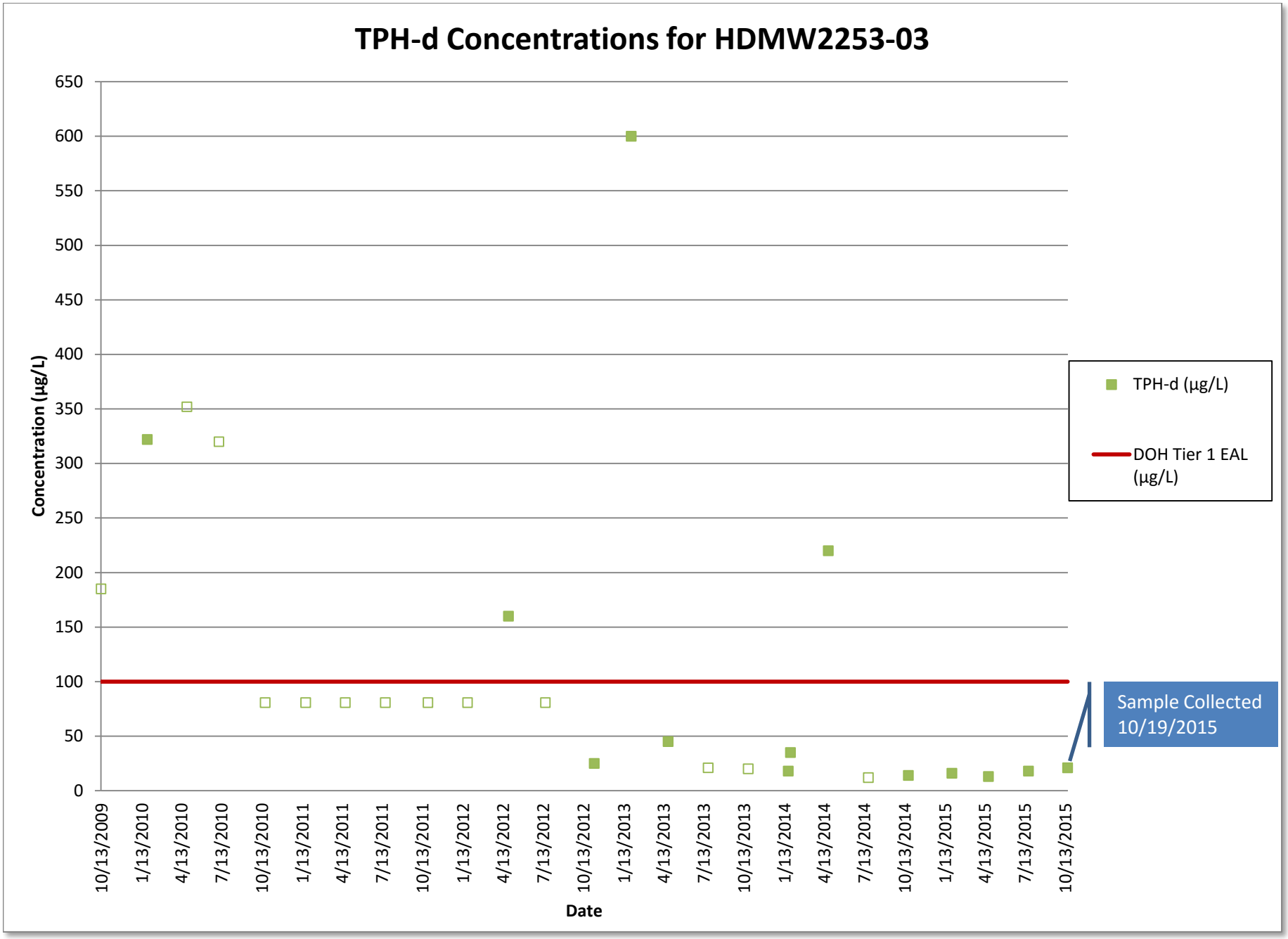

TPH-d Concentrations for RHMW04
400
300
200
100
0
Concentration (µg/L)
8/20/2005
12/20/2005
4/20/2006
8/20/2006
12/20/2006
4/20/2007
8/20/2007
12/20/2007
4/20/2008
8/20/2008
12/20/2008
4/20/2009
8/20/2009
12/20/2009
4/20/2010
8/20/2010
12/20/2010
4/20/2011
8/20/2011
12/20/2011
4/20/2012
8/20/2012
12/20/2012
4/20/2013
8/20/2013
12/20/2013
4/20/2014
8/20/2014
12/20/2014
4/20/2015
8/20/2015
Date
TPH-d (µg/L)
Sample Collected
10/19/2015


TPH-d Concentrations for OWDFMW01
Concentration (µg/L)
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
8/4/2009
11/4/2009
2/4/2010
5/4/2010
8/4/2010
11/4/2010
2/4/2011
5/4/2011
8/4/2011
11/4/2011
2/4/2012
5/4/2012
8/4/2012
11/4/2012
2/4/2013
5/4/2013
8/4/2013
11/4/2013
2/4/2014
5/4/2014
8/4/2014
11/4/2014
2/4/2015
5/4/2015
8/4/2015
Date
TPH-d (µg/L)
DOH Tier 1 EAL (µg/L)
Sample Collected 10/19/2015


TPH-o Concentrations for OWDFMW01
Concentration (µg/L)
400
350
300
250
200
150
100
50
0
8/4/2009
11/4/2009
2/4/2010
5/4/2010
8/4/2010
11/4/2010
2/4/2011
5/4/2011
8/4/2011
11/4/2011
2/4/2012
5/4/2012
8/4/2012
11/4/2012
2/4/2013
5/4/2013
8/4/2013
11/4/2013
2/4/2014
5/4/2014
8/4/2014
11/4/2014
2/4/2015
5/4/2015
8/4/2015
Date
TPH-o (µg/L)
DOH Tier 1 EAL (µg/L)
Sample Collected 10/19/2015


TPH-d Concentrations for HDMW2253-03
Concentration (µg/L)
650
600
550
500
450
400
350
300
250
200
150
100
50
0
10/13/2009
1/13/2010
4/13/2010
7/13/2010
10/13/2010
1/13/2011
4/13/2011
7/13/2011
10/13/2011
1/13/2012
4/13/2012
7/13/2012
10/13/2012
1/13/2013
4/13/2013
7/13/2013
10/13/2013
1/13/2014
4/13/2014
7/13/2014
10/13/2014
1/13/2015
4/13/2015
7/13/2015
10/13/2015
Date
TPH-d (µg/L)
DOH Tier 1 EAL (µg/L)
Sample Collected 10/19/2015