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DEPARTMENT OF HEALTH

STATE OF HAWAII

IN THE MATTER OF Contested Case Hearing Re: Red Hill Permit Application	Case No. 19-UST-EA-01 **NAVY MEMORANDUM IN OPPOSITION TO BWS PREHEARING MOTION FOR NEGATIVE INFERENCE** **DECLARATION OF MARNIE E. RIDDLE AND EXHIBITS A THROUGH M** CERTIFICATE OF SERVICE

MEMORANDUM IN OPPOSITION

In email correspondence with the Navy (attached as Exhibit A to the accompanying Declaration of Marnie E. Riddle (Counsel Dec.)), BWS identified four passages from the Facility Environmental Report (FER) prepared by the Navy's expert, Curt Stanley, and requested the production of four categories of data (Exh. A, pp. 2-3). In this correspondence and in discussions of the issue at status conferences, BWS has repeatedly made two incorrect assertions about the categories of data they identified: (1) that Mr. Stanley relied on it in forming his conclusions, and

(2) that the Navy has wrongly withheld it. BWS has stated that they intend to move for a negative inference against the Navy based on these inaccurate statements.

A negative inference is unwarranted for several reasons. First, BWS already has virtually all of the information they are asking for. The January 8, 2021 Declaration of Curtis Stanley (Counsel Dec. Exh. B) directed BWS to the specific portions of the reports prepared for the Administrative Order on Consent (AOC) and other publicly-available documents that contain the information they requested – almost all of which have been submitted by BWS as exhibits in this contested case. The FER itself identified the documents it listed in Section 4 as those that "contain detailed underlying data for the information presented herein" (Counsel Dec. Exh. F, p. 59). With the exception of software model files, these underlying data are appended to the AOC reports or the work is described in enough detail to allow DOH and EPA, as regulators, to fully evaluate it. Exhibits G through M of the accompanying Counsel Declaration, which consist of pages from BWS's own exhibits, demonstrate that BWS already has this information. The only data BWS has asked for that they do not already have are two sets of modeling files (1) on which Mr. Stanley did not rely in preparing the FER and (2) that were not in a format readily amenable to publication and dissemination on the EPA's Red Hill docket.

Second, BWS has not shown good cause for the Navy to produce the modeling files or any other additional information not contained in the FER references. As his January 8 Declaration (attached as Counsel Dec. Exh. B) makes clear, Mr. Stanley had no need to rely on, and did not rely on, any information that was not already in the documents cited in Section 4 of the FER – which, as discussed above, were comprehensive. BWS's broad-stroke efforts to ascribe knowledge of and reliance on *all* environmental data the Navy has ever collected at Red Hill to Mr. Stanley[1] are misapplied.

The model files BWS has requested do not undergird Mr. Stanley's opinions. Although the Rules of Evidence do not govern this contested case hearing, the approach embodied by Rule 703 of the Federal Rules of Evidence, which allows the disclosure of otherwise-inadmissible "basis evidence" on which an expert relied, "is based on the idea that the disclosure of basis evidence can help the factfinder understand the expert's thought process and determine what weight to give to the expert's opinion." *Williams v. Illinois,* 132 S. Ct. 2221, 2240, 567 U.S. 50, 78 (2012). As previously stated, all of the evidence that underlies Mr. Stanley's thought process in arriving at the conclusions set forth in the FER is contained in the references cited in Section 4 of the FER. Mr. Stanley did not work directly with these models and his opinions do not rely on them (see Counsel Dec. ¶ 15); therefore, they cannot help the factfinder understand his thought process. BWS may confirm this by cross-examining Mr. Stanley.

Even though Mr. Stanley did not rely on them in the FER, the Navy has nonetheless provided BWS with one of the modeling files they requested, the underlying geologic model files, in an effort to resolve this dispute (see Counsel Dec. at ¶ 16). The Navy has previously

[1] At a status conference where this issue was discussed, BWS characterized Mr. Stanley as "the principal author" of the Navy's portfolio of AOC documents. Although Mr. Stanley has contributed substantially to the Navy's AOC compliance efforts, characterizing him as "the principal author" is inaccurate. As he has testified in this case, Mr. Stanley is a principal at GSI. AECOM was contracted by the Navy to collect environmental data and conduct environmental analyses at Red Hill, and AECOM subcontracted GSI in 2017 to assist in this work. Stanley Testimony (excerpted as Counsel Dec. Exh. C), p. 1. Subsequently, Mr. Stanley was appointed as GSI's project manager to "oversee the technical efforts of GSI experts" and has been "one of," though not the only, primary authors for AOC reports "since I was brought onto the project." *Id.* Mr. Stanley then testified that he "helped develop" several of the key reports, which he lists. *Id.*, pp. 5-6. He also named several other experts with whom he has collaborated in these efforts and described their specialized areas of expertise. *Id.*, pp. 6-7.

offered to provide the groundwater flow model files, which contain Department of Defense Critical Infrastructure Information (DCRIT), on the condition that BWS sign an NDA to protect this information, which it has declined to do (see Counsel Dec. at ¶ 5 and Exhs. D and E).[2] As Exhibit D (a 2018 exchange of emails regarding the groundwater flow model and the NDA condition) shows, the groundwater model files were of interest to BWS, and BWS was aware of this offer and condition, well before this contested case arose. BWS's decision should not give rise to a negative inference against the Navy.

The following subsections address each of BWS's requests in more detail.

1. Environmental data set

BWS's first request quotes the following portion of the FER (excerpted as Counsel Dec. Exh. F), page 18:

> "Red Hill is probably the most extensively studied UST system in the State of Hawai'i with the largest environmental data set of any UST system in the State. The Navy has collected a plethora of data that have greatly expanded understanding of the geology and hydrogeology at Red Hill, as well as conditions in the underlying groundwater aquifer, which has enabled the studies and conclusions briefly summarized above. The data serve as the foundation for the Navy's AOC environmental investigation findings and will continue to do so as more data are collected and investigations, evaluations, and decision making continue (see Section 3)."

BWS then requests "the referenced and relied upon environmental data set, including all: geophysical and drilling logs; water level, chemistry, and temperature measurements; and petrophysical measurements." (Counsel Dec. Exh. A, at 2).

The excerpted passage describes historical work done at the Red Hill site as part of the Navy's efforts to comply with the AOC. It does not show that Mr. Stanley "relied upon" any or

[2] HAR § 11-1-31(b) and (c) authorize the hearings officer to grant a request for confidential treatment or closure of the hearing. If production of the groundwater flow model software files is deemed necessary in relation to this contested case hearing, the Navy will evaluate its ability to produce them subject to the confidential treatment specified.

all geophysical and drilling logs, water level, chemistry, and temperature measurements, or petrophysical measurements in forming his opinions. Nor, for that matter, does it mention drilling logs, water levels, chemistry, temperature, or petrophysical measurements at all. BWS has not shown a link between any expert opinion of Mr. Stanley and any of the specific data they have requested.

Moreover, the AOC reports cited in the FER – and produced as exhibits by BWS – already contain the information BWS asked for. Counsel Dec. Exh. G excerpts several pages of Appendix B.2 of the Investigation and Remediation of Releases Report, which BWS itself produced in this contested case as Exhibit B-339. Exhibit G includes representative examples of the types of information found in Appendix B.2: (1) Well Development Logs contain, among other things, water level, pH (acidity), temperature, EC (electrical conductivity), and turbidity information; (2) Geologic Borehole Logs contain information logged during the drilling of monitoring wells and other borings at the site; (3) Geophysical Record pages include geophysical and petrophysical information obtained during well drilling. Counsel Dec. Exhibit H excerpts a few of the 1,000-plus pages of original drilling logs, appended in their entirety to the IRR Report.

Counsel Dec. Exh. I contains excerpts of the Conceptual Site Model Appendix F (Petrographic Analytical Report), which BWS produced for this case as Exhibit B-352. That appendix contains additional petrophysical information about the porosity, density, and permeability of the rock at Red Hill. Finally, Counsel Dec. Exh. J attaches pages from the Quarterly Groundwater Monitoring Reports, a recent example of which was produced by BWS as Exhibit B-83. These Quarterly Reports contain additional chemistry data, including test results at each monitoring well for groundwater contaminants of potential concern.

2. Geologic model

BWS's second request quotes from page 20 of the FER (Counsel Dec. Exh. F):

> "The Navy developed a geologic framework model and a three-dimensional regional geologic model of Red Hill and surrounding environs (including North and South Hālawa Valleys, Moanalua Valley, the Salt Lake area, and Pearl Harbor) to provide geologic support for its groundwater flow modeling effort. The three-dimensional geologic model encompassed the groundwater flow model domain and incorporated information from borehole logs, subsurface structural geology surveys, developed cross sections, and published literature. The Navy used this and other data to prepare detailed geologic cross sections by correlating available geologic logs of cores and the results of field mapping conducted with experts from DOH and the University of Hawaiʻi ("UH") along multiple outcrops in the vicinity of Red Hill and within the Moanalua Tunnel."

BWS then requests "the referenced and relied upon Navy three-dimensional regional geologic model." (Counsel Dec. Exh. A, at 3).

The excerpted passage describes environmental work done by the Navy in accordance with the AOC. It does not show that Mr. Stanley "relied upon" the geologic models in forming his opinions. It does, however, explain how the models were used by the Navy (not Mr. Stanley specifically) "to provide geologic support for its groundwater flow modeling effort" and "to prepare detailed geologic cross sections" along with other data. These geologic models are described in context in the Conceptual Site Model on page 5-13 (in Module D, Vadose Zone), attached as Counsel Dec. Exh. K. For both models, "[d]etails are presented in Appendix E." Counsel Dec. Exh. K also includes the details of the models as they were presented in Appendix E and the "detailed geologic cross sections" that the models were used to prepare.

Given that Mr. Stanley did not prepare the geologic models during his work on the Navy's AOC deliverables, and did not rely on them in forming the opinions set forth in the FER, and given that the details of the models and the geologic cross sections they were used to generate are set forth in Appendix E to the Conceptual Site Model, it is difficult to see how BWS could be prejudiced by a lack of access to the underlying model files themselves in cross-examining Mr. Stanley on the basis for his opinions. Nevertheless, to eliminate any potential prejudice, the Navy has provide BWS with the geologic model files (Counsel Dec. ¶ 16).

3. Strike and dip data

BWS's third request also quotes page 20 of the FER (Counsel Dec. Exh. F):

> "[T]he Navy determined accurate strike and dip measurements of the lava flows and the presence of highly porous clinker units within Red Hill. Strike and dip of a rock outcrop can be used to determine the general direction that a fluid can flow. The measurements were used to identify a general dip direction for Red Hill (south-southwest), which can influence groundwater flow. The Navy then oriented the groundwater flow model to match the general dip direction for Red Hill."

BWS then requests "the referenced and relied upon Navy measurements of strike and dip of lava flows and clinker units." (Counsel Dec. Exh. A at 3).

The excerpted passage describes environmental measurements that have been historically performed at the Red Hill site in the course of the Navy's AOC work. It does not show that Mr. Stanley "relied upon" these measurements in forming his opinions, nor that he was involved in taking these measurements or using them to form any other conclusions about the Red Hill site. These measurements do not fall into the category of "basis evidence" that would help a factfinder understand Mr. Stanley's thought process.

BWS also already has the strike and dip measurements. Appendix C (Strike and Dip Data) of the Conceptual Site Model, which BWS produced in this contested case as Exh. B-352, is attached as Counsel Dec. Exhibit L. Exhibit L also includes pages from Module D (Vadose Zone) of the Conceptual Site Model, which summarizes, explains the significance of, and describes the weighting factors applied to, the strike and dip measurements in Appendix C.

4. Groundwater flow modeling files

BWS's final request quotes page 48 of the FER (Counsel Dec. Exh. F):

> "Understanding the direction and rate of groundwater flow under a variety of reasonable supply well pumping scenarios is critical to assessing the risk that any hypothetical future fuel leak could pose to local drinking water. Initially, the AOC SOW scoped the groundwater flow model effort as one of updating a model developed for a previous 2007 Facility environmental investigation (DON 2007). The Navy modeling team found that updating the 2007 model was insufficient and recommended additional work, including entirely rebuilding, providing more detail, and expanding the model. Working with the AOC Parties and other stakeholders, the Navy refined the modeling domain to extend approximately 51 square miles from Waimalu Valley in the northwest to Kalihi Valley in the southeast, and from near the Koʻolau crest in the northeast to Pearl Harbor and the Pacific Ocean in the southwest (see Location Map, Figure 1), far beyond where any impacts might reasonably be expected. Since there are a range of factors that require consideration, the Navy developed a multi-model approach to bound expected flow conditions (Ajami et al. 2006). Such an effort requires additional work on behalf of the Navy but results in a more reliable range of predictions under given scenarios."

BWS then requests "the referenced and relied upon groundwater flow modeling files, including Model USG and GW Vista files for all of the groundwater flow models generated as part of the Navy's March 2020 Groundwater Flow Model Report." (Counsel Dec. Exh. A, at 3).

The excerpted passage describes work undertaken by Navy experts, in concert with "the AOC Parties and other stakeholders," to refine and update the pre-existing model. It does not show that Mr. Stanley "relied upon" the groundwater flow modeling files – as opposed to the Groundwater Flow Model Report – to form his opinions or conclusions in this contested case. In fact, Mr. Stanley did not even open the groundwater flow modeling files in the course of his work for this contested case, nor was he the original creator of the groundwater flow model (Counsel Dec. ¶ 15).

As discussed above, the Navy has offered to provide BWS the groundwater modeling files if it signed an NDA, but BWS has declined to do so (see Counsel Dec. ¶ 5). But as with the preceding examples, it is difficult to guess what additional information BWS might require that is not thoroughly explicated in the report. The Groundwater Flow Model Report, which BWS itself produced as Exhibit B-361, thoroughly details the model's parameters, assumptions, inputs and outputs. Counsel Dec. Exh. M excerpts pages from the Groundwater Flow Model Report that outline the information contained therein and provide salient examples of the level of detail found in the report. For instance, the excerpted tables show pumping rates for wells in the model, parameter ranges for geologic materials in the model, model calibration statistics, and other defining aspects of the model. The excerpts also provide information about the Navy's multi-model approach.

CONCLUSION

As the foregoing indicates, BWS cannot establish any justification for a negative inference against the Navy. The accompanying Declaration and Exhibits demonstrate that all of the information Mr. Stanley relied on is available to BWS, as is all of the additional information they have requested. The Navy is prepared to brief specific evidentiary issues that arise during this contested case hearing, but respectfully requests that good cause be shown before such issues are set for briefing in advance of the parties' anticipated post-hearing memoranda.

Respectfully Submitted,

Dated: January 29, 2021

/S/ _David Fitzpatrick_ ________________
David Fitzpatrick
Marnie E. Riddle

DEPARTMENT OF HEALTH
STATE OF HAWAII

IN THE MATTER OF Contested Case Hearing Re Permit Application	))))))))))	**DECLARATION OF MARNIE E. RIDDLE IN SUPPORT OF NAVY'S OPPOSITION TO MOTION FOR NEGATIVE INFERENCE**

DECLARATION

I, Marnie E. Riddle, declare:

1. I am a Navy Office of General Counsel attorney admitted *pro hac vice* in Hawaii.
2. Attached as Exhibit A is a true and correct copy of an email sent to counsel for the Navy from BWS counsel David K. Brown, dated December 10, 2020, pertaining to matters that have arisen in the course of the above-captioned matter.
3. Attached as Exhibit B is a true and correct copy of the Declaration of Curtis C. Stanley in the above-captioned matter, dated January 8, 2021.
4. Attached as Exhibit C is a true and correct copy of pages 1 and 5-7 excerpted from the Testimony of Curtis C. Stanley in the above-captioned matter, dated November 25, 2020.
5. Attached as Exhibit D is a true and correct copy of email correspondence between Navy employee Mark Manfredi and BWS employee Erwin Kawata, dated July 19-20, 2018. This correspondence was forwarded to me in January 2021. I am informed and believe that the "well locations and pump rates" referred to at the top of the third page are integrated into the groundwater flow model that I am also informed and believe is the subject of the "ongoing modeling efforts" referred to in the next paragraph of the email.

6. Attached as Exhibit E is a true and correct copy of the Determination of the Director of Administration for the Department of Defense that "information regarding the locations and water production rates for United States Navy's water production wells on the Island of Oahu, Hawaii. … qualifies as DoD critical infrastructure security information (DCRIT), as defined by 10 U.S.C.§ 130e," dated June 19, 2018.
7. Attached as Exhibit F is a true and correct copy of pages 18, 20, 48, and 59 excerpted from the Facility Environmental Report appended to the Testimony of Curtis C. Stanley dated November 25, 2020, in the above-captioned matter.
8. Attached as Exhibit G is a true and correct copy of PDF pages 1314, 1322, 1328-1332, and 1334-1344 of Exhibit B-339, the Investigation and Remediation of Releases Report, Red Hill Bulk Fuel Storage Facility, dated March 25, 2020. These pages are located in Appendix B.2 of the Report, which contains over 400 pages of information that is broadly similar to that excerpted.
9. Attached as Exhibit H is a true and correct copy of PDF pages 141 and 954-959 of Exhibit B-339, the Investigation and Remediation of Releases Report, Red Hill Bulk Fuel Storage Facility, dated March 25, 2020. These pages are located in Appendix B.1 of the Report, which contains over 1,000 pages of photocopied well drilling logs.
10. Attached as Exhibit I is a true and correct copy of PDF pages 779 and 789-793 of Exhibit B-352, the Conceptual Site Model, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, dated June 30, 2019. These pages are located in Appendix F (Petrographic Analytical Report) of the Conceptual Site Model.

11. Attached as Exhibit J is a true and correct copy of PDF pages 53, 55, 141, and 143-177 of Exhibit B-83b, the Second Quarter 2020 – Quarterly Groundwater Monitoring Report, Red Hill Bulk Fuel Storage Facility, dated July 2020. These pages depict Figures 4A and 4B, and Appendix A.2 (Groundwater COPC Graphs) of the Quarterly Groundwater Monitoring Report.
12. Attached as Exhibit K is a true and correct copy of PDF pages 111, 749, 751-765, and 767-777 of Exhibit B-352, the Conceptual Site Model, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, dated June 30, 2019. These pages are located in Module D (Vadose Zone) and in Appendix E (Geologic Framework Model) of the Conceptual Site Model.
13. Attached as Exhibit L is a true and correct copy of PDF pages 101-103, 737, and 739-744 of Exhibit B-352, the Conceptual Site Model, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, dated June 30, 2019. These pages are located in Module D (Vadose Zone) and in Appendix C (Strike and Dip Data) of the Conceptual Site Model.
14. Attached as Exhibit M is a true and correct copy of PDF pages 9-17, 42-43, 63, 67, and 73-74 of Exhibit B-361, the Groundwater Flow Model Report, Red Hill Bulk Fuel Storage Facility, dated March 25, 2020.
15. I am informed and believe that Mr. Stanley did not create the geologic model files or groundwater flow model files that counsel for BWS refers to in Exhibit A. I am further informed and believe that Mr. Stanley does not possess the specialized software required to open such model files.

16. On January 27, 2021, I sent a zipped file containing geologic model files to counsel for BWS and Sierra Club, and to BWS's expert witness Nicole DeNovio, using the DoD SAFE secure file transfer site.

I declare these facts are true to my knowledge and belief under penalty of perjury.

DATED: January 29, 2021 at Alexandria, VA

/S/ Marnie E. Riddle________
Marnie E. Riddle

Exhibit A

Riddle, Marnie E CIV USN OGC WASH DC (USA)

From: Brown, David K. <david.brown@morganlewis.com>
Sent: Thursday, December 10, 2020 4:25 PM
To: Mckay, Jonathan Cross (Jon) CIV USN COMNAVREG SW SAN CA (USA); Riddle, Marnie E CIV USN OGC WASH DC (USA); Minott, Karrin H CIV USN OGC WASH DC (USA)
Cc: Foley Gannon, Ella; 'jlau3@honolulu.gov' (jlau3@honolulu.gov)
Subject: RE: [Non-DoD Source] RE: Meet and Confer - Red Hill

Jon:

I write to continue to meet and confer regarding the documents missing from the Navy productions to date in response to the BWS' motion pending before Hearings Officer Chang in the contested case concerning the Navy's Red Hill UST permit application. As we have discussed on several occasions, the Navy still has not produced certain documents essential to preparation for and resolution of the issues central to this contested case. There is no dispute these documents do or should exist, and we have done everything in our power to identify them with particularity – even going so far as to refer to many by file name or as referenced in the Navy's own documents. Nevertheless, certain of these critical records remain missing from the Navy's document productions and have not been accounted for in any of the provided *Vaughn* indices. Specifically, we identify the following documents or categories of documents that have yet to be produced.

Request 2: *Documentation of releases from the Red Hill USTs*

- On October 20, 2020, we provided a list of leak history records referenced in previously-produced documents that were not included in any Navy production. In a response dated November 6, 2020, the Navy responded that it had located these documents and would be producing them. The following documents remain outstanding:

- **Whitacre 2014a.pdf** [RDHLCC0000657]
- **Whitacre 2014b.pdf** [RDHLCC0000657]
- **Whitacre 2014c.pdf** [RDHLCC0000657]
- **Whitacre 2014d.pdf** [RDHLCC0000657]
- **Whitacre 2014e.pdf** [RDHLCC0000657]
- **Whitacre 2014f.pdf** [RDHLCC0000657]
- **Whitacre 2014g.pdf** [RDHLCC0000657]
- **Whitacre 2014h.pdf** [RDHLCC0000657]

- Photos and/or videos documenting releases from Red Hill USTs (*see, e.g.*, Exhibit BWS-007).

Request 3: *Reports of all work done inspecting and/or certifying the condition of each of the Red Hill USTs*

- Inspection documentation, reports, and/or certifications for Tank 5, including the extensive evaluation, repairs, and testing conducted after the January 2014 fuel release and before Tank 5 was returned to service as reported in March 2020.

  The BWS acknowledges receipt of "Tank 5 Final API 653 Inspection Report REV 1 (sent) SIGNED.pdf". However, it appears that the Navy did not produce:

- "**WGS Warranty Repair & NDE Inspection Certification Report dated September 15, 2016**" [RDHLCC0028613, at 28634]; or
- Any return to service documentation in 2013 or 2019/2020 certifying that repairs were made prior to returning Tank 5 to service.

  Further, the BWS finds it surprising that in the aftermath of the fuel release of at least 27,000 gallons from Tank 5 reported in January 2014, the Navy would not have devoted considerable resources to immediately investigate and inspect this tank in an attempt to stop the release of fuel into the environment and to address the serious tank integrity problem. Since the Navy has produced no other documentation of any inspections performed on Tank 5 in the 2014 to 2020 time period, the only conclusion that can be reached is that the Navy has no documentation that such work was ever performed.

- Inspection documentation, reports, and/or certifications for Tank 14, including the extensive evaluation, repairs, and testing conducted before and after collection of steel liner samples in June 2018 and, specifically, **the data spreadsheet referenced in Section 1.2 of the report titled Red Hill Bulk Fuel Storage Facility Destructive Testing Results Report, AOC/SOW 5.3.3 prepared by Naval Facilities Engineering Command (Jan. 7, 2019)**.

  We know the Navy shared this document with the EPA and DOH in connection with the selection of steel liner samples collected from Tank 14.

- Inspection documentation, reports, and/or certifications, including API 653 or modified API 653 inspections reports for Tanks 1, 3, 4, 9, 11, 12, 18, and/or 19.

  Since the Navy has produced no inspection reports for these tanks, the only conclusion that can be reached is that the Navy has no documentation that such work was ever performed.

- Tank 19 repair documentation provided in the Navy's last supplemental production states:

  "From the 4 or 5 coupons cut from Red Hill tanks other than Tank 19 supplied by Tom Kitchen, it appears that the backside of the steel liners are suffering from two types of corrosion. The first type is a generalized corrosion attack that has resulted in broad areas of metal loss. These areas had corrosion pits of 1/2 to 1 1/2 inches in diameter. The second type of corrosion evident on the coupons is a very localized pitting with holes as small as 1/8 of an inch in diameter that had fully penetrated the 1/4 inch thick steel." [RDHLCC0027623, at 27625]

  Please provide all documentation related to these coupon samples, including the tanks and locations from which the coupons were extracted, data collected from these coupons, testing and analyses performed on these coupons, and/or reports generated in connection with the coupon removal, testing, or analysis.

- A copy of the contract or contracts by or between GTT North America and the Department of Defense or its Defense Innovation Unit to conduct a feasibility study to develop technologies for potential implementation at Red Hill, including related proposals and scopes of work, feasibility study descriptions, reports or analyses generated in connection with this work, if any, and documents relating to whether or not the Navy has committed to implementing such upgrades at Red Hill.

  In addition, we hereby request that the Navy provide the following information that has been referenced in Navy witness testimony and relied upon by Navy witnesses to form the basis of their opinions.

- AOC SOW Section 5.4 draft work plan sent to EPA and DOH on November 16, 2020 as described in the testimonies of Donald Panthen and Robert Jamond, and any request for or response to this work plan (or any drafts thereof) from EPA or DOH.
- Documents relied upon by Curtis Stanley to form his expert opinions as described in the Facility Environmental Report (FER), including:

- "Red Hill is probably the most extensively studied UST system in the State of Hawaiʻi with the largest environmental data set of any UST system in the State. The Navy has collected a plethora of data that have greatly expanded understanding of the geology and hydrogeology at Red Hill, as well as conditions in the underlying groundwater aquifer, which has enabled the studies and conclusions briefly summarized above. The data serve as the foundation for the Navy's AOC environmental investigation findings and will continue to do so as more data are collected and investigations, evaluations, and decision making continue (see Section 3)." [FER, at 18]

  Please produce the referenced and relied upon environmental data set, including all: geophysical and drilling logs; water level, chemistry, and temperature measurements; and petrophysical measurements.

- "The Navy developed a geologic framework model and a three-dimensional regional geologic model of Red Hill and surrounding environs (including North and South Hālawa Valleys, Moanalua Valley, the Salt Lake area, and Pearl Harbor) to provide geologic support for its groundwater flow modeling effort. The three-dimensional geologic model encompassed the groundwater flow model domain and incorporated information from borehole logs, subsurface structural geology surveys, developed cross sections, and published literature. The Navy used this and other data to prepare detailed geologic cross sections by correlating available geologic logs of cores and the results of field mapping conducted with experts from DOH and the University of Hawaiʻi ("UH") along multiple outcrops in the vicinity of Red Hill and within the Moanalua Tunnel." [FER, at 20]

Please produce the referenced and relied upon Navy three-dimensional regional geologic model.

- "[T]he Navy determined accurate strike and dip measurements of the lava flows and the presence of highly porous clinker units within Red Hill. Strike and dip of a rock outcrop can be used to determine the general direction that a fluid can flow. The measurements were used to identify a general dip direction for Red Hill (south-southwest), which can influence groundwater flow. The Navy then oriented the groundwater flow model to match the general dip direction for Red Hill." [FER, at 20]

  Please produce the referenced and relied upon Navy measurements of strike and dip of lava flows and clinker units.

- "Understanding the direction and rate of groundwater flow under a variety of reasonable supply well pumping scenarios is critical to assessing the risk that any hypothetical future fuel leak could pose to local drinking water. Initially, the AOC SOW scoped the groundwater flow model effort as one of updating a model developed for a previous 2007 Facility environmental investigation (DON 2007). The Navy modeling team found that updating the 2007 model was insufficient and recommended additional work, including entirely rebuilding, providing more detail, and expanding the model. Working with the AOC Parties and other stakeholders, the Navy refined the modeling domain to extend approximately 51 square miles from Waimalu Valley in the northwest to Kalihi Valley in the southeast, and from near the Koʻolau crest in the northeast to Pearl Harbor and the Pacific Ocean in the southwest (see Location Map, Figure 1), far beyond where any impacts might reasonably be expected. Since there are a range of factors that require consideration, the Navy developed a multi-model approach to bound expected flow conditions (Ajami et al. 2006). Such an effort requires additional work on behalf of the Navy but results in a more reliable range of predictions under given scenarios." [FER, at 48]

  Please produce the referenced and relied upon groundwater flow modeling files, including Model USG and GW Vista files for all of the groundwater flow models generated as part of the Navy's March 2020 Groundwater Flow Model Report.

The BWS appreciates the parties' ongoing efforts to meet and confer to address the exchange of information crucial to the resolution of this contested case. Given the issues associated with the Navy's prior document productions, our review of Navy documents remains ongoing and the BWS reserves its right to amend, modify, or supplement these requests in the future.

Please do not hesitate to contact us if you have any questions or would like to discuss this matter forward. We intend to update the Hearings Officer as to the status of these meet and confer efforts next week.

Best,

David K. Brown
Morgan, Lewis & Bockius LLP
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-----Original Message-----
From: Mckay, Jonathan Cross (Jon) CIV USN COMNAVREG SW SAN CA (USA) <jonathan.c.mckay@navy.mil>
Sent: Monday, November 30, 2020 5:41 PM
To: Foley Gannon, Ella <ella.gannon@morganlewis.com>; Brown, David K. <david.brown@morganlewis.com>; Riddle, Marnie E CIV USN OGC WASH DC (USA) <marnie.riddle@navy.mil>
Cc: Minott, Karrin H CIV USN OGC WASH DC (USA) <karrin.minott@navy.mil>
Subject: RE: [Non-DoD Source] RE: Meet and Confer - Red Hill

[EXTERNAL EMAIL]

Ella,

We are available Thursday for a brief call before 1pm Pacific.

Exhibit B

Jonathan C. McKay
Marnie E. Riddle
Karrin H. Minott
Dave Fitzpatrick 6803
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DEPARTMENT OF HEALTH

STATE OF HAWAII

IN THE MATTER OF Contested Case Hearing Re Red Hill Permit Application	Case No. 19-UST-EA-01 **DECLARATION OF CURTIS STANLEY** CERTIFICATE OF SERVICE

DECLARATION OF CURTIS STANLEY

1. I previously testified in this contested case hearing that I helped develop the Facility Environmental Report ("FER") that was prepared for this contested case and attached to my prior testimony. (Testimony of Curtis Stanley ("Stanley Testimony"), pp. 5-6.) I briefly described the important findings that were summarized in the FER. (Stanley Testimony, pp. 8-12.)

2. The FER is not intended to independently replicate, validate, or critically analyze the extensive environmental investigations and studies that have already been performed by the Navy. Instead, it contextualizes these investigations, and highlights and explains the findings and conclusions that may be relevant and useful for this contested case hearing. (*See* FER, p. 1.) The FER does not fulfill any requirement of the Administrative Order on Consent ("AOC"). The information relied on to prepare the FER is contained in the site investigations and environmental reports that were conducted by the Navy pursuant to the AOC, listed in FER Section 4. The underlying datasets used by the Navy to prepare those reports were not re-analyzed in the FER.

3. I have been informed by counsel for the Navy that counsel for the Board of Water Supply ("BWS") made the following set of requests for documents, quoting the enclosed passages from the FER:

> Documents relied upon by Curtis Stanley to form his expert opinions as described in the Facility Environmental Report (FER), including:
>
> > "Red Hill is probably the most extensively studied UST system in the State of Hawai'i with the largest environmental data set of any UST system in the State. The Navy has collected a plethora of data that have greatly expanded understanding of the geology and hydrogeology at Red Hill, as well as conditions in the underlying groundwater aquifer, which has enabled the studies and conclusions briefly summarized above. The data serve as the foundation for the

> Navy's AOC environmental investigation findings and will continue to do so as more data are collected and investigations, evaluations, and decision making continue (see Section 3)." [FER, at 18]

Please produce the referenced and relied upon environmental data set, including all: geophysical and drilling logs; water level, chemistry, and temperature measurements; and petrophysical measurements.

> "The Navy developed a geologic framework model and a three-dimensional regional geologic model of Red Hill and surrounding environs (including North and South Hālawa Valleys, Moanalua Valley, the Salt Lake area, and Pearl Harbor) to provide geologic support for its groundwater flow modeling effort. The three-dimensional geologic model encompassed the groundwater flow model domain and incorporated information from borehole logs, subsurface structural geology surveys, developed cross sections, and published literature. The Navy used this and other data to prepare detailed geologic cross sections by correlating available geologic logs of cores and the results of field mapping conducted with experts from DOH and the University of Hawaiʻi ("UH") along multiple outcrops in the vicinity of Red Hill and within the Moanalua Tunnel." [FER, at 20]

Please produce the referenced and relied upon Navy three-dimensional regional geologic model.

> "[T]he Navy determined accurate strike and dip measurements of the lava flows and the presence of highly porous clinker units within Red Hill. Strike and dip of a rock outcrop can be used to determine the general direction that a fluid can flow. The measurements were used to identify a general dip direction for Red Hill (south-southwest), which can influence groundwater flow. The Navy then oriented the groundwater flow model to match the general dip direction for Red Hill." [FER, at 20]

Please produce the referenced and relied upon Navy measurements of strike and dip of lava flows and clinker units.

> "Understanding the direction and rate of groundwater flow under a variety of reasonable supply well pumping scenarios is critical to assessing the risk that any hypothetical future fuel leak could pose to local drinking water. Initially, the AOC SOW scoped the groundwater flow model effort as one of updating a model developed for a previous 2007 Facility environmental investigation (DON 2007). The Navy modeling team found that updating the 2007 model was insufficient and recommended additional work, including entirely rebuilding, providing more detail, and expanding the model. Working with the AOC Parties and other stakeholders, the Navy refined the modeling domain to extend approximately 51 square miles from Waimalu Valley in the northwest to Kalihi Valley in the southeast, and from near the Koʻolau crest in the northeast to Pearl Harbor and the Pacific Ocean in the southwest (see Location Map, Figure 1), far beyond where

> any impacts might reasonably be expected. Since there are a range of factors that require consideration, the Navy developed a multi-model approach to bound expected flow conditions (Ajami et al. 2006). Such an effort requires additional work on behalf of the Navy but results in a more reliable range of predictions under given scenarios." [FER, at 48]

Please produce the referenced and relied upon groundwater flow modeling files, including Model USG and GW Vista files for all of the groundwater flow models generated as part of the Navy's March 2020 Groundwater Flow Model Report.

4. Section 4 of the FER lists documents that "contain detailed underlying data for the information presented herein or are otherwise considered important enough [to] incorporate into the record in this contested case," and provides URLs where these documents can be accessed by members of the public (FER, p. 59). The FER passages quoted above reference and rely upon these documents. In the following paragraphs, I will identify the specific documents listed in Section 4 of the FER where the data I relied upon in forming my conclusions can be found, and where appropriate will identify additional documents that may contain data of interest to the parties.

5. Page 18 of the FER, quoted above in BWS's document request, states that the Navy has collected a large amount of environmental data, and that this data forms the basis for the Navy's studies of and conclusions about the environmental impacts of the Red Hill Facility and "the foundation for the Navy's AOC environmental investigation findings." (FER, p. 18.) It was neither necessary nor practicable to independently re-analyze all such environmental data, nor replicate all of the Navy's past environmental investigations, before preparing the FER for use in this contested case. The results of the Navy's studies and investigations are described in the references listed in Section 4 of the FER, including the Investigation and Remediation of

Releases Report,[1] Groundwater Flow Model Report,[2] Conceptual Site Model report,[3] and Groundwater Protection and Evaluation Considerations Report.[4] Current groundwater monitoring data is provided in quarterly monitoring reports, like the Second Quarter 2020 Groundwater Monitoring Report.[5]

6. In connection with the above passage on page 18 of the FER, BWS has specifically requested "geophysical and drilling logs; water level, chemistry, and temperature measurements; and petrophysical measurements." The FER did not independently re-analyze any data in these categories underlying the Navy's site investigations. However, discussions, summaries, tables, and other presentations of data falling into these categories can be found in the following documents, referenced in Section 4 of the FER and/or publicly available.

Geophysical and drilling logs:

- Investigation and Remediation of Releases Report, Appendix B.2

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[1] This document was produced to BWS by the Navy along with the FER, and can be found at Bates range NAVYREF0014424 to NAVYREF0016641, as well as Exhibit N-078. It was produced by BWS as Exhibit B-339. It is also publicly available at https://www.epa.gov/sites/production/files/2020-04/documents/red-hill-investigation-and-remediation-of-releases-report-rev00-redacted-2020-03-25.pdf

[2] This document was produced to BWS by the Navy along with the FER, and can be found at Bates range NAVYREF0003407 to NAVYREF0004104. It was produced by BWS as Exhibit B-361. It is also publicly available at https://www.epa.gov/sites/production/files/2020-04/documents/red-hill-groundwater-flow-model-report-redacted-2020-03-25-.pdf

[3] This document was produced to BWS by the Navy along with the FER, and can be found at Bates range NAVYREF0002443 to NAVYREF0003406. It was produced by BWS as Exhibit B-352. It is also publicly available at https://www.epa.gov/sites/production/files/2019-07/documents/red_hill_conceptual_site_model_20190630-redacted.pdf

[4] This document was produced to BWS by the Navy along with the FER, and can be found at Bates range NAVYREF0001983 to NAVYREF0002442. It was produced by BWS as Exhibit B-348. It is also publicly available at https://www.epa.gov/sites/production/files/2018-09/documents/red_hill_interim_groundwater_flow_model-rev00_2018- 07-27-redacted.pdf

[5] This document was produced to BWS by the Navy along with the FER, and can be found at Bates range NAVYREF0005200 to NAVYREF0014423. It was produced by BWS as Exhibit B-83. It can also be found at https://health.hawaii.gov/shwb/ust-red-hill-project-main/red-hill-technical-documents-2020/ and at https://health.hawaii.gov/shwb/files/2020/10/2020-07-2nd-qtr-gw-monitoring-rept-part-1.pdf, https://health.hawaii.gov/shwb/files/2020/10/2020-07-2nd-qtr-gw-monitoring-rept-part-2.pdf and https://health.hawaii.gov/shwb/files/2020/10/2020-07-2nd-qtr-gw-monitoring-rept-part-3.pdf

- Groundwater Flow Model Progress Reports, available at https://www.epa.gov/red-hill/groundwater-flow-patterns-red-hill-additional-documents and produced by BWS as Exhibits B-340, B-342, B-343, B-347, B-350, B-351, B-353, B-354, B-355

Water levels:

- Red Hill Quarterly Groundwater Monitoring Reports, available under "Red Hill Technical Documents" at https://health.hawaii.gov/shwb/ust-red-hill-project-main/
- Groundwater Flow Model Progress Reports

Chemistry and temperature measurements:

- Red Hill Quarterly Groundwater Monitoring Reports

Petrophysical measurements:

- Conceptual Site Model report, Appendix F

7. Page 20 of the FER, quoted above in BWS's document request, explains that the Navy developed a geologic framework model and a 3-D regional geologic model of Red Hill in the course of preparing its groundwater flow model. I did not independently review or re-analyze the data underlying these models, nor did I run any of the model software files, in the course of preparing the FER or my conclusions. In fact, the quoted passage simply summarizes some of the work previously performed by the Navy in its environmental studies of the site. The geologic framework model and 3D regional geologic model, as well as the Navy's use of them, are described in more detail in Appendices C ("Strike and Dip Data"), D ("Evaluation of Potential Pahoehoe Lava Flow Paths Through Tank Farm Area"), E ("Geologic Framework Model"), F ("Petrographic Analytical Report"), and G ("Infiltration Study Report") of the Conceptual Site Model listed in Section 4 of the FER, which is available to BWS (see footnote 3, above). More information about the geologic model is available in the Investigation and

Remediation of Releases Report, page A-18 (see footnote 1, above); the Existing Data Summary and Evaluation Report, pages 3-1 to 3-2 (BWS Exhibit B-331), and Seismic Profiling to Map Hydrostratigraphy in the Red Hill Area (BWS Exhibit B-346).

8. On page 20, the FER summarizes, but does not independently re-evaluate, past Navy investigations of the strike and dip of lava flows at Red Hill. The FER relies on information about strike and dip data that is available in Appendix C ("Strike and Dip Data") of the Conceptual Site Model (see footnote 3, above).

9. On page 48, the FER briefly describes work done by the Navy to model groundwater flows as required by the AOC. The FER does not independently evaluate, validate, or analyze this work itself, and all of the information in the passage quoted by BWS is available in the documents referenced in FER Sections 4 and 6. For example, the FER describes the Navy's expansion of the modeling domain to include the entire area from Waimalu Valley to Kalihi Valley and from near the Ko'olau crest to Pearl Harbor; this is also reported on page 1-2 of the Groundwater Flow Model Report (see footnote 2, above). Similarly, the Navy's use of a multimodel approach, briefly described in the quoted passage of the FER, is discussed in detail in the Groundwater Flow Model Report (see, e.g., pp. 1-1, 1-10 to 1-12, 2-1 to 2-5, 4-1, and Section 5) cited in FER Section 4.

10. BWS has requested "Model USG and GW Vista files for all of the groundwater flow models generated as part of the Navy's March 2020 Groundwater Flow Model Report." No groundwater flow model files were generated, validated, or independently re-analyzed in order to form the conclusions in the FER. The FER relies on the groundwater flow information as presented in the Groundwater Flow Model Report in order to form its conclusions.

Executed this 8th day of January, 2021, at Boerne, Texas.

/S/ [signature]
Curtis Stanley

DEPARTMENT OF HEALTH
STATE OF HAWAII

IN THE MATTER OF Contested Case Hearing Re Permit Application	)	CERTIFICATE OF SERVICE

CERTIFICATE OF SERVICE

I hereby certify that, on this date, a true and correct copy of the foregoing document was emailed to the following:

Hearings Officer

Lou.chang@hula.net

Board of Water Supply

ella.gannon@morganlewis.com
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Honolulu Corporate Counsel

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James.c.paige@hawaii.gov

Sierra Club

davidkimofrankel@gmail.com

Respectfully Submitted,

Dated: January 8, 2021

/S/ Marnie E. Riddle____________
Marnie E. Riddle
Agency Representative

Exhibit C

I. INTRODUCTION

Q. PLEASE STATE YOUR NAME, EMPLOYER, AND BUSINESS ADDRESS.

A. My name is Curtis Stanley. I am the president of Curt Stanley Consulting Group, LLC and am under contract as a Principal to GSI Environmental Inc ("GSI"). GSI is a subcontractor to AECOM Technical Services Inc ("AECOM"), which has been contracted by the Navy to collect environmental data and conduct environmental analyses at the Red Hill Bulk Storage Facility (the "Facility").

Q. ON WHOSE BEHALF ARE YOU TESTIFYING IN THIS MATTER?

A. I am testifying on behalf of the U.S. Navy.

Q. WHAT IS YOUR POSITION AT GSI AND HOW LONG HAVE YOU BEEN SO EMPLOYED?

A. I am a Principal with GSI and have 43 years of environmental experience in investigations and remediation. I have been employed in this position with GSI since September 2016. Prior to joining GSI, I was the Global Discipline Leader for Soil and Groundwater as part of my 37-year tenure at Shell, where I became Shell's first hydrogeologist in 1982.

Q. WHAT DOES YOUR POSITION AT GSI ENTAIL?

A. As a Principal at GSI, I serve in a variety of roles including as a project manager and hydrogeological technical lead.

environment, such that an operating permit for the Facility should be issued in accordance with the State of Hawai'i Underground Storage Tank ("UST") statute and regulations.

II. REVIEW AND ANALYSIS

Q. WHAT HAS BEEN YOUR GENERAL ROLE ON THIS PROJECT.

A. During the summer of 2017, AECOM hired GSI as a subcontractor to help provide deep technical expertise related to various environmental activities at the Facility in support of the US Navy. Due to my background, I was appointed as GSI's project manager responsible for the technical work conducted by GSI to help satisfy the Administrative Order on Consent ("AOC") Section 6 – Investigation and Remediation of Releases and Section 7 – Groundwater Protection and Evaluation.

Q. WHAT DID YOU DIRECTLY OVERSEE AND WHAT DID YOU ADVISE ON?

A. I provide advice to AECOM and the Navy for field efforts such as monitoring well design and installation, groundwater sampling and analysis, and development of specific field investigations and related analyses such as natural source zone depletion ("NSZD"), monitored natural attenuation ("MNA"), etc. In addition, I oversee the technical efforts of GSI experts related to various efforts such as the NSZD investigation, data evaluation, groundwater modeling, and report writing. I have been one of the primary authors for all of the reports submitted under the AOC since I was brought onto the project. Key reports that I helped develop include the following:

(1) Conceptual Site Model Report.

(2) Groundwater Protection and Evaluation of Considerations for the Red Hill Bulk Fuel Storage Facility.

(3) Groundwater Flow Model Report.

(4) Investigations and Remediation of Releases Report.

(5) Facility Environmental Report ("FER"), which will be filed in this contested case in support of this testimony.

In addition, I participate in various meetings and technical collaboration efforts with stakeholders including the Groundwater Modeling Working Group Meetings, Technical Working Group Meetings, and public meetings.

Finally, I was a coauthor of a peer-reviewed scientific paper on natural source zone depletion evidenced at Red Hill which was recently published in the Journal of Contaminant Hydrology (McHugh et al. 2020), and which is included as Appendix D to the FER.

Q. ARE THERE OTHER KEY EXPERTS THAT YOU HAVE RELIED ON IN PREPARING THE FACILITY REPORTS AND THIS TESTIMONY?

A. Yes. While GSI has a group of approximately 20 scientists and engineers that have supported the Red Hill effort, I have particularly relied on:

(1) Dr. Sorab Panday for groundwater modeling. Dr. Panday is a member of the National Academy of Engineering and is a world-renown groundwater modeler.

(2) Dr, Ileana Rhodes for her expertise in fuel chemistry and analysis of groundwater and drinking water samples (especially for her expertise in analysis of Total Petroleum Hydrocarbons). Dr. Rhodes is a world-renown petroleum chemist and has led various industry and agency training efforts, including for the DOH.

(3) Dr. Tom McHugh for his expertise related to attenuation of hydrocarbons in the subsurface. Dr. McHugh is a widely recognized and published expert.

I have also relied upon several senior staff at AECOM, including but not limited to two of its former Red Hill project managers, who remain involved with the project:

(4) Jeff Johnson, a hydrogeologist with over 30 years of experience conducting environmental investigations, most of which was in the State of Hawaii.

(5) Frank Cioffi, a Hawaii-licensed Civil (environmental) Professional Engineer with over 25 years conducting environmental investigations at underground storage tank and other sites, most of which was in the State of Hawaii.

Exhibit D

From:	Riddle, Marnie E CIV USN OGC WASH DC (USA)
To:	Riddle, Marnie E CIV USN OGC WASH DC (USA)
Subject:	FW: Data sharing
Date:	Friday, January 8, 2021 12:53:59 PM

From: Erwin Kawata <EKAWATA@hbws.org>
Sent: Friday, July 20, 2018 11:23 AM
To: Manfredi, Mark S CIV CNRH, N4A <mark.manfredi@navy.mil>
Cc: Ernest Lau <elau@hbws.org>; Lisa Kim <LKIM@hbws.org>; 'Steven Linder (linder.steven@epa.gov)' <linder.steven@epa.gov>; 'Shalev, Omer' <Shalev.Omer@epa.gov>; 'Ichinotsubo, Lene K (lene.ichinotsubo@doh.hawaii.gov)' <lene.ichinotsubo@doh.hawaii.gov>; 'Kwan, Roxanne S' <roxanne.kwan@doh.hawaii.gov>
Subject: [Non-DoD Source] FW: Data sharing

Mark,

Thank you for sharing a copy of the Office of the Secretary of Defense's confirmation concerning information regarding the location and pumping rates of Navy water production wells. As you know BWS is equally concerned with similar information for our wells and can understand the Navy's position. At the same time, please know that BWS regards the Navy as an official government agency and we have no objections providing you, without conditions, BWS well information to an agency we believe knows how to safeguard such information.

In this regard, the BWS believes it has responded to all of the Navy's data requests to date and we have met your needs per our ongoing data sharing discussions. Below is a summary of my understanding of BWS' data sharing efforts to date.

BWS submitted its pumping data for Halawa Shaft, Moanalua Wells, and Kalihi Shaft collected during the synoptic water level study and water level data from Halawa T45 and Manaiki T24 to USGS. The BWS understood that all interested parties agreed that USGS would collect this data from the agencies participating in the study. BWS has no objections to USGS making our data available to the Navy as a groundwater modeling working group participant, provided that the Navy treat this information as confidential and abide by any and all safeguards afforded to such information by existing federal and state laws.

Regarding the Navy's June 6, 2017 letter to Mayor Caldwell, BWS responded on June 27, 2017 (copy enclosed). Our letter states that on June 22, 2017, the EPA, Navy, DOH and BWS met to discuss information exchange, including the Navy's June 6, 2017 letter. During the meeting, we discussed the need for a formal process for data and information exchange to address past BWS experiences and concerns with this subject. At that time, EPA instructed the meeting participants to defer action on exchanging information, including the Navy's June 6, 2017 letter, until a formal data sharing process was established.

As the discussions between EPA, DOH, Navy and BWS continued, BWS sent another letter to EPA dated July 31, 2017 proposing each party designate an individual or individuals to clarify scope of any then-existing information requests and to discuss appropriate timeframes for response. At that time, BWS understood this approach was the go-forward plan for exchanging information. On August 3, 2017, I received your email that provided me with your list of what the Navy considered to be the top 3 data sets (see attached email) that it needed. The BWS has since responded to all of the data requests on your August 3, 2017 email and understood this satisfied the requests set forth in the Navy's June 6, 2017 letter.

On July 19, 2018, I received your email below which again included the Navy's June 6, 2017 letter and a spreadsheet purporting to show certain requested information items as complete and incomplete. BWS does not believe these documents portray the current state of data sharing. First, the spreadsheet is also dated from June 2017 and does not appear to be accurate in light of data BWS has provided since that time.

Second, the spreadsheet and request overlooks the fact that some of the requested information is publically available or has been provided to other sources equally accessible to the Navy. For example, in addition to the data provided to USGS, and as explained in the past, the Navy should consult the BWS 30-year master plan and watershed management plans for information about our water resource and development plans. These documents are available on the BWS' website at www.boardofwatersupply.com

Third, the context in which the email and spreadsheet were sent appears to suggest that BWS has not been forthright in providing information. Please know that BWS firmly disagrees with any such implication. As set forth above, BWS has responded to the Navy's requests fully and, in fact, we remain open to the designated individuals meeting to discuss and clarify the scope of any requests for information as well as appropriate timeframes for a response.

If you have any questions, feel free to call me at 748-5080. Thanks.

Erwin

-----Original Message-----
From: Manfredi, Mark S CIV CNRH, N4A <mark.manfredi@navy.mil>
Sent: Thursday, July 19, 2018 9:18 AM
To: Erwin Kawata <EKAWATA@hbws.org>
Cc: Ichinotsubo, Lene K <lene.ichinotsubo@doh.hawaii.gov>; 'roxanne.kwan@doh.hawaii.gov' <roxanne.kwan@doh.hawaii.gov>; Shalev, Omer <Shalev.Omer@epa.gov>; Linder, Steven (Linder.Steven@epa.gov) <Linder.Steven@epa.gov>; TU, LYNDSEY (Tu.Lyndsey@epa.gov) <Tu.Lyndsey@epa.gov>; Waki, Cory K CIV NAVFAC HI, EV1 <cory.waki@navy.mil>
Subject: Data sharing

Erwin,
I wanted to share with you confirmation we received from the Office of the Secretary of Defense concerning information regarding the location and pumping rates of navy water production wells. The document (attached) states "This information qualifies as DoD critical infrastructure security

information (DCRIT), as defined by 10 U.S.C.§ 130e, because the disclosure of well locations and pump rates would reveal the primary water source for bases and commands on and adjacent to Joint Base Pearl Harbor-Hickam which are critical to national security." As such, we are required to protect such information from public disclosure. (I recognize BWS is equally concerned with similar information on their wells.). Further, we are also required to ensure certain measures are in place to prevent such disclosure; which is why we require NDAs and cannot provide this information to one or any organization we do not have a signed NDA with.

I understand BWS's position regarding NDA's, and don't intend to revisit that discussion. However, I also recognize the significance of this information as well as other non-navy data has on the accuracy/reliability of ongoing modeling efforts. To that end, would BWS consider an NDA or other such MOU/MOA, that only addresses specific data sets, rather than a blanket document? For example, the paper would state something to the effect that "BWS agrees to not share the geographic location and pumping rate data for Navy's Red Hill Shaft". Of course, we would sign something similar for any BWS related information. Absent something like that, we would unfortunately not be able to provide BWS with that specific information. Let me know your thoughts.

To that end, I would also like to ask again for the following data. This information in particular is critical to our modeling efforts:
1. Pumping data for Halawa Shaft, Moanalua Wells, and Kalihi Shaft during the synoptic water level study (approximately July 1, 2018 through March 31, 2018 or what they provided to USGS) 2. Synoptic water level data from wells Halawa T45 (3-2255-033) and Manaiki T24 (3-2153-009) that were monitored by BWS 3. Any data that they can provide from the new well (BWS2253-J1 [State Well No. 3-2253-006]) installed by BWS near RHMW09 in addition to what was provided by DLNR as described in the attached table

Thanks

v/r
Mark

M. S. Manfredi
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Exhibit E

DETERMINATION OF THE DIRECTOR OF ADMINISTRATION

Under the authority delegated to me by the Secretary of Defense, I have determined that the following information is exempt from disclosure under Exemption 3 of the Freedom of Information Act (5 U.S.C. § 552(b)(3)) because it meets the requirements for exemption under 10 U.S.C. § 130e:

> Locations and production rates of U.S. Navy-owned water production wells on the Island of Oahu, Hawaii.

Date: 6·19·18

Michael L. Rhodes
Director of Administration

STATEMENT OF THE BASIS FOR THE DETERMINATION BY THE DIRECTOR OF ADMINISTRATION

In accordance with 10 U.S.C. § 130e, I reviewed information regarding the locations and water production rates for United States Navy's water production wells on the Island of Oahu, Hawaii. I determined this information qualifies as DoD critical infrastructure security information (DCRIT), as defined by 10 U.S.C.§ 130e, because the disclosure of well locations and pump rates would reveal the primary water source for bases and commands on and adjacent to Joint Base Pearl Harbor-Hickam which are critical to national security. As defined by 10 U.S.C. § 130e, DCRIT includes:

> "…sensitive but unclassified information that, if disclosed, would reveal vulnerabilities in Department of Defense critical infrastructure that, if exploited, would likely result in the significant disruption, destruction, or damage of or to Department of Defense operations, property, or facilities, including information regarding the securing and safeguarding of explosives, hazardous chemicals, or pipelines, related to critical infrastructure or protected systems owned or operated by or on behalf of the Department of Defense, including vulnerability assessments prepared by or on behalf of the Department of Defense, explosives safety information (including storage and handling), and other site-specific information on or relating to installation security."

The disclosure of Navy well pump rates and their locations would reveal the primary water source for Department of Defense (DoD) installations on and adjacent to Joint Base Pearl Harbor-Hickam. Exploitation of this information, individually or in the aggregate, would likely endanger public health and safety and result in significant disruption, destruction, or damage of or to DoD operations, personnel, property, or facilities.

I considered the public interest in the disclosure of well locations and production rates against the risk of harm that might result if this information was exploited by an adversary. The U.S. Navy already discloses information on water quality from these wells to the State of Hawaii Department of Health and the United States Environmental Protection Agency for further distribution to the public. The harm that would likely result from disclosure of the well locations and pump rates is very serious and extremely significant. Therefore, the public interest consideration does not outweigh the national security risk posed by disclosure.

Exhibit F

relatively low-permeability geological layers known to be present in Red Hill, which further impede the downward flow of hydrocarbons.

- **Plume Stability.** The dissolved-constituent impacts are confined to groundwater near the tanks and do not appear to be increasing over the life of the groundwater monitoring program. In terms commonly used in the environmental field, this means that the impacts are "stable," "attenuated," and not migrating toward any human or ecological receptors (*see* Sidebar 8).

2.3 RED HILL'S SUBSTANTIAL ENVIRONMENTAL DATA COLLECTION

Red Hill is probably the most extensively studied UST system in the State of Hawai'i with the largest environmental data set of any UST system in the State. The Navy has collected a plethora of data that have greatly expanded understanding of the geology and hydrogeology at Red Hill, as well as conditions in the underlying groundwater aquifer, which has enabled the studies and conclusions briefly summarized above. The data serve as the foundation for the Navy's AOC environmental investigation findings and will continue to do so as more data are collected and investigations, evaluations, and decision making continue (*see* Section 3). Therefore, it is worth noting the variety of data sources and monitoring locations that have been and continue to be used to ensure that operation of the Facility remains protective of human health and the environment.

Figure 5 overlays all the features and testing locations described below to show the breadth and extent of data considered for the Navy's various environmental studies. This sizable dataset has allowed the Navy to:

- Refine the understanding of the local and regional geology and geohydrology.
- Conduct hydraulic analyses related to groundwater flow.
- Comprehensively evaluate groundwater chemistry.
- Analyze and quantify naturally occurring conditions and processes (NSZD and natural attenuation).
- Develop potential remedial alternatives for hypothetical future fuel releases.

Figure 6a through Figure 6l present different types of data and monitoring locations that have been employed (and which collectively compose Figure 5), which are briefly summarized below.

(a) **Drinking Water Supply Wells.** The three closest drinking water supply wells to the Facility are Red Hill Shaft, Hālawa Shaft, and the Moanalua Wells (Figure 6a).

(1) Red Hill Shaft (Hawai'i Well Identification [ID] 2254-01) is a potable water pumping station operated by Naval Facilities Engineering Systems Command, Hawaii's Utilities and Energy Division. The pumping station is located within the Facility's lower tunnel system approximately one-half mile *makai* (seaward) of the Facility tanks. The station pumps groundwater from a water development tunnel (also called an infiltration gallery) that extends from the pumping station to within 1,530 feet of the nearest Facility fuel storage tank. The pumping station supplies the Joint Base Pearl Harbor-Hickam water distribution system, which serves approximately 65,200 military workers, members, and their families.

(2) Hālawa Shaft (2354-01) is a municipal water supply well with an associated water development tunnel operated by BWS located approximately 4,400 feet northwest of the tank farm. The pumping station is located in an underground pump room approximately 150 feet below ground. Groundwater is pumped from a water development tunnel to provide municipal drinking water for O'ahu.

Navy's 2017 subsurface structural geology survey transect conducted along that location for its AOC environmental investigation (*see* Item (f)), and (2) improving the understanding of the presence and extent of valley fill and saprolite in South Hālawa Valley, and whether those geologic formations extend below the approximate elevation of the regional basal aquifer. The borehole was not converted to a monitoring well due to its proximity to the Hālawa Deep well. This borehole was also fitted with instruments that provide additional data regarding hydraulic conditions within the valley fill, saprolite, and underlying unweathered basalt volcanics.

(d) **Oily Waste Disposal Facility Monitoring Wells.** The Oily Waste Disposal Facility, located approximately 0.6 mile west and topographically downgradient of the Red Hill Facility, was constructed in the 1940s as a collection point for oily wastewater generated by the cleaning of Red Hill's fuel storage tanks. A series of two reclamation and disposal pits were constructed in the same approximate location and used intermittently from 1943 until 1986, when operations ceased. Several monitoring wells were installed at the site as part of environmental investigations in the 1990s and early 2000s (Figure 6c). The Navy incorporated the geologic and water level data from the boring logs into the CSM. One monitoring well from the earlier environmental investigations (now referred to as OWDFMW01) was added to the Red Hill groundwater monitoring network in 2016.

(e) **Groundwater Level Data Evaluation.** Since 2017, the USGS, on behalf of the Navy, has been executing a detailed groundwater level monitoring program (synoptic study). The USGS has deployed water level instruments (known as transducers) in conventional wells and multilevel wells at the Facility and in the surrounding vicinity (Figure 6d). The Navy initiated the synoptic study to provide data for development of both the CSM and groundwater flow modeling. Data derived from the synoptic study have been used extensively for both purposes.

(f) **Subsurface Structural Geology Surveys.** The Navy conducted subsurface structural geology surveys throughout the Red Hill area in December 2017 to better define subsurface conditions and hydrogeologic boundaries beneath Red Hill, North Hālawa Valley, South Hālawa Valley, and Moanalua Valley (DON 2018a). Results of nine acquired subsurface structural geologic profiles (Figure 6e) showed that valley fill sediments are constrained to the upper ~60 feet below land surface in all three valleys, and the saprolite base (a highly impermeable barrier to groundwater flow) extends to hundreds of feet below sea level in portions of North and South Hālawa Valleys (typical basal groundwater elevations in the Red Hill/Hālawa Valley area are approximately 18–20 feet above sea level).

(g) **Geologic Field Mapping.** The Navy developed a geologic framework model and a three-dimensional regional geologic model of Red Hill and surrounding environs (including North and South Hālawa Valleys, Moanalua Valley, the Salt Lake area, and Pearl Harbor) to provide geologic support for its groundwater flow modeling effort. The three-dimensional geologic model encompassed the groundwater flow model domain and incorporated information from borehole logs, subsurface structural geology surveys, developed cross sections, and published literature. The Navy used this and other data to prepare detailed geologic cross sections by correlating available geologic logs of cores and the results of field mapping conducted with experts from DOH and the University of Hawai'i ("UH") along multiple outcrops in the vicinity of Red Hill and within the Moanalua Tunnel (Figure 6f). In addition, the Navy determined accurate strike and dip measurements of the lava flows and the presence of highly porous clinker units within Red Hill. Strike and dip of a rock outcrop can be used to determine the general direction that a fluid can flow. The measurements were used to identify a general dip direction for Red Hill (south-southwest), which can influence groundwater flow. The Navy then oriented the groundwater flow model to match the general dip direction for Red Hill.

The pilot study data will also be used to identify action levels for a full-scale continuous monitoring system, should one be developed. This will help to identify new fuel releases while minimizing false positive results. If this approach is deemed appropriate, data can be reviewed and action levels can be refined on a tank-by-tank basis to further improve release-detection capabilities.

3.1.4 Expanded Groundwater Monitoring Network and Continued Long-Term Monitoring

The Navy continues to expand its Red Hill groundwater monitoring network. From 5 wells that were being used before the 2014 Tank 5 Release to 19 wells in operation today, the current plans are to increase that number to 27 wells by 2023 (*see* Sidebar 15).[38] Due to the significant depth to groundwater, the complicated drilling in this heterogenous basaltic environment, and the limited number of on-island contractors (only one) with the equipment capable of performing this complicated drilling, each well takes significant time and care to install and comes at considerable expense. As new basal groundwater monitoring wells come online, they are added to the quarterly groundwater monitoring events, with results reported to DOH and made available to the public on at least a quarterly basis.

Not only will the additional data help document the safety of the drinking water supply, the geologic and hydrogeologic data collected during well drilling and installation will also greatly expand the understanding of subsurface conditions across Hālawa Valley. The Navy will incorporate the additional data to perform future modeling efforts, establish a formal groundwater monitoring network under the AOC SOW, and update the GWPP (*see* Sections 3.1.5–3.1.7).

3.1.5 Groundwater Flow Modeling

Understanding the direction and rate of groundwater flow under a variety of reasonable supply well pumping scenarios is critical to assessing the risk that any hypothetical future fuel leak could pose to local drinking water. Initially, the AOC SOW scoped the groundwater flow model effort as one of updating a model developed for a previous 2007 Facility environmental investigation (DON 2007). The Navy modeling team found that updating the 2007 model was insufficient and recommended additional work, including entirely rebuilding, providing more detail, and expanding the model. Working with the AOC Parties and other stakeholders, the Navy refined the modeling domain to extend approximately 51 square miles from Waimalu Valley in the northwest to Kalihi Valley in the southeast, and from near the Ko'olau crest in the northeast to Pearl Harbor and the Pacific Ocean in the southwest (*see* Location Map, Figure 1), far beyond where any impacts might reasonably be expected. Since there are a range of factors that require consideration, the Navy developed a multi-model approach to bound expected flow conditions (Ajami et al. 2006). Such an effort requires additional work on behalf of the Navy but results in a more reliable range of predictions under given scenarios.[39]

[38] As is the case with soil vapor monitoring, it bears noting that "groundwater monitoring," although not required for this Facility, is generally an acceptable release detection method under the Hawaii UST regulations. HAR §11-280.1-43(6). While the Navy acknowledges that the depth to water is greater at the Facility than set forth in the regulations, HAR §11-280.1-43(6)(B), the other requirements are generally met. Perhaps most importantly, a compliant groundwater monitoring system must include "methods used can detect the presence of at least one-eighth of an inch of free product on top of the groundwater in the monitoring wells." HAR §11-280.1-43(6)(F). No such free product has ever been measured in any of the (currently 19) groundwater monitoring wells during the entire course of the long-term groundwater monitoring program.

[39] In the past, investigators often tried to complete a single predictive model for a given site. However, there is always a certain level of variation in environmental conditions at any site, especially one as geologically and hydrologically complicated as Red Hill, such that one single model cannot be counted upon to be completely accurate or precise. Therefore, many modern experts recommend the use of a multi-model approach, wherein a set of models are used to analyze different potential aquifer conditions, resulting in models that encompass or "bound" the reasonably likely outcomes (Scavia, DePinto, and Bertani 2016).

4. Documents Incorporated Into the Record

The Navy has collected a plethora of data and conducted a vast number of analyses for the Facility prior to and pursuant to the AOC, which are described in a host of documents related to the Facility. Several of the documents contain detailed underlying data for the information presented herein or are otherwise considered important enough they incorporate into the record in this contested case. Table 1 lists Red Hill environment-related documents that the Navy submits for incorporation into the record for this Contested Case Hearing; links to official government websites are provided where available.

Table 1: Environmental Documents to be Incorporated Into the Record

Document	URL
1. AOC SOW § 2: Tank Inspection, Repair, and Maintenance (TIRM):	
a. Navy's TIRM Report	https://www.epa.gov/sites/production/files/2016-10/documents/red-hill-aoc-section-2-2-tirm-report-2016-10-11.pdf
b. Navy's TIRM Decision Document	https://www.epa.gov/sites/production/files/2017-09/documents/red_hill_aoc_tirm_decision_document.pdf
c. Navy's Red Hill Facility Evaluation Report (concludes Facility is safe)	https://www.epa.gov/sites/production/files/2017-06/documents/red_hill_facility_compliance_evaluation_report_june_2017.pdf
d. AOC Regulatory Agencies' Approval of TIRM Decision Document	https://www.epa.gov/sites/production/files/2017-09/documents/epa_and_doh_approval_of_tirm_decision_document.pdf
2. AOC SOW § 3: Tank Upgrade Alternatives (TUA):	
a. Navy's Proposed TUA and Release Detection Decision Document [a]	https://www.epa.gov/sites/production/files/2019-09/documents/red_hill_aoc_tua_proposal_decision_document_20190919.pdf
b. AOC Regulatory Agencies' Notice of Deficiencies for the TUA and New Release Detection Alternatives Decision Document (Disapproval)	https://www.epa.gov/red-hill/tank-upgrade-alternatives-red-hill#file-575447
3. AOC SOW § 4: Release Detection/Tank Tightness Testing:	
a. Navy's Current Fuel Release Monitoring Systems Report	https://www.epa.gov/sites/production/files/2016-04/documents/current-fuel-release-monitoring-systems-report-with-appendices-2016-04-04.pdf
b. AOC Regulatory Agencies' Approval of Current Fuel Release Monitoring Systems Report	https://www.epa.gov/sites/production/files/2016-09/documents/approval_of_current_fuel_release_monitoring_systems_report_15_sep_2016.pdf
c. Navy's Proposed TUA and Release Detection Decision Document [a]	https://www.epa.gov/sites/production/files/2019-09/documents/red_hill_aoc_tua_proposal_decision_document_20190919.pdf
d. AOC Regulatory Agencies' Notice of Deficiencies for the TUA and New Release Detection Alternatives Decision Document (Disapproval)	https://www.epa.gov/red-hill/tank-upgrade-alternatives-red-hill#file-575447
3. AOC SOW § 5: Corrosion and Metal Fatigue Practices:	
a. Navy's Destructive Testing Results Report	https://www.epa.gov/sites/production/files/2019-07/documents/red-hill-destructive-testing-results-report-20190707.pdf
b. AOC Regulatory Agencies' Joint Response to Destructive Testing Results Report (Disapproval)	https://www.epa.gov/sites/production/files/2020-03/documents/joint-response-red-hill-corrosion_metal_fatigue_practices_destructive_testing_results-signed-2020-03-16.pdf
c. Navy's Response to AOC Regulatory Agencies' Disapproval	https://www.epa.gov/sites/production/files/2020-07/documents/red_hill_dtrr_aoc_sow_sec_5_2jun.pdf
d. Regulatory Agencies' Response (Conditional Approval of Completion of AOC SOW § 5.3.3)	https://www.epa.gov/sites/production/files/2020-07/documents/red_hill_joint_regulatory_agency_response_2020-07-07.pdf
5. AOC SOW § 6: Investigation and Remediation of Releases:	
a. Navy's Investigation and Remediation of Releases Report [a]	https://www.epa.gov/sites/production/files/2020-04/documents/red-hill-investigation-and-remediation-of-releases-report-rev00-redacted-2020-03-25.pdf

Exhibit G

Appendix B.2
Boring Logs

Well Development Log

Location: Red Hill BFSF	**Station ID:**	**Station Name:** RHMW02	**Diameter:** 2"	**Date:** 9/8/2005
Sys_Samp_Code:		**Elevation:**	**Material:** PVC	**Time** **Start:** 1400
Sampler: Shawn/Tim		**Dry:** yes / no	**Balier Dia./L (in):** 1.5 X 90	**Finish:** 1530
CO.: TEC/VWD		**TD:** [redacted]	**Development Method:** SS Bailer	

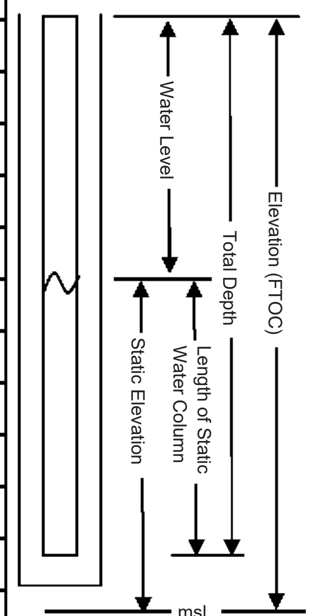
Date	Time	Water Level (FTOC)	Volume Removed (gal)	pH	Temp C°	Color	EC	Turbidity/ Sand (ppt)	Comments
9/8/05	1434	87.3'	3.50	7.48	25.0	Slightly Cloudy	0.83	0.41	
9/8/05	1445	87.3'	6.50	7.30	24.5	Slightly Cloudy	0.82	0.41	
9/8/05	1456	87.3'	10.25	7.26	24.3	Slightly Cloudy	0.84	0.42	
9/8/05	1502	87.3'	13.50	7.21	24.2	Slightly Cloudy	0.81	0.40	
9/8/05	1505	87.3'	14.25	7.24	24.2	Slightly Cloudy	0.81	0.41	
9/8/05	1507	87.3'	15.00	7.22	24.3	Slightly Cloudy	0.81	0.41	

Casing Volume Information

A	Hole Diam.	=	5.00
B	Well OD	=	2.375
C	Well ID	=	1.939
D	H2O Level	=	87.31
E	TD	=	[redacted]
F	Est. Filter Porosity	=	0.40

Vc=3.14(C/2)^2(E-D)

Vf=3.14[(A/2)^2-(B/2)^2](E-D)(F)



Casing ID	VOL Gal/Ft
1.00	0.04
1.50	0.09
2.00	0.16
2.50	0.26
3.00	0.37
3.50	0.50
4.00	0.65
4.50	0.83
6.00	1.50
7.00	2.00
8.00	2.60

Notes:

Well	**Vc=**	1.78	gal
	Vf=	3.67	gal
	Vt=	5.45	gal
	3Vt=	16.35	gal
Bailer	**V=**	0.68	gal

■ FOIA §(b)(3), Critical Infrastructure

Well Development Log

Location: Red Hill BFSF | **Station ID:** | **Station Name:** RHMW03 | **Diameter:** 2" | **Date:** 9/7/2005

Sys_Samp_Code: | **Elevation:** | **Material:** PVC | **Time** **Start:**

Sampler: Shawn/Mike D. | **Dry: yes / no** | **Balier Dia./L (in):** 1.5 X 30 | **Finish:**

CO.: TEC/VWD | **TD:** [redacted] | **Development Method:** PVC Bailer

Date	Time	Water Level (FTOC)	Volume Removed (gal)	pH	Temp C°	Color	EC	Turbidity/ Sand (ppt)	Comments
9/7/05	1421	104.2	0.23	5.40	26.7	Dk Grayish	1.42	0.71	
9/7/05	1428	104.2	0.69	6.21	26.5	Dk Grayish	1.44	0.72	
9/7/05	1433	104.2	1.61	6.24	26.4	Dk Grayish	1.37	0.69	
9/7/05	1437	104.2	2.30	6.27	26.3	Dk Grayish	1.36	0.68	
9/7/05	1444	104.2	2.99	6.36	26.2	Dk Grayish	1.20	0.60	
9/7/05	1451	104.2	4.14	6.33	26.1	Dk Grayish	1.20	0.60	
9/7/05	1455	104.2	4.83	6.30	26.1	Dk Grayish	1.15	0.57	
9/7/05	1500	104.2	5.52	6.32	26.2	Dk Grayish	1.01	0.55	
9/7/05	1510	104.2	6.67	5.39	26.2	Dk Grayish	1.03	0.52	
9/7/05	1518	104.2	7.59	5.37	26.2	Dk Grayish	1.02	0.51	
9/7/05	1526	104.2	8.51	5.39	26.2	Dk Grayish	1.02	0.50	
9/7/05	1527	104.2	8.74	5.57	26.3	Dk Grayish	1.01	0.50	

Notes:

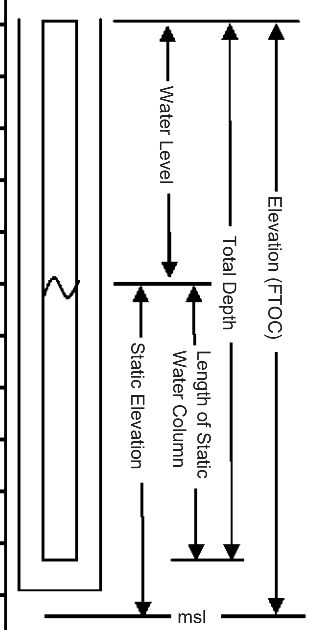
Well	**Vc=**	2.00	gal
	Vf=	4.11	gal
	Vt=	6.11	gal
	3Vt=	18.32	gal
Bailer	**V=**	0.23	gal

Casing Volume Information

A	Hole Diam.	=	5.00
B	Well OD	=	2.375
C	Well ID	=	1.939
D	H2O Level	=	104.20
E	TD	=	[redacted]
F	Est. Filter Porosity	=	0.40

Vc=3.14(C/2)^2(E-D)

Vf=3.14[(A/2)^2-(B/2)^2](E-D)(F)



Casing ID	VOL Gal/Ft
1.00	0.04
1.50	0.09
2.00	0.16
2.50	0.26
3.00	0.37
3.50	0.50
4.00	0.65
4.50	0.83
6.00	1.50
7.00	2.00
8.00	2.60

■ FOIA §(b)(3), Critical Infrastructure

TEC inc.

GEOLOGIC BOREHOLE LOG

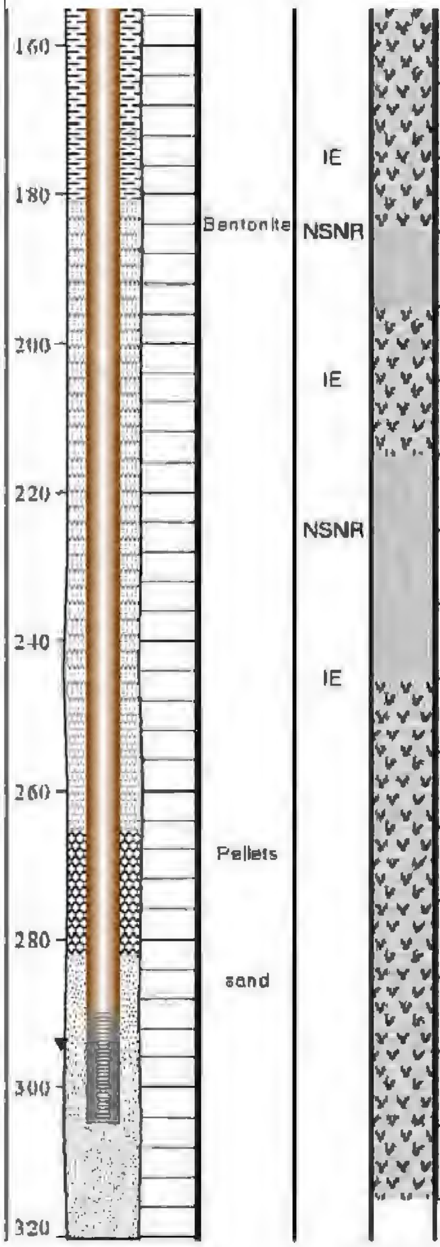
Location: **RHFSF**	Station Name: **RHMW04**	Location Type: **Monitoring Well**
Location Description: **west. access rd., S of Navy Firing Range**	Establishing Company: **TEC Inc.**	
Drilling Foreman: **Tomas Fernandez**	Drilling Company: **Valley Well Drilling**	
Geologist: **N. Griffin/S. MacMillan**	Ground Surface Elevation (ft): **313.03**	Datum: **MSL**
Drilling Sampling Method: **Rock Coring**	Borehole Diameter (in): **8**	
Total Depth (ft): **320.5**	Date Drilling Started: **22 July 2005**	Date Drilling Ended: **26 July 2005**
Remarks:		

Well Construction	Well Fill	USCS	Soil Description	Soil Sample
0	Cement Grout	GW	Well-graded gravel with sand - dark reddish brown (5YR 2.5/2), medium stiff, moist, 80% gravel, 15% fines, 5% fines, road base.	RHMW04S02
			Basalt bedrock.	
			Basalt - moderate brown (5YR 3/4). Rate = 5/5, 50 - 80% vesicles.	
			Basalt - dark gray (blue rock) (N3). Rate = 5/10, massive, 5% small crystals.	
20		IE	Basalt - dark gray (N3). Rate = 5/10, 70 - 90% vesicles:small.	
			Basalt - dark gray (N3). Rate = 5/7, massive.	
			Basalt - dark gray (N3). Rate = 5/10, 70 - 90% vesicles.	
40			Basalt - dark gray (N3). Rate = 5/10, vesicles.	
			Basalt - dark gray (N3). Rate = 5/10, vesicles.	
60			Basalt - dark gray (N3). Rate = 5/12, vesicles.	
		NSNR	Rate = 5/18, no recovery.	
80			Basalt - moderate brown to dark gray (5YR 3/4 to N3). Rate = 5/12, vesicles.	
			Basalt - dark gray (N3). Rate = 5/16, vesicles with min. deposits. Perched water encountered - to approx. 130 feet.	
100			Basalt - dark gray (N3). Rate = 5/15, massive.	
			Basalt - dark reddish brown to dark gray (10YR 3/4 to N3). Rate = 5/20, vesicles.	
120			Basalt - medium dark gray to dark gray (N4 to N3). Rate = 5/15, vesicles.	
		IE	Basalt - dark reddish brown to dark gray (10YR 3/4 to N3). Rate = 5/15, massive and vesicles.	
140			Basalt - dark reddish brown (10YR 3/4). Rate = 5/10, vesicles.	
			Basalt - dark gray (N3). Rate = 5/12, vesicles.	

GEOLOGIC BOREHOLE LOG

Location: **RHFSF**	Station Name: **RHMW04**	Location Type: **Monitoring Well**
Location Description: **west. access rd., S of Navy Firing Range**	Establishing Company: **TEC Inc.**	
Drilling Foreman: **Tomas Fernandez**	Drilling Company: **Valley Well Drilling**	
Geologist: **N. Griffin/S. MacMillan**	Ground Surface Elevation (ft): **313.03**	Datum: **MSL**
Drilling Sampling Method: **Rock Coring**	Borehole Diameter (in): **8**	
Total Depth (ft): **320.5**	Date Drilling Started: **22 July 2005**	Date Drilling Ended: **26 July 2005**

Remarks:



Basalt - dark gray (N3). Rate = 5/ 5. vesicles.

Basalt - dark gray (N3). Rate = 5/ 15. vesicles

Basalt - dark gray (N3). Rate = 5/ 30. vesicles.

Rate = 5/ 14. No recovery.

Basalt - dark gray (N3). Rate = 5/ 10. vesicles.

Basalt - dark gray (N3). Rate = 5/ 13. vesicles.

Rate = 5/ 10. No recovery

Rate = 5/ 15. No recovery.

Rate = 5/ 12. No recovery

Basalt - dark gray (N3). Rate = 5/ 12. vesicles

Basalt - medium dark gray (N4). Rate = 5/ 10. vesicles.

Basalt - medium dark gray (N4). Rate = 5/ 10. vesicles.

Basalt - medium dark gray (N4). Rate = 5/ 10. vesicles.

Basalt - dark gray (N3). Rate = 5/ 10. vesicles.

Basalt - dark gray (N3). Rate = 5/ 10. vesicles.

Basalt - dark gray to blackish red (N3 to 5R 2/ 2). Rate = 5/ 8. vesicles. water at 311'

~~For Red Hill AOC Party Use Only~~

Well Construction Log

Location:	Red Hill BFSF	**Station ID:**		**Station Name:**	RHMW04	**Date:**	7/22/2005
Sys_Samp_Code:		**Elevation:**		**TD:**	320.5'	**Time** Start:	
Driller:	Tomas	**CO.:**	VWD	**Date Finished:**	7/26/2005	Finish:	

Drilling Protocol

Hole Diameter:	8"	**Drilling Method:**	Air Rotary	**Inclination:**	90°	**Azimuth:**	n/a

Casing

Material:	PCV Sch 80	**Diameter**	**ID:** 3.826"	**From:**	0'	
			OD: 4.5"	**To:**	290'	

Screen

Material:	PCV Sch 80	**Diameter**	**ID:** 3.826"	**From:**	290'	**Slot #:**	0.02
			OD: 4.5"	**To:**	305'		

Annular Fill

Sand:	Monterey #3	**Type**	**Bentonite**	**Chips:**	16 **Bags**	**Grout:**	2 **Bags**	
	6	**Bags**		**Pellets:**	6 **Bkts**	**Cement:**	40 **Bags**	

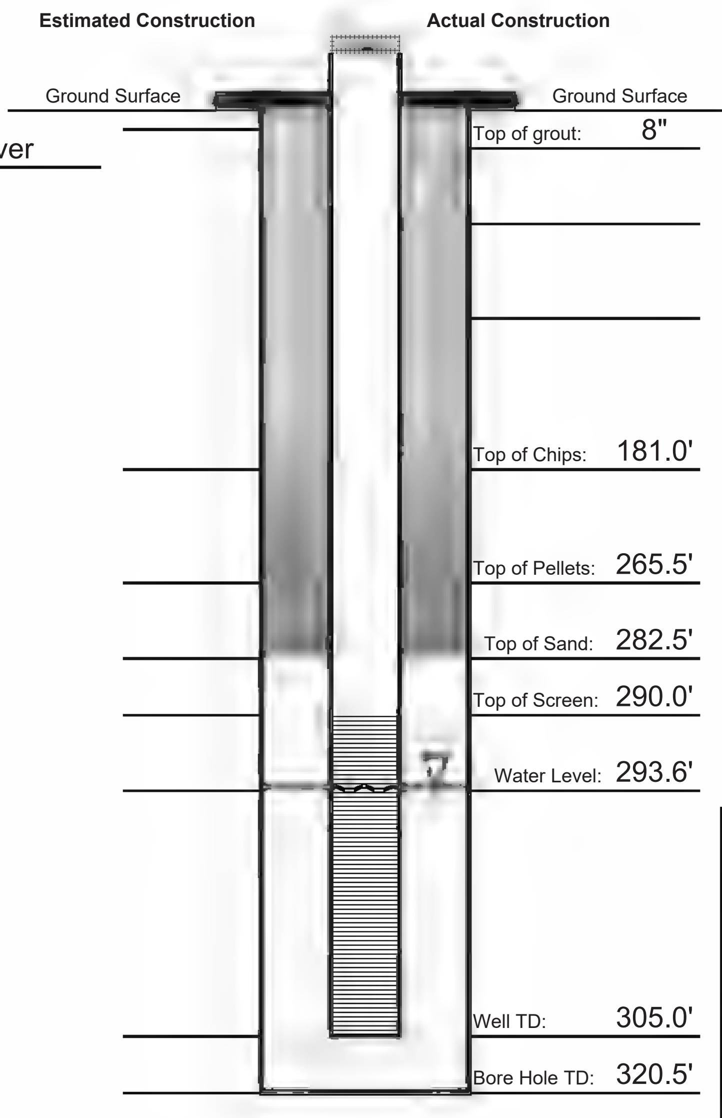
Surface Casing

Type: Traffic Cover

Diameter: 12"

Length: 12"

Pad: 3X3



Notes:

Legend: Cement, Grout, B. Chips, B. Pellets, Sand

For Red Hill AOC Party Use Only

Well Development Log

Location: Red Hill BFSF	Station ID:	Station Name: RHMW04	Diameter: 4"	Date: 7/26/2005
Sys_Samp_Code:		Elevation:	Material: PVC	Time — Start: 1415
Sampler: Tomas		Dry: yes / no	Balier Dia./L (in): 4 X 48	Time — Finish: 1515
CO.: VWD		TD: 305'	Development Method: SS Bailer	

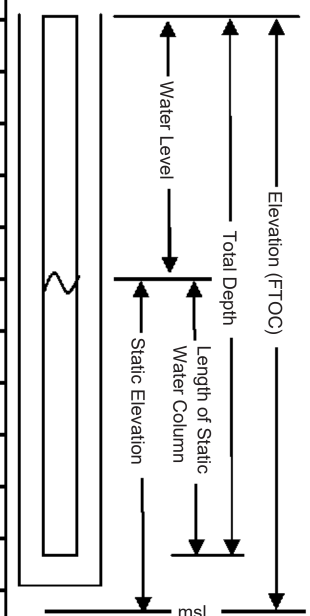
Date	Time	Water Level (FTOC)	Volume Removed (gal)	pH	Temp C°	Color	EC	Turbidity/ Sand (NTU)	Comments
7/26/05	1418	294.1	5.00	7.68	22.3	-----	0.58	450	
7/26/05	1425	294.1	10.00	7.38	22.9	-----	0.53	999+	
7/26/05	1431	294.1	15.00	7.26	22.7	-----	0.56	999+	
7/26/05	1436	294.1	20.00	7.30	22.8	-----	0.54	999+	
7/26/05	1443	294.1	25.00	7.17	22.4	-----	0.53	999+	
7/26/05	1451	294.1	30.00	7.20	22.6	-----	0.53	650	
7/26/05	1456	294.1	35.00	7.27	22.48	-----	0.52	600	
7/26/05	1503	294.1	40.00	7.21	22.33	-----	0.52	400	
7/26/05	1508	294.1	45.00	7.21	22.12	-----	0.53	450	

Casing Volume Information

A	Hole Diam.	=	8.00
B	Well OD	=	4.500
C	Well ID	=	3.826
D	H2O Level	=	294.10
E	TD	=	305.00
F	Est. Filter Porosity	=	0.40

Vc=3.14(C/2)^2(E-D)

Vf=3.14[(A/2)^2-(B/2)^2](E-D)(F)



Casing ID	VOL Gal/Ft
1.00	0.04
1.50	0.09
2.00	0.16
2.50	0.26
3.00	0.37
3.50	0.50
4.00	0.65
4.50	0.83
6.00	1.50
7.00	2.00
8.00	2.60

Notes:

Well	Vc=	6.47	gal
Well	Vf=	7.73	gal
Well	Vt=	14.20	gal
Well	3Vt=	42.59	gal
Bailer	V=	2.59	gal

GEOLOGIC LOG

DATE STARTED: 28-Aug-14	LOGGER: [illegible]		
DATE COMPLETED: 17-Sept-14	WEATHER: 90 degrees Fahrenheit	WELL NO.: RHMW06	
COMPANY NAME: PARSONS	DRILLING SUBCONTRACTOR: Valley Well Drilling	SURFACE ELEV.: 255.81 ft amsl	
OFFICE LOCATION: South Jordan, Utah	DRILL RIG TYPE: Mobile B-59 and B-90	SOUNDING TUBE ELEV.: 259.01 ft	
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01	DRILLING METHOD: Auger, HQ core, Air Rotary	NORTHING: [redacted]	
LOCATION: Red Hill BFSF, HI; JOB NUMBER: 749435	BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	EASTING: [redacted]	

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD
0.0–10.0	(0.0, 10.0) Clay	CLAY		
10.0–11.5	(10.0, 11.5) Clay: dark brown, CL, little silt, plastic, small rounded pebbles, poor recovery, Note: basalt cobbles and boulders within clay are present from ground surface to the saprolite contact	CLAY	0.0	12/19/19
11.5–15.0	(11.5, 15.0) Clay	CLAY		
15.0–16.5	(15.0, 16.5) Clay: dark yellowish brown, CH, stiff, plastic, small angular rock fragments, poor recovery			21/25/100 for 4"
16.5–20.0	(16.5, 20.0) Clay			
20.0–21.5	(20.0, 21.5) Clay: dark yellowish brown to gray, friable, dry	CLAY	0.0	
21.5–23.0	(21.5, 23.0) Clay	CLAY	0.0	
23.0–24.5	(23.0, 24.5) Clay: gray basalt in tip, cobble (?), only tip recovery	SAPR	0.0	
24.5–35.0	(24.5, 35.0) Saprolite: start coring, in and out of weathered basalt and saprolite, mottled yellowish to dark yellowish brown saprolite, thin bands of gray vesicular basalt, solid rock contact at about 35 feet bgs, NOTE: THE GSA ROCK COLOR CHART (1991) WAS USED FOR THE FOLLOWIING WET COLOR DESCRIPTIONS	VLBA	0.0	

WELL CONSTRUCTION INFORMATION

SURFACE COMPLETION: 3.5' x 3.5' x 2' concrete pad w/ 8" above-ground steel casing

WELL CASING:
- Material: SCH. 80 PVC
- Diameter: 4"
- Interval: +3.2-230 bgs

WELL SCREEN:
- Material: SCH. 80 PVC
- Screen Opening: 0.020
- Diameter: 4"
- Interval: 230-260 bgs

CONDUCTOR CASING:
- Material: PVC
- Diameter: 10"
- Interval: 0-40 bgs

DEPTH INTERVAL:
- Concrete: 0-3
- Cement Grout: 3-40 bgs
- Bentonite Chips: 40-215 bgs
- Bentonite Seal: 215-223 bgs
- Sand Pack: 223-269 bgs
- Hole Cuttings: 269-270 bgs

NOTE: All intervals are measured from ground surface.

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ppmv - Parts per Million, Volume per Volume
SAA - Same as Above
Horizontal Survey System: NAD 83 Epoch 2010.0
Elevations: Local Mean Sea Level (feet)

DP - Direct Push
HSA - Hollow Stem Auger
SSA - Solid Stem Auger
TD - Total Depth
HS - Head Space
ERPIMS CODE DESCRIPTIONS:
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CLAY - Clay
CLGV - Clay and Gravel
CLSD - Clay and Sand
CLSL - Clay and Silt

CN - Concrete
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CORL - Coral
FILL - Fill or other Man-Made Deposits
GVL - Gravel
GVLP - Gravel, predominantly pebble-sized
GVSL - Gravel and Silt
NDPS - No Description Provided, Problems in Sampling
NSNR - No Sample or No Recovery Obtained
PTHM - Peat, Humus, and other Organic Material
SAPR - Saprolite

SD - Sand
SDSL - Sand and Silt
SDGR - Sand and Gravel
SEDU - Sedimentary (Undifferentiated)
SLCL - Silt and Clay
SLGV - Silt and Gravel
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VLBA - Basalt, Lava
VLTF - Volcanic Tuff

■ FOIA § (b)(9), Well Information

GEOLOGIC LOG

DATE STARTED: 28-Aug-14	LOGGER: T. Jensen	
DATE COMPLETED: 17-Sept-14	WEATHER: 90 degrees Fahrenheit	WELL NO.: RHMW06
COMPANY NAME: PARSONS	DRILLING SUBCONTRACTOR: Valley Well Drilling	SURFACE ELEV.: 255.81 ft amsl
OFFICE LOCATION: South Jordan, Utah	DRILL RIG TYPE: Mobile B-59 and B-90	SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01	DRILLING METHOD: Auger, HQ core, Air Rotary	NORTHING: [redacted]
LOCATION: Red Hill BFSF, HI — JOB NUMBER: 749435	BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
30							
35	(35.0, 40.0) Basalt: olive gray, 5Y 4/1, pumice-like vesicular with small semi-round voids, vertical fracture at 37 ft with iron stained and weathered surfaces, 3 ft. recovery				75%		
40	(40.0, 45.0) Basalt : SAA, vesicular with 30% small and round voids, competent, infilled voids near bottom at 44 ft.				90%		
45	(45.0, 50.0) Basalt: SAA, vesicular with up to 35% voids, variable size and shape voids-some larger than 5 mm., moderate strength w/ mechanical fractures		VLBA	0.0	80%		
50	(50.0, 55.0) Basalt: olive gray to greenish gray, dense, 10% voids, oblique fractures w/ weathered surfaces, drilling water return		VLBA	0.0	50%		
55	(55.0, 60.0) Basalt: greenish gray and dense from 55-57, up to 1 in. vugs w/ some secondary infilling, transitions back to olive gray vesicular basalt		VLBA	0.0	NA		
60							

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SEDU - Sedimentary (Undifferentiated)
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VLBA - Basalt, Lava
VLTF - Volcanic Tuff

■ FOIA § (b)(9), Well Information

GEOLOGIC LOG

DATE STARTED: 28-Aug-14	LOGGER: TW Jensen	PAGE 3 OF 10	
DATE COMPLETED: 17-Sept-14	WEATHER: 90 degrees Fahrenheit	WELL NO.: RHMW06	

For Red Hill AOC Party Use Only

COMPANY NAME: PARSONS	DRILLING SUBCONTRACTOR: Valley Well Drilling	SURFACE ELEV.: 255.81 ft amsl
OFFICE LOCATION: South Jordan, Utah	DRILL RIG TYPE: Mobile B-59 and B-90	SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01	DRILLING METHOD: Auger, HQ core, Air Rotary	NORTHING: [redacted]
LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435	BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
60	(60.0, 65.0) Basalt: olive gray, vesicular w/ 30% small round voids, iron-stained voids and natural fractures from 63-65 ft.		VLBA	0.0	75%		
65	(65.0, 70.0) Basalt: SAA, large angled fracture at 67.5 ft., voids infilled with white mineral, grades to non-vesicular and more dense at 69 ft.		VLBA	0.0	80%		
70	(70.0, 75.0) Basalt: lost core, trip out, recover 2 ft. of gray vesicular basalt		VLBA	0.0	NA		
75	(75.0, 80.0) Basalt: brownish black 5YR 2/1, vesicular, grades to brownish gray 5YR 4/1 with larger voids at 76 ft., some secondary infilling of voids from 76-77 ft, some fractures		VLBA	0.0	75%		
80	(80.0, 85.0) Basalt: grayish black (N2), dense, vugs with pristine "needle-like" zeolite cyrstals, light coating of white to bluish gray amporphous silica within voids indicative of the movement of water, large fracture at 82 ft. with secondary rust colored mineralization		VLBA	0.0	80%		
85	(85.0, 90.0) Basalt: dark gray (N3), hard, dense, competent, 10% open voids, as large as 5 mm., some infilling of voids with amorphous quartz or zeolite, 10% slightly weathered olivine phenocrysts, Note: first occurrence of phenocrysts, rock above is aphanitic w/ very few phenocryts		VLBA	0.0	80%		
90							

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■ FOIA § (b)(9), Well Information

GEOLOGIC LOG

DATE STARTED: 28-Aug-14	LOGGER: TW Jensen	
DATE COMPLETED: 17-Sept-14	WEATHER: 90 degrees Fahrenheit	WELL NO.: RHMW06
COMPANY NAME: PARSONS	DRILLING SUBCONTRACTOR: Valley Well Drilling	SURFACE ELEV.: 255.81 ft amsl
OFFICE LOCATION: South Jordan, Utah	DRILL RIG TYPE: Mobile B-59 and B-90	SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01	DRILLING METHOD: Auger, HQ core, Air Rotary	NORTHING: [redacted]
LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435	BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
90	(90.0, 93.0) Basalt: partial run, SAA, transitions to as much as 35% voids, zones where voids are infilled with reddish orange clay-like soft silica, large infilled fracture at 90-91 ft.		VLBA	0.0	80%		
	(93.0, 98.0) Basalt: SAA, 25 % voids, range from 1 mm. to 8 mm., zones w/ infilling of voids, few fractures		VLBA		90%		
95				0.0			
	(98.0, 100.0) Basalt: SAA, few healed or infilled fracture zones		VLBA		60%		
100	(100.0, 105.0) Basalt: SAA, grades dense, competent, and unweathered at 104 ft., cyrstalline texture, few olivine phenocrysts, lost circulation, switched over to all water and no air		VLBA	0.0	75%		
105	(105.0, 110.0) Basalt: SAA, grades from dense and hard to low density and weak pumice-like vesicular w/ 50% small and round voids at 109 ft.		VLBA	0.0	85%		
110	(110.0, 115.0) Basalt: SAA, dark gray vesicular, zones with reddish orange soft silica along fractures and in voids, 6 in. clay zone at 114 ft., possibly a weathered zone between flows		VLBA	0.0	50%		
115	(115.0, 120.0) Basalt: SAA, dark gray, variable void percentage througout, mechanical breaks, reddish orange soft silica where weathered		VLBA	0.0	60%		
120							

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■ FOIA § (b)(9), Well Information

GEOLOGIC LOG

DATE STARTED: 28-Aug-14	LOGGER: T. W. Jensen	
DATE COMPLETED: 17-Sept-14	WEATHER: 90 degrees Fahrenheit	WELL NO.: RHMW06

COMPANY NAME: PARSONS	DRILLING SUBCONTRACTOR: Valley Well Drilling	SURFACE ELEV.: 255.81 ft amsl
OFFICE LOCATION: South Jordan, Utah	DRILL RIG TYPE: Mobile B-59 and B-90	SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01	DRILLING METHOD: Auger, HQ core, Air Rotary	NORTHING: [redacted]
LOCATION: Red Hill BFSF, HI — JOB NUMBER: 749435	BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
120	(120.0, 125.0) Basalt: SAA, washout from 123-124 ft., 60% recovery		VLBA	0.0	50%		
125	(125.0, 130.0) Basalt: dark gray (N3), stronger rock, 25% voids, large irregular voids up to 10 mm., fresh high-angle fracture at 128.5 ft., minor infilling of voids at 129 ft. w/ reddish orange soft silica, mechanical breaks		VLBA	0.0	85%		
130	(130.0, 135.0) Basalt: dark gray (N3), overall brown from oxidation, looks like broken up rubble zone at top of flow, lava inclusions, secondary infilling in weak zones		VLBA	0.0	40%		
135	(135.0, 140.0) Basalt: dark gray (N3), harder and dense, vesicular basalt, 20% voids, two high-angle fractures at 139 ft., coated fracture surfaces and some infilling of voids		VLBA	0.0	85%		
140	(140.0, 145.0) Basalt: SAA, aphanitic-crystalline texture, dense, irregular voids, a few fresh fractures w/light iron-oxide staining		VLBA	0.0	80%		
145	(145.0, 150.0) Basalt: dark gray, compentent, moderate strength, mechanical breaks, not much infilling of voids		VLBA	0.0	90%		
150							

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■ FOIA § (b)(9), Well Information

GEOLOGIC LOG

DATE STARTED: 28-Aug-14
DATE COMPLETED: 17-Sept-14
LOGGER: TW Jensen
WEATHER: 90 degrees Fahrenheit
WELL NO.: RHMW06

COMPANY NAME: PARSONS
OFFICE LOCATION: South Jordan, Utah
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01
LOCATION: Red Hill BFSF, HI
JOB NUMBER: 749435

DRILLING SUBCONTRACTOR: Valley Well Drilling
DRILL RIG TYPE: Mobile B-59 and B-90
DRILLING METHOD: Auger, HQ core, Air Rotary
BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air

SURFACE ELEV.: 255.81 ft amsl
SOUNDING TUBE ELEV.: 259.01 ft
NORTHING: [redacted]
EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
150	(150.0, 155.0) Basalt: dark gray, crystalline, dense, some olivine, 5% voids, mechanical breaks		VLBA	0.0	80%		
155	(155.0, 160.0) Clinker: switched bits and went to air, poor recovery, bad core resulting from air coring, rounded, red rock possibly clinker		VLBA	0.0	NA		
160	(160.0, 163.0) Clinker: grayish red 10R 4/2 clinker, lost water circulation, diesel odor in ambient air from apparent venting of tanks		VLBA	BG=1.5	NA		
	(163.0, 168.0) Basalt: dark gray, hard, dense, crystalline texture, some quartz, 10% voids, trace secondary black mineral coating, fresh fractures w/ little secondary mineralization on surfaces, PID interference from background fumes in ambient air		VLB	BG=27	90%		
165							
	(168.0, 170.0) Basalt: SAA, finish run, silica-coated vertical fracture, some mechanical breaks		VLBA	0.0			
170	(170.0, 175.0) Basalt: SAA, dark gray, two healed fractures from 170-171, grades to rubbly broken zone, weathered rock and mud from 172-175, poor recovery		VLBA	0.0	NA		
175	(175.0, 180.0) Basalt: dark gray and less compentent pumice-like vesicular w/ about 30% small round voids, few thin broken zones, several healed fractures		VLBA	0.0	50%		
180							

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■ FOIA § (b)(9), Well Information

GEOLOGIC LOG	DATE STARTED: 28-Aug-14 DATE COMPLETED: 17-Sept-14	LOGGER: T.W. Jensen WEATHER: 90 degrees Fahrenheit	PAGE 7 OF 10 WELL NO.: RHMW06
COMPANY NAME: **PARSONS** OFFICE LOCATION: South Jordan, Utah		DRILLING SUBCONTRACTOR: Valley Well Drilling DRILL RIG TYPE: Mobile B-59 and B-90	SURFACE ELEV.: 255.81 ft amsl SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435		DRILLING METHOD: Auger, HQ core, Air Rotary BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	NORTHING: [redacted] EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
180	(180.0, 185.0) Basalt: dark gray vesicular, variable void percentage, broken zone from 181-183 ft., fractures and voids infilled with reddish orange soft silica		VLBA	0.0	50%		
185	(185.0, 190.0) Basalt: SAA, grades to brownish gray then back to dark gray, less voids from 190-192 ft, fractured w/ gouged slickenside surfaces at 193 ft., infilling of voids with soft silica		VLBA	0.0	70%		
190	(190.0, 195.0) Basalt: dark gray (N3), vesicular, variable void size, shape, and percentage, more compentent, fractures at 194 ft., coated fracture surface with reddish orange silica and black oxides and infilling of voids below fractures, mechanical breaks,		VLBA	0.0	70%		
195	(195.0, 200.0) Basalt: dark gray, vesicular, larger connected voids, dense, light olive brown coating in voids indicative of the movement of water, some olivine, few horizontal fractures		VLBA	0.0	50%		
200	(200.0, 205.0) Basalt: dark gray (N3), cyrstalline texture, compentent and consistent core, subtle flow layering w/ stretched voids, horizontal fractures from 200-201 feet, secondary black oxides		VLBA	0.0	90%		
205	(205.0, 210.0) Basalt: dark gray, weathered w/ secondary infilling, broken zones		VLBA	0.0	50%		
210							

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■ FOIA § (b)(9), Well Information

GEOLOGIC LOG	DATE STARTED: 28-Aug-14 DATE COMPLETED: 17-Sept-14	[illegible] WEATHER: 90 degrees Fahrenheit	 WELL NO.: RHMW06

COMPANY NAME: PARSONS OFFICE LOCATION: South Jordan, Utah	DRILLING SUBCONTRACTOR: Valley Well Drilling DRILL RIG TYPE: Mobile B-59 and B-90	SURFACE ELEV.: 255.81 ft amsl SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435	DRILLING METHOD: Auger, HQ core, Air Rotary BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	NORTHING: [redacted] EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
210	(210.0, 215.0) Basalt: brownish gray 5YR 4/1, 30% voids, less dense, broken w/ soft silica infillling, dark reddish brown non-vesicular bands, grades to dark gray at 214 ft.		VLBA	0.0			
215	(215.0, 220.0) Basalt: brownish gray 5YR 4/1, w/ dark yellowish brown bands, less competent, moderate strength, broken zone from 218-219 w/ secondary infilling, olive gray w/ 10% voids from 219-220 ft.		VLBA	0.0			
220	(220.0, 225.0) Basalt: grayish red 10R 4/2, low density and weak, weathered matrix,		VLBA	0.0	75%		
225	(225.0, 230.0) Basalt: SAA, alternating with dark gray vesicular, olive gray basalt w/ 30% voids at 229 ft., irregular voids up to 1 in., light silica coating in voids indicative of the movement of water		VLBA	0.0			
230	(230.0, 235.0) Basalt: SAA, but more competent, up to 30% irregular voids, increase in void percentage near bottom of run, black oxide secondary mineralization in some voids and surfaces		VLBA	0.0	90%		
235	(235.0, 240.0) Basalt: dark brown to dark yellowish brown to olive to greenish black, possible alteration to serpentine or chlorite in places, friable in places, non-competent, weathered to clay		VLBA	0.0	25%		
240							

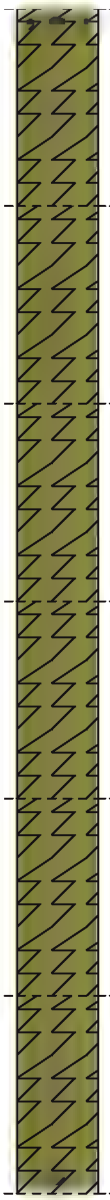
amsl - Above Mean Sea Level	DP - Direct Push	CN - Concrete	SD - Sand
bgs - Below Ground Surface	HSA - Hollow Stem Auger	COBL - Cobble or Boulder	SDSL - Sand and Silt
ft - feet	SSA - Solid Stem Auger	CORL - Coral	SDGR - Sand and Gravel
mm - millimeter(s)	TD - Total Depth	FILL - Fill or other Man-Made Deposits	SEDU - Sedimentary (Undifferentiated)
N/A - Not Applicable	HS - Head Space	GVL - Gravel	SLCL - Silt and Clay
NS - Not Sampled	ERPIMS CODE DESCRIPTIONS:	GVLP - Gravel, predominantly pebble-sized	SLGV - Silt and Gravel
PID - Photoionization Detector	ASPT - Asphalt	GVSL - Gravel and Silt	SLSD - Silt and Sand
ppmv - Parts per Million, Volume per Volume	CLAY - Clay	NDPS - No Description Provided, Problems in Sampling	VLBA - Basalt, Lava
SAA - Same as Above	CLGV - Clay and Gravel	NSNR - No Sample or No Recovery Obtained	VLTF - Volcanic Tuff
Horizontal Survey System: NAD 83 Epoch 2010.0	CLSD - Clay and Sand	PTHM - Peat, Humus, and other Organic Material	
Elevations: Local Mean Sea Level (feet)	CLSL - Clay and Silt	SAPR - Saprolite	

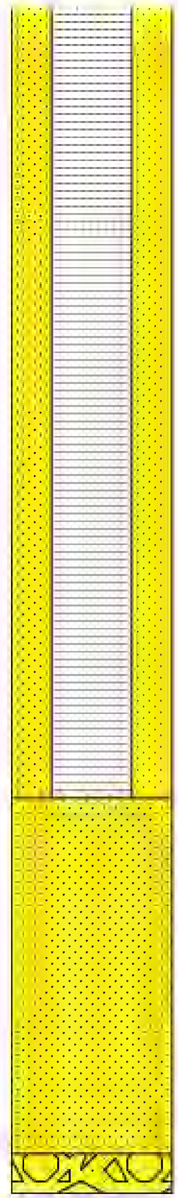
■ FOIA § (b)(9), Well Information

GEOLOGIC LOG

DATE STARTED: 28-Aug-14	LOGGED BY: [illegible] For Red Hill AOC Party Use Only	PAGE 9 OF 10
DATE COMPLETED: 17-Sept-14	WEATHER: 90 degrees Fahrenheit	WELL NO.: RHMW06
COMPANY NAME: PARSONS	DRILLING SUBCONTRACTOR: Valley Well Drilling	SURFACE ELEV.: 255.81 ft amsl
OFFICE LOCATION: South Jordan, Utah	DRILL RIG TYPE: Mobile B-59 and B-90	SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01	DRILLING METHOD: Auger, HQ core, Air Rotary	NORTHING: [redacted]
LOCATION: Red Hill BFSF, HI — JOB NUMBER: 749435	BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
240	(240.0, 245.0) Basalt: brownish gray, moderate density and strength, low void percentage, grades to olive gray vesicular basalt that is low density and weak, zones of infilling with clay-like pinkish gray soft silica		VLBA	0.0	60%		
245	(245.0, 250.0) Basalt: olive gray, 3-foot partial run, blocked off, variable void percentage, moderate density and strength, large and irregular open voids that are lightly coated with secondary amporphous silica indicative of water saturated conditions, finish 2-foot run, SAA, <10% voids, voids infilled with white mineral		VLBA	0.0	75%		
250	(250.0, 255.0) Basalt: SAA, from 250-253, more infilling of voids, grades to olive black 5YR 2/1 basalt, shows slickenlines along fracture plane and possible serpentine or talc-like secondary alteration on fracture surfaces		VLBA	0.0	70%		
255	(255.0, 260.0) Basalt: SAA, olive black, light density and weak, pumice-like vesicular, 30% small and round voids, some infilled, grades to olive gray and more dense basalt w/ larger voids, slickenlines on fracture surfaces		VLBA	0.0	50%		
260	(260.0, 265.0) Basalt: SAA from 260-262 ft., grades back to olive black light density vesicular basalt, 3 in. band of white silica at 263 ft., weak rock and strongly oxidized at 264 ft., lost water pressure during coring at 263 feet		VLBA	0.0	50%		Well TD = 260 ft bgs
265	(265.0, 270.0) Basalt: SAA, poor recovery, weak and broken rock		VLBA	0.0	NA		
270							





amsl - Above Mean Sea Level	DP - Direct Push	CN - Concrete	SD - Sand
bgs - Below Ground Surface	HSA - Hollow Stem Auger	COBL - Cobble or Boulder	SDSL - Sand and Silt
ft - feet	SSA - Solid Stem Auger	CORL - Coral	SDGR - Sand and Gravel
mm - millimeter(s)	TD - Total Depth	FILL - Fill or other Man-Made Deposits	SEDU - Sedimentary (Undifferentiated)
N/A - Not Applicable	HS - Head Space	GVL - Gravel	SLCL - Silt and Clay
NS - Not Sampled	ERPIMS CODE DESCRIPTIONS:	GVLP - Gravel, predominantly pebble-sized	SLGV - Silt and Gravel
PID - Photoionization Detector	ASPT - Asphalt	GVSL - Gravel and Silt	SLSD - Silt and Sand
ppmv - Parts per Million, Volume per Volume	CLAY - Clay	NDPS - No Description Provided, Problems in Sampling	VLBA - Basalt, Lava
SAA - Same as Above	CLGV - Clay and Gravel	NSNR - No Sample or No Recovery Obtained	VLTF - Volcanic Tuff
Horizontal Survey System: NAD 83 Epoch 2010.0	CLSD - Clay and Sand	PTHM - Peat, Humus, and other Organic Material	
Elevations: Local Mean Sea Level (feet)	CLSL - Clay and Silt	SAPR - Saprolite	

■ FOIA § (b)(9), Well Information

GEOLOGIC LOG	DATE STARTED: 28-Aug-14 DATE COMPLETED: 17-Sept-14	LOGGER: T.W. Jensen WEATHER: 90 degrees Fahrenheit	PAGE 10 OF 10 WELL NO.: RHMW06
COMPANY NAME: PARSONS OFFICE LOCATION: South Jordan, Utah		DRILLING SUBCONTRACTOR: Valley Well Drilling DRILL RIG TYPE: Mobile B-59 and B-90	SURFACE ELEV.: 255.81 ft amsl SOUNDING TUBE ELEV.: 259.01 ft
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 LOCATION: Red Hill BFSF, HI	JOB NUMBER: 749435	DRILLING METHOD: Auger, HQ core, Air Rotary BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air	NORTHING: [redacted] EASTING: [redacted]

DEPTH (ft bgs)	DESCRIPTION OF MATERIALS	GRAPHIC LOG	ERPIMS LITHO-LOGIC CODE	PID HS, ppmv (DEPTH, ft bgs)	BLOW COUNT/ RQD	WELL CONSTRUCTION (ft bgs)	WELL CONSTRUCTION INFORMATION
270	(270.0, 275.0) Basalt: olive gray, large open voids coated with silica and black oxides from 270-272 ft., grades to more dense and fractured, back to brownish gray at the bottom		VLBA	0.0	75%		
275	(275.0, 280.0) Basalt: SAA, grades back to olive gray, zone w/ large coated open voids, some infilling w/ white mineral in smaller voids, few vertical fractures w/ slickenlines on fresh fracture surfaces		VLBA	0.0	75%		
280							

amsl - Above Mean Sea Level
bgs - Below Ground Surface
ft - feet
mm - millimeter(s)
N/A - Not Applicable
NS - Not Sampled
PID - Photoionization Detector
ppmv - Parts per Million, Volume per Volume
SAA - Same as Above
Horizontal Survey System: NAD 83 Epoch 2010.0
Elevations: Local Mean Sea Level (feet)

DP - Direct Push
HSA - Hollow Stem Auger
SSA - Solid Stem Auger
TD - Total Depth
HS - Head Space
ERPIMS CODE DESCRIPTIONS:
ASPT - Asphalt
CLAY - Clay
CLGV - Clay and Gravel
CLSD - Clay and Sand
CLSL - Clay and Silt

CN - Concrete
COBL - Cobble or Boulder
CORL - Coral
FILL - Fill or other Man-Made Deposits
GVL - Gravel
GVLP - Gravel, predominantly pebble-sized
GVSL - Gravel and Silt
NDPS - No Description Provided, Problems in Sampling
NSNR - No Sample or No Recovery Obtained
PTHM - Peat, Humus, and other Organic Material
SAPR - Saprolite

SD - Sand
SDSL - Sand and Silt
SDGR - Sand and Gravel
SEDU - Sedimentary (Undifferentiated)
SLCL - Silt and Clay
SLGV - Silt and Gravel
SLSD - Silt and Sand
VLBA - Basalt, Lava
VLTF - Volcanic Tuff

■ FOIA § (b)(9), Well Information

CLIENT: JBPHH SITE: Red Hill Bulk Fuel Storage Facility

DATE: 9-10 October 2014 WELL NUMBER: RHMW06

DEVELOPER SIGNATURE: TMJ

DEVELOPMENT DESCRIPTION: Surged with block for 15 min, removed about 40 gallons on 9 October by surging and bailing with a clean 6-foot long, 3.5-inch-diameter, 4-gallon stainless steel bailer. Water was too turbid to measure accurately. Another 250 gallons were removed on 10 October until the turbidity was lower and the water relatively sediment free. A total of 290 gallons were removed. The evacuated groundwater was transferred to properly labeled 55-gallon drums and the on-site roll-off bin pending analytical results for proper off-site disposal.

Depth to well bottom (ft-btoc):	263.3	Water Column in Well Pipe (ft)	22.09
Depth to water (ft-btoc)	241.21	Well Pipe Diameter (in)	4.0
Water Column (ft)	22.09	Well Pipe Factor (gal/ft)	0.65
Sand Pack Length (ft)	46	**Water Volume in Well Pipe (gal)**	**14.36**
Water Column in Sand Pack (ft)	22.09	**One Well Volume (gal)**	**18.782**
Borehole Diameter (in)	8	Volumes to be removed (min)	10
Sand Pack Factor (gal/ft)	0.2	**Gallons to be removed (min)**	**187.78**
Water Volume in Sand Pack (gal)	**4.42**		

PURGE MEASUREMENTS: A Horiba U-52 meter with flow cell was used.

Purge Device: Stainless steel bailer Purge Rate (gal/hr): 40 to 50

Time	Vol (gal)	Temp (ºC)	pH	Cond (mS/cm)	Turb (NTU)	DO (mg/L)	ORP (mv)	Comments
1400	20	23.39	7.42	1.27	over	4.62	142	Turbid
1430	40	23.43	7.61	0.992	over	5.08	145	No drawdown
10/10								
0735	60	24.20	7.02	0.840	953	4.87	196	
0754	80	23.08	7.74	0.771	623	4.76	155	Sediment
0924	120	24.03	7.52	0.701	227	4.73	157	
1005	170	24.41	7.17	0.671	112	4.70	148	Let settle
1050	195	24.49	7.43	0.655	87.6	4.65	136	
1210	250	24.53	6.85	0.650	90.3	5.06	130	
1226	275	24.37	6.99	0.656	89.1	4.53	129	
1236	285	23.98	6.82	0.656	83.9	4.76	124	
1320	290	24.39	6.86	0.665	79.3	4.94	130	Some fine sand

Notes: Final water level was the same as pre-development. Final height of well casing was same as for development or about 2.5 ft above ground surface. Limited drawdown indicates good recharge and high permeability at this location.

Exhibit H

Appendix B.1
Field Logbooks

CONTENTS

PAGE	REFERENCE	DATE

Book #11

Location Red Hill - Lower tunnel Date 4-18-19

Project / Client

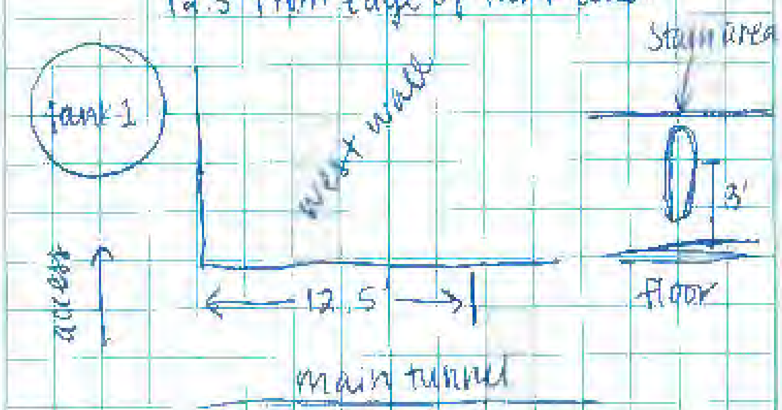
0630 Eric Wetzstein (EW) arrives WH starts setting equipment together

0820 Safety meeting at WH with FLOMMS DH & EW

0920 DH & EW arrive on site [redacted]

FOIA §§ (b)(3), Critical Infrastructure; (b)(7), Law Enforcement

0941 mobilize to tank 1, took pictures & took first sample (EK# 820) 12.5' from edge of tank wall



sample ID: tank 1 - west wall, collected @ 0955

Book 11

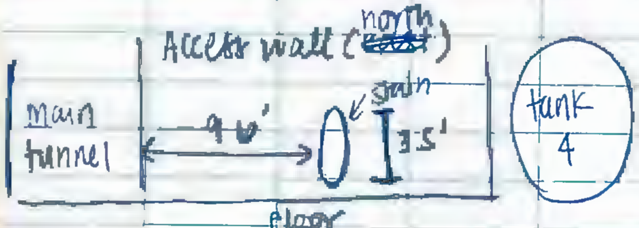
Location Lower tunnel Date 4-18-19

Project / Client

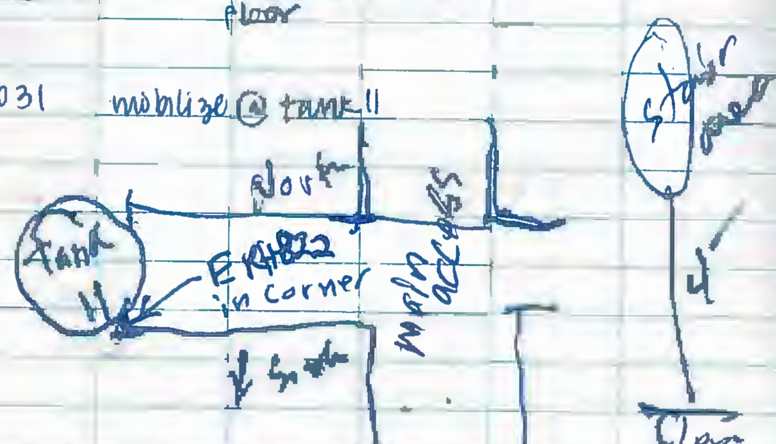
1005 noticed staining inside access walls of tank 4 staining coming from a drilled hole ERH 821, collected @ 1014, petroleum odor

Sample ID: tank 4 ~~east~~ north wall ~~access tunnel~~

MultiRAE readings: oxygen = 20.9 % H_2S = 0 ppm VOC = 0 ppm LEL = 0 % CO = 0 ppm



1031 mobilize @ tank 11



hydrocarbon odor noted at sample location

Sample collected @ 1041

Sample ID: tank 11 - west access wall

Book 11

Location Lower tunnel Date 4-18-19

Project / Client

DH 4/18/19

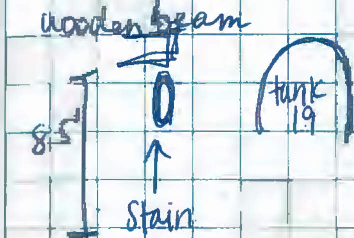
~~1005 noticed staining inside access wall of tank 4, staining coming from a drilled hole~~

1100 take elevator to UT, went to tank 19

took sample ERH 823

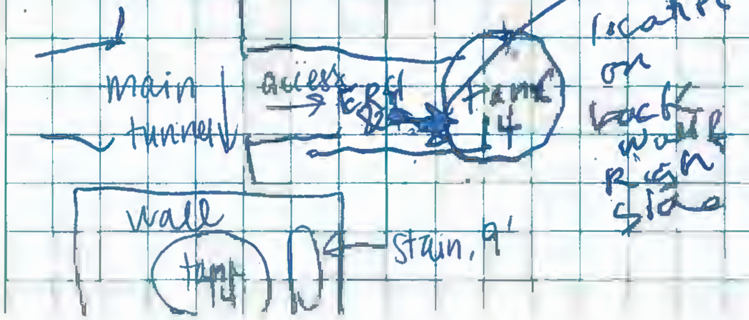
Sample ID tank 19 - beam wall @ 1134

sample was seep like



1227 Collecting Sample at tank #14

ERH 824



Book 11

Location Lower Tunnel Date 4-18-19

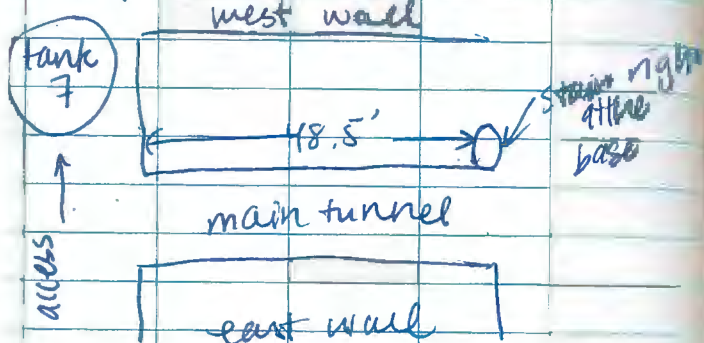
Project / Client

Mobilize to tank 7

no hydrocarbon odor

sample EEH 825 collected

sample ID tank 7-west wall



Departed site for WH (EW + DH)

DH + EW arrive at WH + unpack equipment

EW departs WH

DH ships samples from FedEx departs FedEx to return to office

Location Lower tunnel Date 4-18-19

Project / Client

1530: DH returns to office

DH 4/18/19

DH 4/18/19

Location Red Hill HCF RHMW12 Date 5/8/19
Project Client

0550 MH + Jack Flaherty (JF) @ warehouse to load equipment.
Objective: Mobilize + set up @ RHMW12 for drilling / HSA / handclearing
Weather: 40°, light variable wind, 70% humidity, partly cloudy
Personnel: AECOM (MH, JF, JK) VWD (RK, SS, BM)
0600 AECOM departs warehouse proceed to HCF
0615 AECOM + VWD arrive @ HCF discuss plan for the day & conduct H+S tailgate (see sign in sheet for details)
0640 Sign in w/ guard shack + proceed to RHMW12. Setting up drill rig and visqueen. Borehole located ~ 13.5 ft North from edge of AC pavement.
0745 MH + JF take down orange fencing from RHTB01 + RHMW14 for use @ RHMW12. Also take orange delineators from RHTB01.
0830 MH & JF download mosdax

Location 5/8/19 cont. Date
Project Client

data from RHMW14. Data from 5/6/19 through 5/8/19 is suspect. Error code 'E' reported indicating probe communication error, low battery icon displayed on mosdax upon arrival. changed battery.
0850 download data from RHMW11
0915 back @ RHMW12. VWD setting up plumbing for GAC.
0930 proceed to staging area to observe cores from RHTB01
1045 return to RHMW12
1130 VWD filling water tanks by pumping through GAC
1200 Fan belt on B59 broke VWD working on repair.
1500 No part available for repair, clean up site
1515 depart site end field day

5/8/19 [signature] [signature] 5/8/19

Location Red Hill RHMW12 Date 5/9/19

Project / Client

0550 MH + JF @ warehouse, load up equipment and calibrate PID s/n 913390, Noise pro dosimeter S/N NXS 050035 + Dustmeter S/N 6770, see cal logs for details.

weather: Partly cloudy, 80°, light variable wind, 75% humidity

Personnel: AECOM (MH, JF) UWO (RK, SJ)

objective: collect potable water sample, hand clear @ RHMW12 to 5 ft bgs; then commence HSA

0615 depart warehouse, proceed to HCF

0635 @ HCF, UWO already in lot, sign in then proceed to RHMW12

0640 conduct H+S tailgate (see sign in sheet for details)

0650 UWO begins working on fan belt repair

0710 collect TB ERH 826 3×40mL voas w/HCl

0750 Drill rig repair complete. UWO filling water tanks.

0759 Collect FB ERH 828* from near

Location RHMW12 5/9/19 cont. Date

Project / Client

drill rig working area while rig is running.

0820 Driller concerned about moyno water pump output. Says used to get ~70 gpm. Now only gets ~30 gpm. Says may need new pump / rebuild

0930 UWO troubleshooting pump

0945 RK says pump needs to be repaired / replaced offsite. UWO demobbing drill rig.

*AECOM empties FB ERH 828 into IDW. Will collect new sample next shift when pump is functional.

1030 UWO departs site w/ drill rig. AECOM begins hand augering

1130 hand auger to 4.3 ft bgs, encounter boulder making progress too difficult, clean up site.

1200 depart site, proceed to staging area to meet UWO. RK called and said pump is fine.

For Red Hill AOC Party Use Only

Location ____ Date ____

Project / Client 5/9/19 cont

VWO bringing rig to staging area.

1230 SS onsite w/ drill rig, position over RHMW12

1300 All depart site. MH + SF proceed to warehouse

1330 @ warehouse, end field day.

5/9/19

5/9/19

Location Red Hill RHMW1X2 JF Date ____

Project / Client 5/10/19

0550 MH + SF @ warehouse, load equipment + calibrate PID s/n 592-902229, Noise dosimeter S/N WXJ 050035, + dust meter s/n 6790, see cal logs for details.

Weather: Partly cloudy, 80°, mod. trade wind 70% humidity

Personnel: AECOM (MH, SF), VWO (RK, MS)

Objective: Re-collect potable water sample, HSA @ RHMW12

0605 depart warehouse, proceed to HCF

0630 @ HCF, VWO onsite already, sign in and proceed to RHMW12 conduct H+S tailgate see sign in sheet for details, VWO

MH flushing drill rig pump + lines w/ alconox during meeting.

0645 end alconox flush. VWO plumbing in GAC filter.

* Note ERH 526 TB was collected during the prev. shift @ 0710 (5/9/19).

Exhibit I

Appendix F:
Petrographic Analytical Report

Petroleum Services

Table 1
Free Product Mobility Data
Water Drive Method

AECOM Technical Services Core Lab File No: 1703942

Project Name: Red Hill Bulk Fuel Storage Facility
Project No: 60481245
Project Location: Joint Base Pearl Harbor-Hickman, Oahu HI

		METHODS:	API RP 40		API RP 40	Core Lab, API RP40				
						Pore Fluid Saturations, frac pore volume				
Sample ID.	Depth ft.	Sample Orientation (1)	Density		Total Porosity, frac	Initial Fluid Saturations (2)		Injection Pressure, ft-wtr(4)	Final Fluid Saturations (2)	
			Bulk (Dry) g/cc	Grain g/cc		Water	NAPL (3)		Water	NAPL (3)
ERH 509 65.7-66.4	65.90	V	1.70	2.94	0.418	0.711	0.289	50.0	0.861	0.139
ERH 510 81.0-81.7	81.10	V	2.70	3.00	0.051	0.436	0.564	50.0	0.436	0.564
ERH 511 155.2-155.9	155.30	V	1.80	3.05	0.412	0.639	0.361	50.0	0.693	0.307
ERH 512 105.9	106.10	V	1.66	2.98	0.447	0.750	0.250	50.0	0.871	0.129
ERH 513 133.0	133.20	V	2.12	2.99	0.289	0.574	0.426	50.0	0.778	0.222
ERH 514 162.8	162.95	V	2.40	3.04	0.211	0.367	0.633	50.0	0.644	0.356
ERH 515 181.5	Unable to obtain sufficient sample for testing									
ERH 516 242.6	242.70	V	1.76	3.05	0.409	0.707	0.293	50.0	0.707	0.293
ERH 517 341.3	341.40	V	1.77	3.06	0.428	0.241	0.759	4.6	0.415	0.585
ERH 521 171.0-171.8	171.35	V	1.89	3.05	0.374	0.574	0.426	50.0	0.576	0.424
ERH 522 200.2-201	200.30	V	1.80	2.95	0.390	0.849	0.151	50.0	0.849	0.151
ERH 523 218.2-219	218.80	V	2.45	3.00	0.176	0.511	0.489	50.0	0.781	0.219
ERH 524 248.8-249.5	249.00	V	1.58	3.00	0.483	0.644	0.356	4.6	0.644	0.356
ERH 525 289-289.8	289.25	V	2.11	3.08	0.299	0.630	0.370	50.0	0.827	0.173
ERH 526 108.5-109	108.70	V	2.12	3.02	0.294	0.805	0.195	50.0	0.805	0.195
ERH 527 137.6-138.4	137.80	V	2.55	3.00	0.133	0.556	0.444	50.0	0.556	0.444
ERH 528 155.4-156	155.60	V	2.22	3.00	0.262	0.699	0.301	50.0	0.699	0.301
ERH 529 177.2-178	177.40	V	2.10	3.07	0.292	0.694	0.306	50.0	0.694	0.306
ERH 530 214.4-216.0	215.50	V	2.58	2.99	0.118	0.523	0.477	50.0	0.523	0.477
ERH 531 296.6-297.2	296.95	V	1.51	3.02	0.513	0.556	0.444	11.5	0.619	0.381

Table 1
Free Product Mobility Data
Water Drive Method

Petroleum Services

AECOM Technical Services — Core Lab File No: 1703942

Project Name: Red Hill Bulk Fuel Storage Facility
Project No: 60481245
Project Location: Joint Base Pearl Harbor-Hickman, Oahu HI

		METHODS:	API RP 40		API RP 40	Core Lab, API RP40				
						Pore Fluid Saturations, frac pore volume				
Sample ID.	Depth ft.	Sample Orientation (1)	Density		Total Porosity, frac	Initial Fluid Saturations (2)		Injection Pressure, ft-wtr(4)	Final Fluid Saturations (2)	
			Bulk (Dry) g/cc	Grain g/cc		Water	NAPL (3)		Water	NAPL (3)
ERH 532 325.2-325.7	325.35	V	2.30	3.01	0.233	0.481	0.519	50.0	0.481	0.519
ERH 533 393.5-394.2	393.60	V	2.56	3.00	0.133	0.364	0.636	50.0	0.364	0.636
ERH 534 489.5-490.0	489.65	V	1.97	3.04	0.351	0.624	0.376	2.3	0.673	0.327
		Max	2.70	3.08	0.513	0.849	0.759	50.0	0.871	0.636
		Min	1.51	2.94	0.051	0.241	0.151	2.3	0.364	0.129
		Avg	2.08	3.02	0.305	0.588	0.412	42.0	0.659	0.341

(1) V = vertical, H = horizontal
(2) NAPL Density = 0.8066 g/cc
(3) NAPL = Jet Fuel supplied by AECOM
(4) 50ft-wtr = 21.7psi

Table 2
VISCOSITY and DENSITY DATA
(METHODOLOGY: ASTM D445, ASTM D1481, API RP40)

PETROLEUM SERVICES

Company: **AECOM Technical Services**
Project Name: Red Hill Bulk Fuel Storage Facility
Project No: 60481245
Project Location: Joint Base Pearl Harbor-Hickman, Oahu HI

Core Lab File No: 1703942

Lab Sample No.	Project No.	Matrix	Sample Source	Sample Date	Analysis Date	Temperature °F	Density g/cc	°API	Viscosity centistokes	Viscosity centipoise
1703942-1	60481245	Jet Fuel	Client	N/A	8/17/18	60	0.8135	42.4	—	—
						76	0.8070		1.530	1.234
						80	0.8054		1.482	1.193
						91	0.8010		1.304	1.044

API measured by pycnometer
Viscosity measured by a Crossarm Viscometer

Table 3
INTERFACIAL / SURFACE TENSION DATA
(METHODOLOGY: DuNuoy Method - ASTM D971)

Phase Pair		Temp., °F	Interfacial Tension, Dynes/centimeter
Air	Water	60	69.9
Air	Jet Fuel	60	25.0
Water	Jet Fuel	60	15.7

Core Lab

Table 4
Basic Rock Properties
(METHODOLOGY: API RP40)

PETROLEUM SERVICES

AECOM Technical Services — Core Lab File No: 1703942EN

Project Name: Red Hill Bulk Fuel Storage Facility
Project No: 60481245
Project Location: Joint Base Pearl Harbor-Hickman, Oahu HI

Sample ID	Depth, ft.	Measured at 250psi Net Confining Stress*: Permeability to Air (Kair), md: Pre-Test	Post Test Re-Run: A --> B	Post Test Re-Run: B --> A	Total Porosity %Vb	Helium Pore Volume cc	Helium Grain Volume cc	Grain Density g/cc	Core Description Provided by AECOM
ERH 509 56.7-66.4	65.90	619			41.6	21.94	30.57	2.94	Weathered a'a clinker
ERH 510 81.0-81.7	81.10	0.018			5.11	3.04	56.38	3.00	welded a'a clinker
ERH 511 155.2-155.9	155.30	7.05			41.2	23.35	33.35	3.05	massive a'a
ERH 512 105.9	106.10	3287	302	305	44.7	18.33	22.69	2.98	Weathered a'a clinker
ERH 513 133.0	133.20	21.8			28.9	16.19	39.84	2.99	pahoehoe
ERH 514 162.8	162.95	0.097			21.1	11.93	44.70	3.04	pahoehoe
ERH 515 181.5	Unable to obtain sufficient sample for testing								Weathered a'a clinker
ERH 516 242.6	242.70	0.241			40.9	22.41	32.44	3.05	massive a'a
ERH 517 341.3	341.40	53.3			42.9	24.36	32.42	3.06	pahoehoe
ERH 521 171.0-171.8	171.35	1.77			37.4	21.67	36.29	3.05	pahoehoe
ERH 522 200.2-201	200.30	5371	632	614	39.0	19.67	30.80	2.95	Weathered a'a clinker
ERH 523 218.2-219	218.80	31.8			17.6	7.24	33.94	3.00	welded a'a clinker
ERH 524 248.8-249.5	249.00	7873	16543	16543	48.3	28.25	30.21	3.00	pahoehoe
ERH 525 289-289.8	289.25	0.380			29.9	16.28	38.10	3.08	pahoehoe
ERH 526 108.5-109	108.70	4.96			29.4	17.25	41.38	3.02	welded a'a clinker
ERH 527 137.6-138.4	137.80	0.050			13.3	5.64	36.81	3.00	massive a'a
ERH 528 155.4-156	155.60	2.65			26.2	15.99	45.12	3.00	Weathered a'a clinker
ERH 529 177.2-178	177.40	0.284			29.2	16.26	39.47	3.07	pahoehoe
ERH 530 214.4-216.0	215.50	0.069			11.8	7.32	54.60	2.99	massive a'a

*250 psi confining stress to minimize bypass around sample
Vb = Bulk Volume

Core Lab

Table 4
Basic Rock Properties
(METHODOLOGY: API RP40)

PETROLEUM SERVICES

AECOM Technical Services — Core Lab File No: 1703942EN

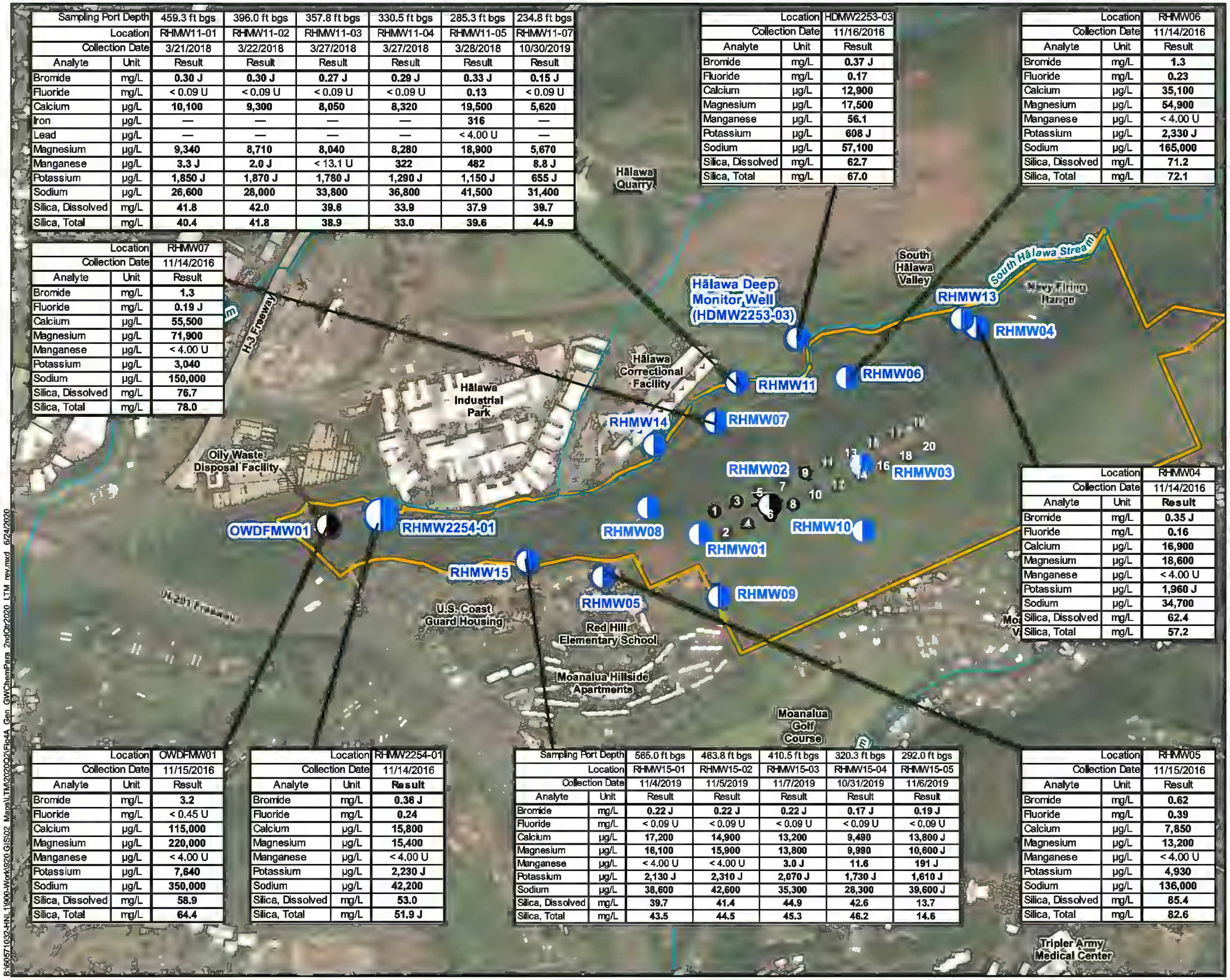
Project Name: Red Hill Bulk Fuel Storage Facility
Project No: 60481245
Project Location: Joint Base Pearl Harbor-Hickman, Oahu HI

Sample ID	Depth, ft.	Measured at 250psi Net Confining Stress* — Permeability to Air (Kair), md — Pre-Test	Post Test Re-Run A -> B	Post Test Re-Run B -> A	Total Porosity %Vb	Helium Pore Volume cc	Helium Grain Volume cc	Grain Density g/cc	Core Description Provided by AECOM
ERH 531 296.6-297.2	296.95	3917	4529	4529	51.3	30.08	28.60	3.02	Pahoehoe - oxidized dark reddish brown, highly vesicular 50%, small vesicles
ERH 532 325.2-325.7	325.35	0.098			23.3	13.35	44.01	3.01	Pahoehoe - gray, large vesicles 15%, some infilling in vesicles
ERH 533 393.5-394.2	393.60	0.149			13.3	7.70	49.99	3.00	Pahoehoe - gray, vesicular 25%, small to medium vesicles
ERH 534 489.5-490.0	489.65	11716	11716	11716	35.1	20.18	37.32	3.04	Pahoehoe - sl. oxidized reddish brown, vesicular 25%, small to medium vesicles
	Max	11716			51.3	30.1	56.4	3.08	
	Min	0.018			5.11	3.04	22.7	2.94	
	Avg	1496			30.5	16.7	38.1	3.02	

QC Check Samples	Assay, md	Measured, md	Diff %
Core Lab CK D	131	132	-0.76
Core Lab CK E	928	949	+0.76

*250 psi confining stress to minimize bypass around sample
Vb = Bulk Volume

Exhibit J



Sampling Port Depth		459.3 ft bgs	396.0 ft bgs	357.8 ft bgs	330.5 ft bgs	285.3 ft bgs	234.8 ft bgs
Location		RHMW11-01	RHMW11-02	RHMW11-03	RHMW11-04	RHMW11-05	RHMW11-07
Collection Date		3/21/2018	3/22/2018	3/27/2018	3/27/2018	3/28/2018	10/30/2019
Analyte	Unit	Result	Result	Result	Result	Result	Result
Bromide	mg/L	**0.30 J**	**0.30 J**	**0.27 J**	**0.29 J**	**0.33 J**	**0.15 J**
Fluoride	mg/L	< 0.09 U	< 0.09 U	< 0.09 U	< 0.09 U	**0.13**	< 0.09 U
Calcium	µg/L	**10,100**	**9,300**	**8,050**	**8,320**	**19,500**	**5,620**
Iron	µg/L	—	—	—	—	**316**	—
Lead	µg/L	—	—	—	—	< 4.00 U	—
Magnesium	µg/L	**9,340**	**8,710**	**8,040**	**8,280**	**18,900**	**5,670**
Manganese	µg/L	**3.3 J**	**2.0 J**	< 13.1 U	**322**	**482**	**8.8 J**
Potassium	µg/L	**1,850 J**	**1,870 J**	**1,780 J**	**1,290 J**	**1,150 J**	**655 J**
Sodium	µg/L	**26,600**	**28,000**	**33,800**	**36,800**	**41,500**	**31,400**
Silica, Dissolved	mg/L	**41.8**	**42.0**	**39.6**	**33.9**	**37.9**	**39.7**
Silica, Total	mg/L	**40.4**	**41.8**	**38.9**	**33.0**	**39.6**	**44.9**

Location		HDMW2253-03
Collection Date		11/16/2016
Analyte	Unit	Result
Bromide	mg/L	**0.37 J**
Fluoride	mg/L	**0.17**
Calcium	µg/L	**12,900**
Magnesium	µg/L	**17,500**
Manganese	µg/L	**56.1**
Potassium	µg/L	**608 J**
Sodium	µg/L	**57,100**
Silica, Dissolved	mg/L	**62.7**
Silica, Total	mg/L	**67.0**

Location		RHMW06
Collection Date		11/14/2016
Analyte	Unit	Result
Bromide	mg/L	**1.3**
Fluoride	mg/L	**0.23**
Calcium	µg/L	**35,100**
Magnesium	µg/L	**54,900**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**2,330 J**
Sodium	µg/L	**165,000**
Silica, Dissolved	mg/L	**71.2**
Silica, Total	mg/L	**72.1**

Location		RHMW07
Collection Date		11/14/2016
Analyte	Unit	Result
Bromide	mg/L	**1.3**
Fluoride	mg/L	**0.19 J**
Calcium	µg/L	**55,500**
Magnesium	µg/L	**71,900**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**3,040**
Sodium	µg/L	**150,000**
Silica, Dissolved	mg/L	**76.7**
Silica, Total	mg/L	**78.0**

Location		RHMW04
Collection Date		11/14/2016
Analyte	Unit	Result
Bromide	mg/L	**0.35 J**
Fluoride	mg/L	**0.16**
Calcium	µg/L	**16,900**
Magnesium	µg/L	**18,600**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**1,960 J**
Sodium	µg/L	**34,700**
Silica, Dissolved	mg/L	**62.4**
Silica, Total	mg/L	**57.2**

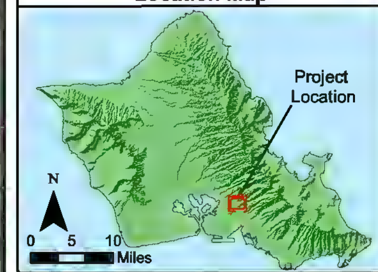
Location		OWDFMW01
Collection Date		11/15/2016
Analyte	Unit	Result
Bromide	mg/L	**3.2**
Fluoride	mg/L	< 0.45 U
Calcium	µg/L	**115,000**
Magnesium	µg/L	**220,000**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**7,640**
Sodium	µg/L	**350,000**
Silica, Dissolved	mg/L	**58.9**
Silica, Total	mg/L	**64.4**

Location		RHMW2254-01
Collection Date		11/14/2016
Analyte	Unit	Result
Bromide	mg/L	**0.36 J**
Fluoride	mg/L	**0.24**
Calcium	µg/L	**15,800**
Magnesium	µg/L	**15,400**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**2,230 J**
Sodium	µg/L	**42,200**
Silica, Dissolved	mg/L	**53.0**
Silica, Total	mg/L	**51.9 J**

Sampling Port Depth		565.0 ft bgs	463.8 ft bgs	410.5 ft bgs	320.3 ft bgs	292.0 ft bgs
Location		RHMW15-01	RHMW15-02	RHMW15-03	RHMW15-04	RHMW15-05
Collection Date		11/4/2019	11/5/2019	11/7/2019	10/31/2019	11/6/2019
Analyte	Unit	Result	Result	Result	Result	Result
Bromide	mg/L	**0.22 J**	**0.22 J**	**0.22 J**	**0.17 J**	**0.19 J**
Fluoride	mg/L	< 0.09 U	< 0.09 U	< 0.09 U	< 0.09 U	< 0.09 U
Calcium	µg/L	**17,200**	**14,900**	**13,200**	**9,490**	**13,800 J**
Magnesium	µg/L	**16,100**	**15,900**	**13,800**	**9,990**	**10,600 J**
Manganese	µg/L	< 4.00 U	< 4.00 U	**3.0 J**	**11.6**	**191 J**
Potassium	µg/L	**2,130 J**	**2,310 J**	**2,070 J**	**1,730 J**	**1,610 J**
Sodium	µg/L	**38,600**	**42,600**	**35,300**	**28,300**	**39,600 J**
Silica, Dissolved	mg/L	**39.7**	**41.4**	**44.9**	**42.6**	**13.7**
Silica, Total	mg/L	**43.5**	**44.5**	**45.3**	**46.2**	**14.6**

Location		RHMW05
Collection Date		11/15/2016
Analyte	Unit	Result
Bromide	mg/L	**0.62**
Fluoride	mg/L	**0.39**
Calcium	µg/L	**7,850**
Magnesium	µg/L	**13,200**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**4,930**
Sodium	µg/L	**136,000**
Silica, Dissolved	mg/L	**85.4**
Silica, Total	mg/L	**82.6**

Location Map



Legend

- Monitoring Well with Screening Criteria Exceedance(s)
- Existing Monitoring Well Location
- Red Hill Tank
- Stream
- Red Hill Facility Boundary

Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015
3. Only analytes with detections and associated SGC data (if applicable) are shown.

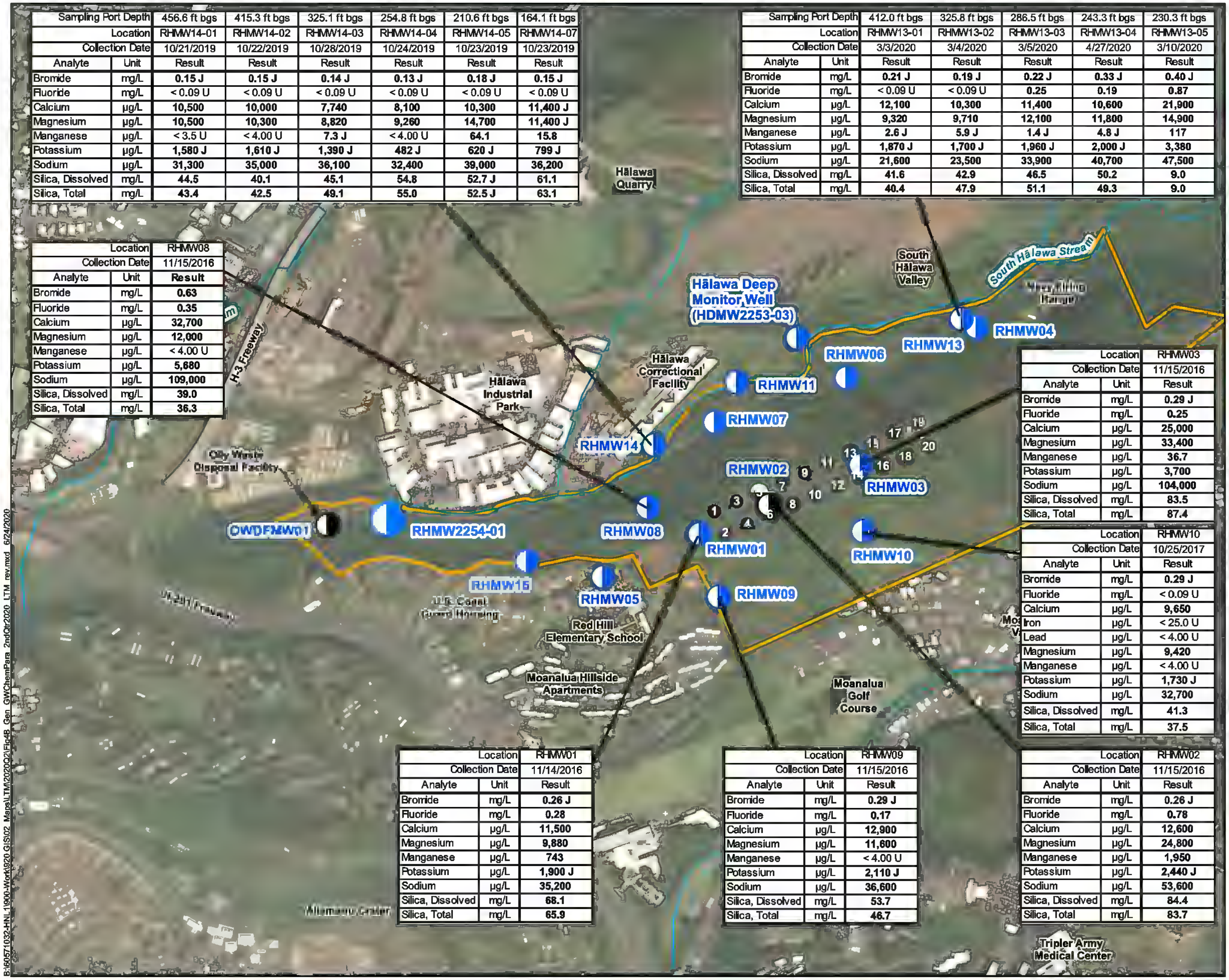
ABBREVIATIONS:

FD	field duplicate sample
ID	identification
J	estimated value
N	primary (normal) sample
SGC	silica gel cleanup
SSRBL	site-specific risk based level
TPH-d	total petroleum hydrocarbon - diesel range organics
TPH-g	total petroleum hydrocarbon - gasoline range organics
TPH-o	total petroleum hydrocarbon - oil/residual organics
U	non-detect value (reported as less than the limit of detection)
µg/L	microgram per liter

Monitoring Well with **COPC** Screening Criteria Exceedance(s)

Figure 4A
General Groundwater Chemistry Parameters
2nd Qtr 2020 Groundwater LTM Report
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

B:\60571032-HNL 1900-Work\1920 GIS\02_Maps\LTM\2020\02\Fig4A_Gen_GWChemPara_2ndQtr2020_LTM_rev.mxd 6/24/2020



Sampling Port Depth		456.6 ft bgs	415.3 ft bgs	325.1 ft bgs	254.8 ft bgs	210.6 ft bgs	164.1 ft bgs
Location		RHMW14-01	RHMW14-02	RHMW14-03	RHMW14-04	RHMW14-05	RHMW14-07
Collection Date		10/21/2019	10/22/2019	10/28/2019	10/24/2019	10/23/2019	10/23/2019
Analyte	Unit	Result	Result	Result	Result	Result	Result
Bromide	mg/L	**0.15 J**	**0.15 J**	**0.14 J**	**0.13 J**	**0.18 J**	**0.15 J**
Fluoride	mg/L	< 0.09 U	< 0.09 U	< 0.09 U	< 0.09 U	< 0.09 U	< 0.09 U
Calcium	µg/L	**10,500**	**10,000**	**7,740**	**8,100**	**10,300**	**11,400 J**
Magnesium	µg/L	**10,500**	**10,300**	**8,820**	**9,260**	**14,700**	**11,400 J**
Manganese	µg/L	< 3.5 U	< 4.00 U	**7.3 J**	< 4.00 U	**64.1**	**15.8**
Potassium	µg/L	**1,580 J**	**1,610 J**	**1,390 J**	**482 J**	**620 J**	**799 J**
Sodium	µg/L	**31,300**	**35,000**	**36,100**	**32,400**	**39,000**	**36,200**
Silica, Dissolved	mg/L	**44.5**	**40.1**	**45.1**	**54.8**	**52.7 J**	**61.1**
Silica, Total	mg/L	**43.4**	**42.5**	**49.1**	**55.0**	**52.5 J**	**63.1**

Sampling Port Depth		412.0 ft bgs	325.8 ft bgs	286.5 ft bgs	243.3 ft bgs	230.3 ft bgs
Location		RHMW13-01	RHMW13-02	RHMW13-03	RHMW13-04	RHMW13-05
Collection Date		3/3/2020	3/4/2020	3/5/2020	4/27/2020	3/10/2020
Analyte	Unit	Result	Result	Result	Result	Result
Bromide	mg/L	**0.21 J**	**0.19 J**	**0.22 J**	**0.33 J**	**0.40 J**
Fluoride	mg/L	< 0.09 U	< 0.09 U	**0.25**	**0.19**	**0.87**
Calcium	µg/L	**12,100**	**10,300**	**11,400**	**10,600**	**21,900**
Magnesium	µg/L	**9,320**	**9,710**	**12,100**	**11,800**	**14,900**
Manganese	µg/L	**2.6 J**	**5.9 J**	**1.4 J**	**4.8 J**	**117**
Potassium	µg/L	**1,870 J**	**1,700 J**	**1,960 J**	**2,000 J**	**3,380**
Sodium	µg/L	**21,600**	**23,500**	**33,900**	**40,700**	**47,500**
Silica, Dissolved	mg/L	**41.6**	**42.9**	**46.5**	**50.2**	**9.0**
Silica, Total	mg/L	**40.4**	**47.9**	**51.1**	**49.3**	**9.0**

Location		RHMW08
Collection Date		11/15/2016
Analyte	Unit	Result
Bromide	mg/L	**0.63**
Fluoride	mg/L	**0.35**
Calcium	µg/L	**32,700**
Magnesium	µg/L	**12,000**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**5,680**
Sodium	µg/L	**109,000**
Silica, Dissolved	mg/L	**39.0**
Silica, Total	mg/L	**36.3**

Location		RHMW03
Collection Date		11/15/2016
Analyte	Unit	Result
Bromide	mg/L	**0.29 J**
Fluoride	mg/L	**0.25**
Calcium	µg/L	**25,000**
Magnesium	µg/L	**33,400**
Manganese	µg/L	**36.7**
Potassium	µg/L	**3,700**
Sodium	µg/L	**104,000**
Silica, Dissolved	mg/L	**83.5**
Silica, Total	mg/L	**87.4**

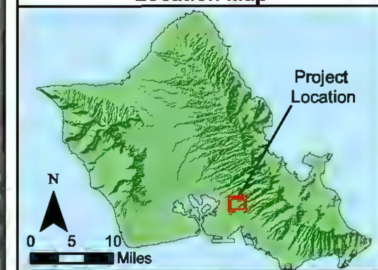
Location		RHMW10
Collection Date		10/25/2017
Analyte	Unit	Result
Bromide	mg/L	**0.29 J**
Fluoride	mg/L	< 0.09 U
Calcium	µg/L	**9,650**
Iron	µg/L	< 25.0 U
Lead	µg/L	< 4.00 U
Magnesium	µg/L	**9,420**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**1,730 J**
Sodium	µg/L	**32,700**
Silica, Dissolved	mg/L	**41.3**
Silica, Total	mg/L	**37.5**

Location		RHMW01
Collection Date		11/14/2016
Analyte	Unit	Result
Bromide	mg/L	**0.26 J**
Fluoride	mg/L	**0.28**
Calcium	µg/L	**11,500**
Magnesium	µg/L	**9,880**
Manganese	µg/L	**743**
Potassium	µg/L	**1,900 J**
Sodium	µg/L	**35,200**
Silica, Dissolved	mg/L	**68.1**
Silica, Total	mg/L	**65.9**

Location		RHMW09
Collection Date		11/15/2016
Analyte	Unit	Result
Bromide	mg/L	**0.29 J**
Fluoride	mg/L	**0.17**
Calcium	µg/L	**12,900**
Magnesium	µg/L	**11,600**
Manganese	µg/L	< 4.00 U
Potassium	µg/L	**2,110 J**
Sodium	µg/L	**36,600**
Silica, Dissolved	mg/L	**53.7**
Silica, Total	mg/L	**46.7**

Location		RHMW02
Collection Date		11/15/2016
Analyte	Unit	Result
Bromide	mg/L	**0.26 J**
Fluoride	mg/L	**0.78**
Calcium	µg/L	**12,600**
Magnesium	µg/L	**24,800**
Manganese	µg/L	**1,950**
Potassium	µg/L	**2,440 J**
Sodium	µg/L	**53,600**
Silica, Dissolved	mg/L	**84.4**
Silica, Total	mg/L	**83.7**

Location Map



Legend

- Monitoring Well with Screening Criteria Exceedance(s)
- Existing Monitoring Well Location
- Red Hill Tank
- Stream
- Red Hill Facility Boundary

Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015
3. Only analytes with detections and associated SGC data (if applicable) are shown.

ABBREVIATIONS:

FD	field duplicate sample
ID	identification
J	estimated value
N	primary (normal) sample
SGC	silica gel cleanup
SSRBL	site-specific risk based level
TPH-d	total petroleum hydrocarbon - diesel range organics
TPH-g	total petroleum hydrocarbon - gasoline range organics
TPH-o	total petroleum hydrocarbon - oil/residual organics
U	non-detect value (reported as less than the limit of detection)
µg/L	microgram per liter

Monitoring Well with **COPC** Screening Criteria Exceedance(s)

N

0 400 800 1,600 Feet

Figure 4B
General Groundwater Chemistry Parameters
2nd Qtr 2020 Groundwater LTM Report
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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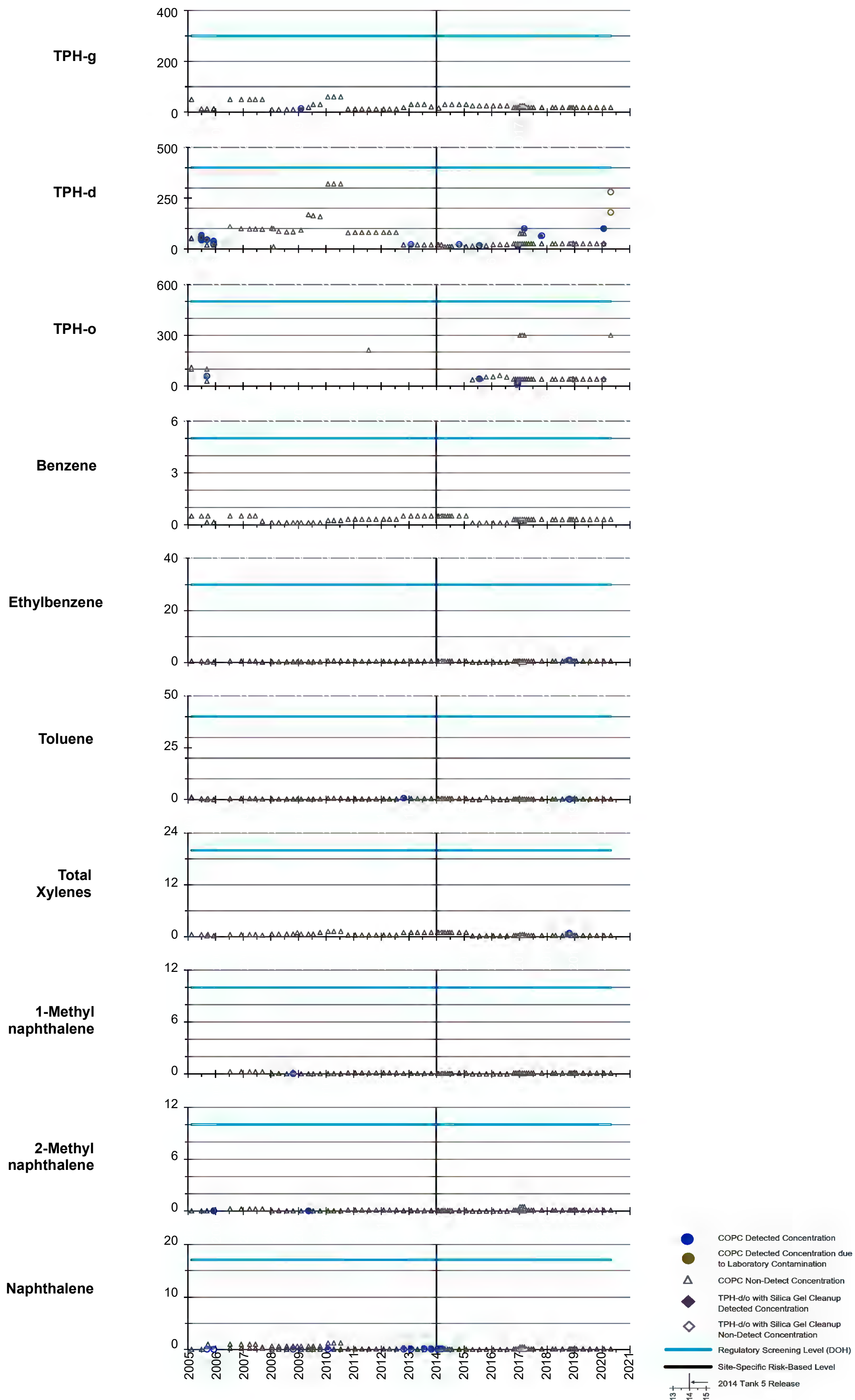
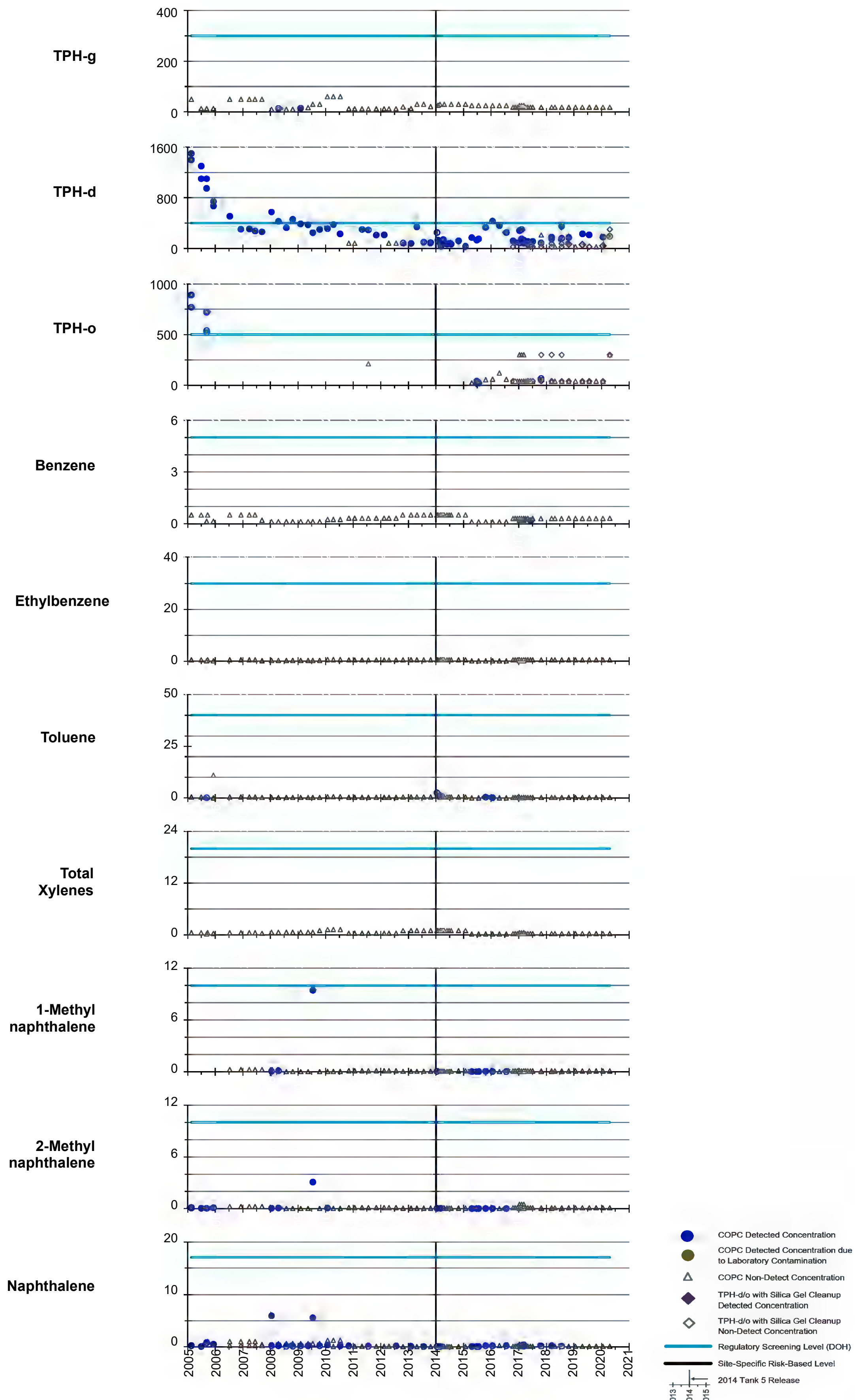
Appendix A.2:
Groundwater COPC Graphs

RHMW2254-01



All results in micrograms per liter (µg/L or parts per billion).
EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.
Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

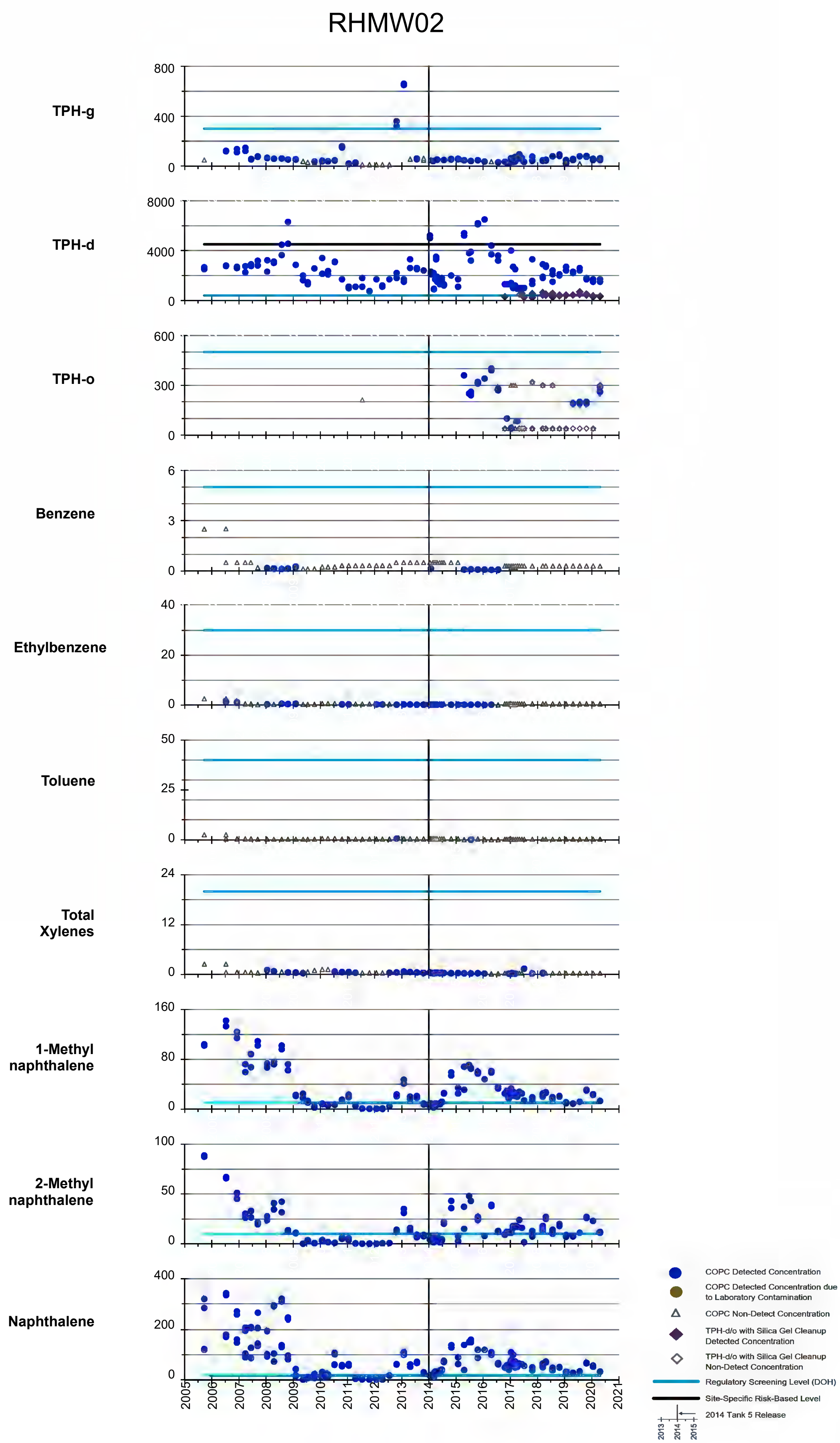
RHMW01



All results in micrograms per liter (µg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Fourth Quarters 2017, First Quarter 2018, and Third Quarter 2018 included in the graphs.

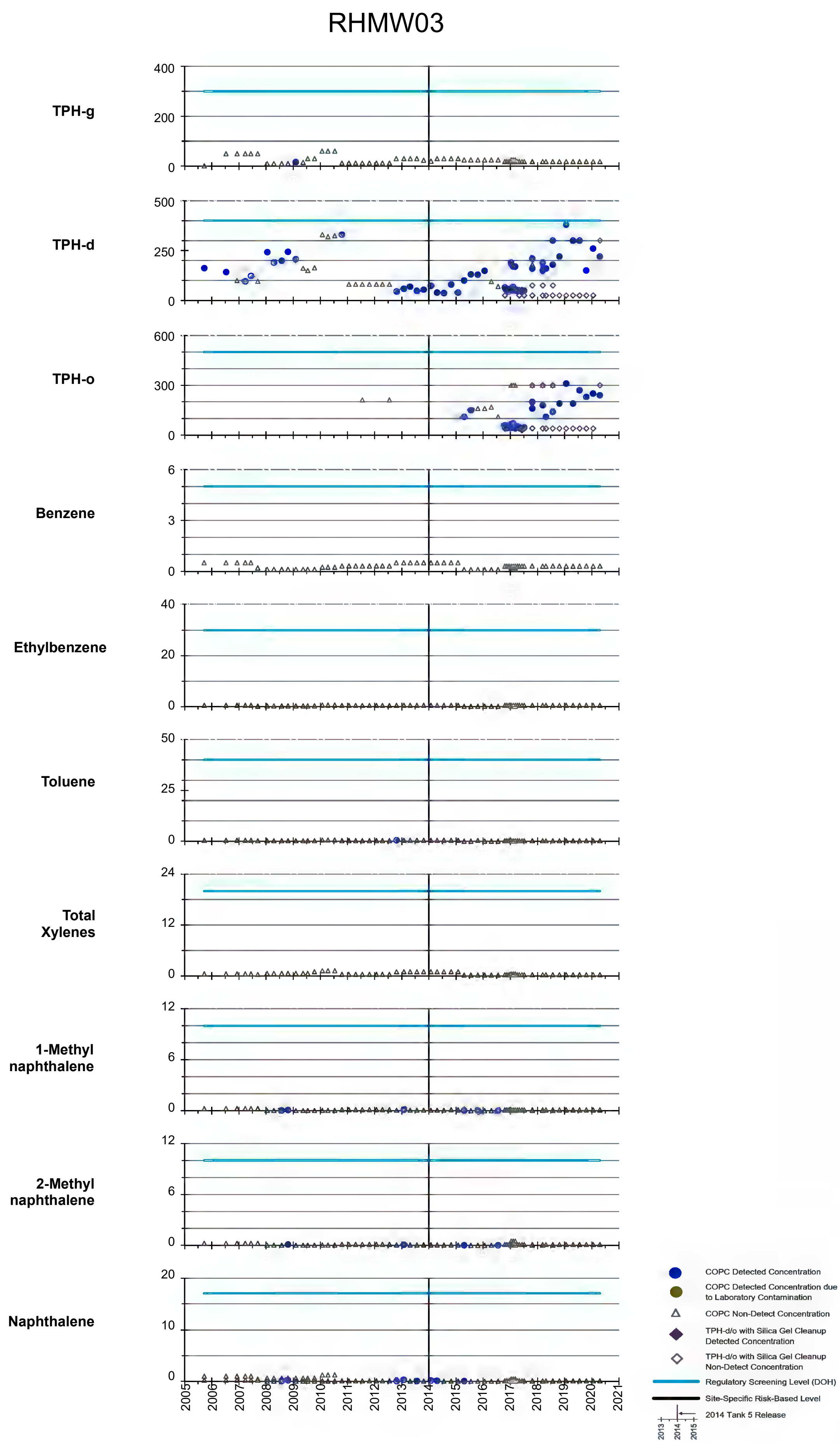
Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).



All results in micrograms per liter (µg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Fourth Quarters 2017, First Quarter 2018, and Third Quarter 2018 included in the graphs.

Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

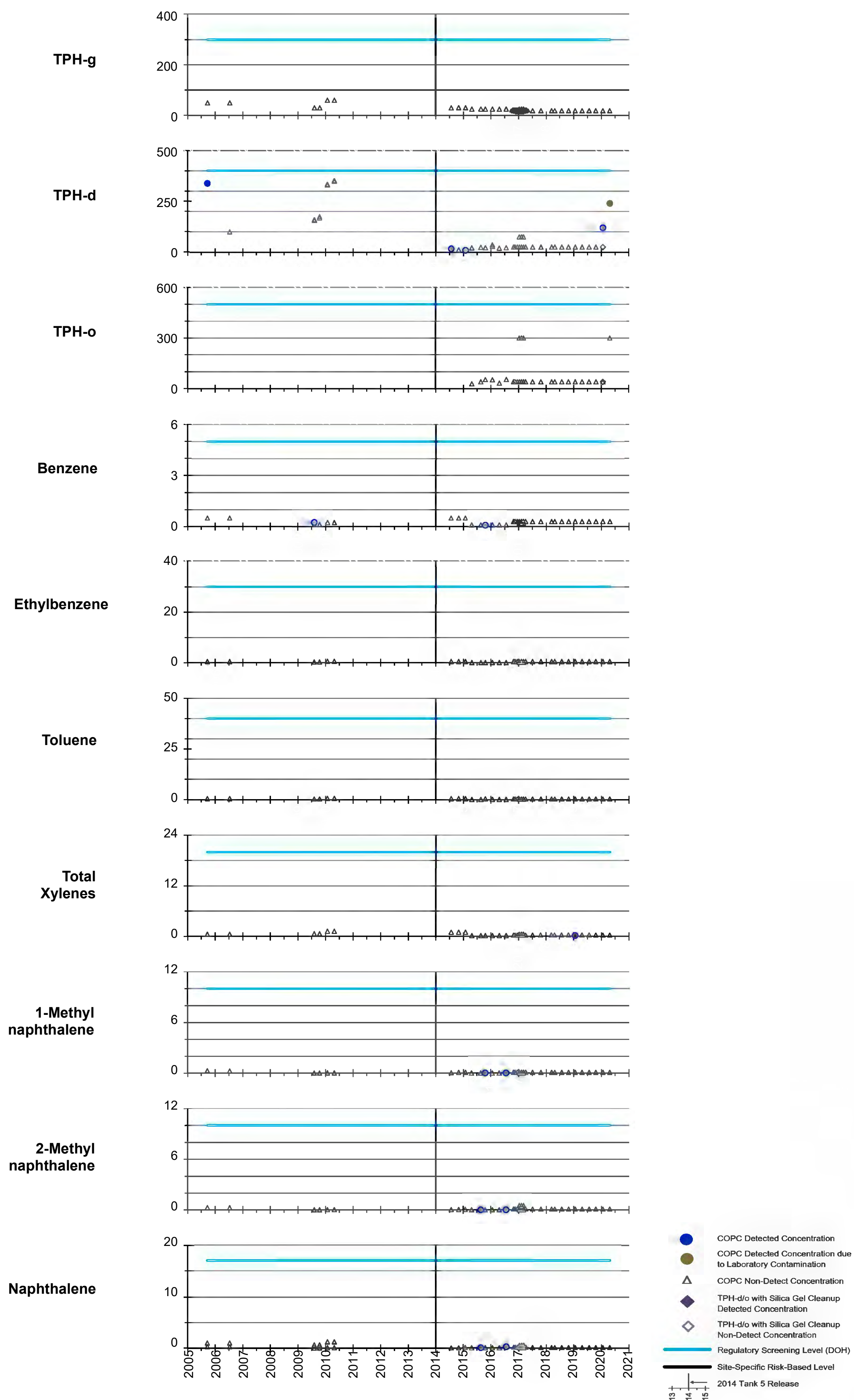


All results in micrograms per liter (µg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Fourth Quarters 2017, First Quarter 2018, and Third Quarter 2018 included in the graphs.

Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

RHMW04

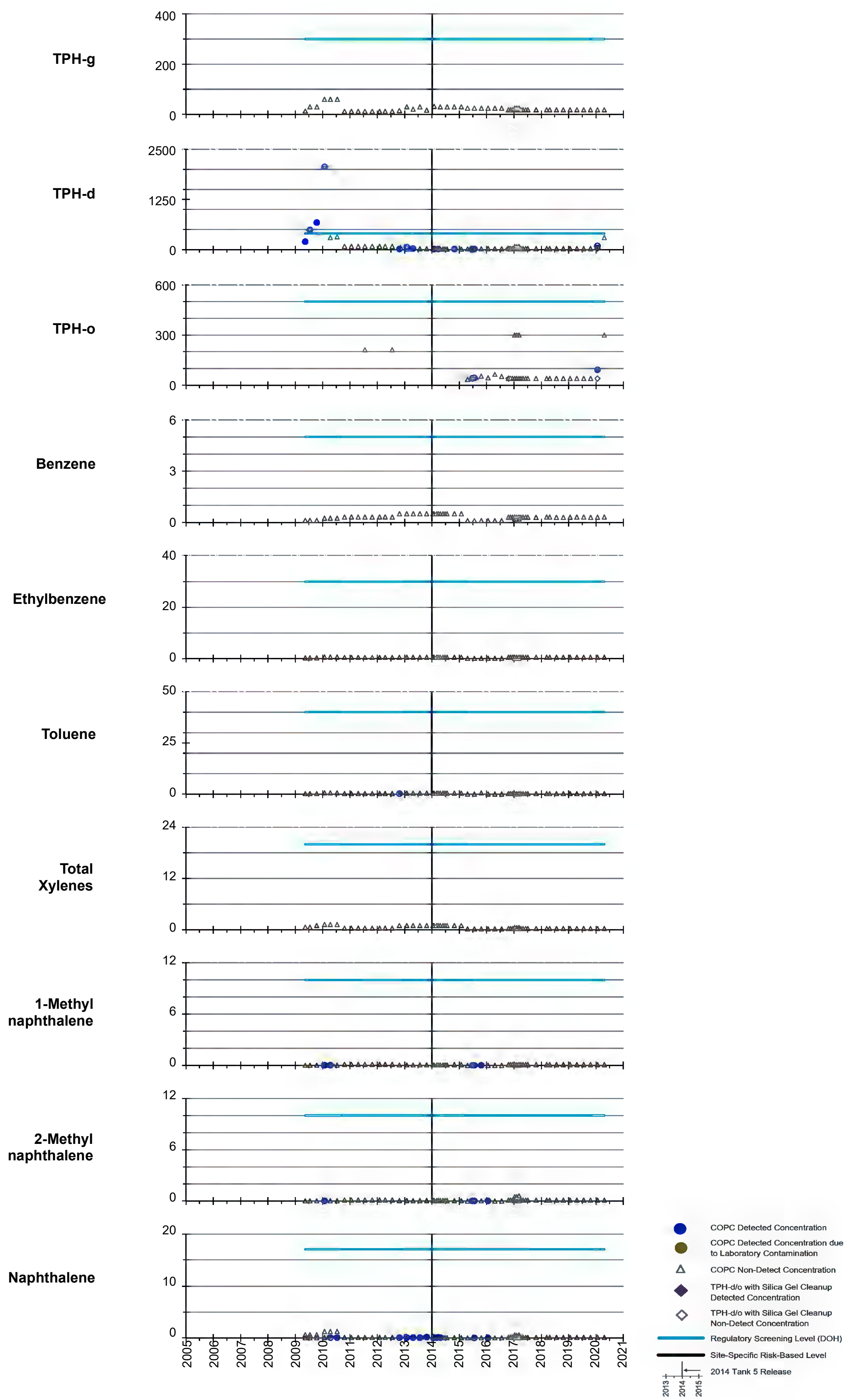


All results in micrograms per liter (μg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.

Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

RHMW05

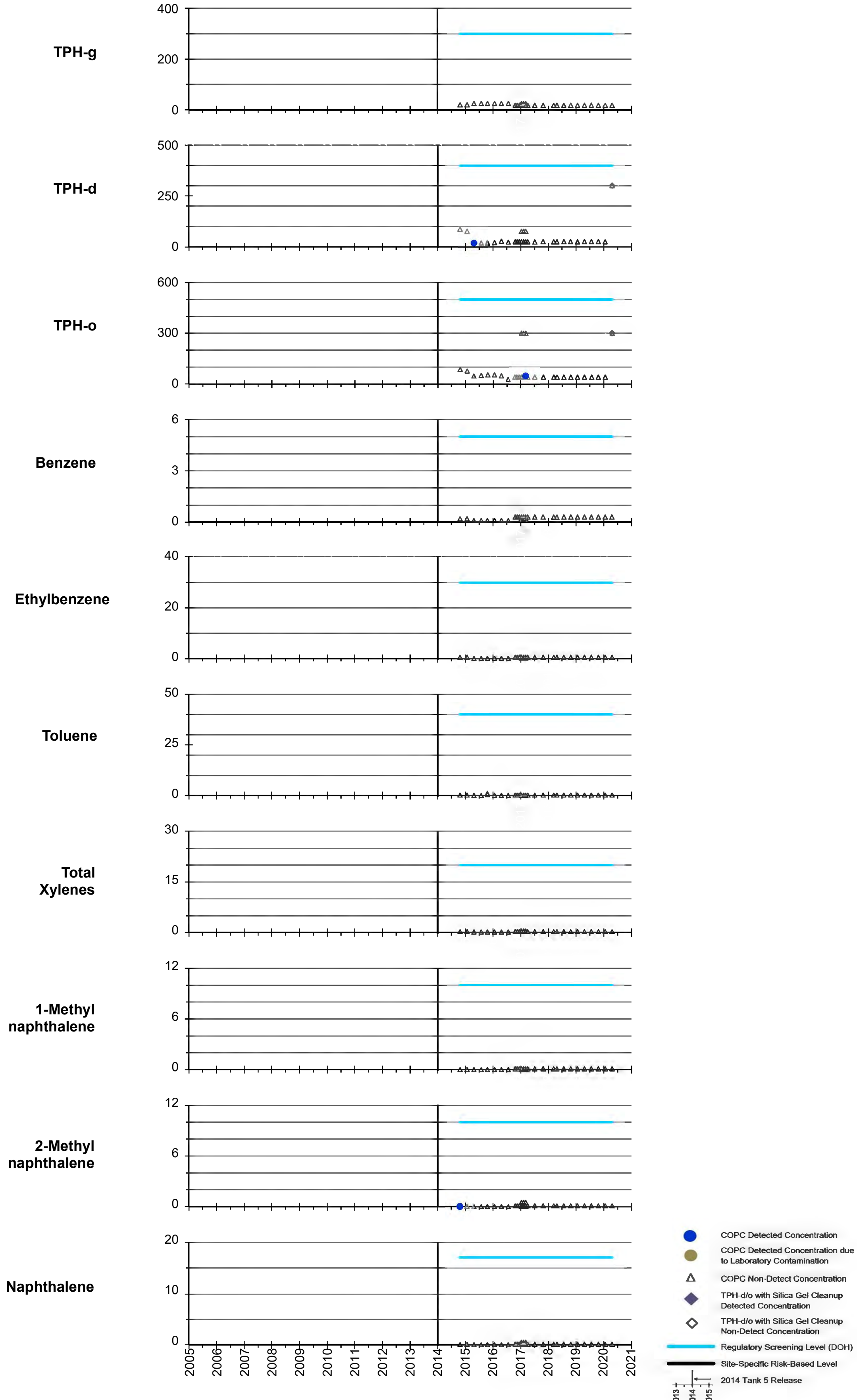


All results in micrograms per liter (µg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.

Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

RHMW06



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EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.

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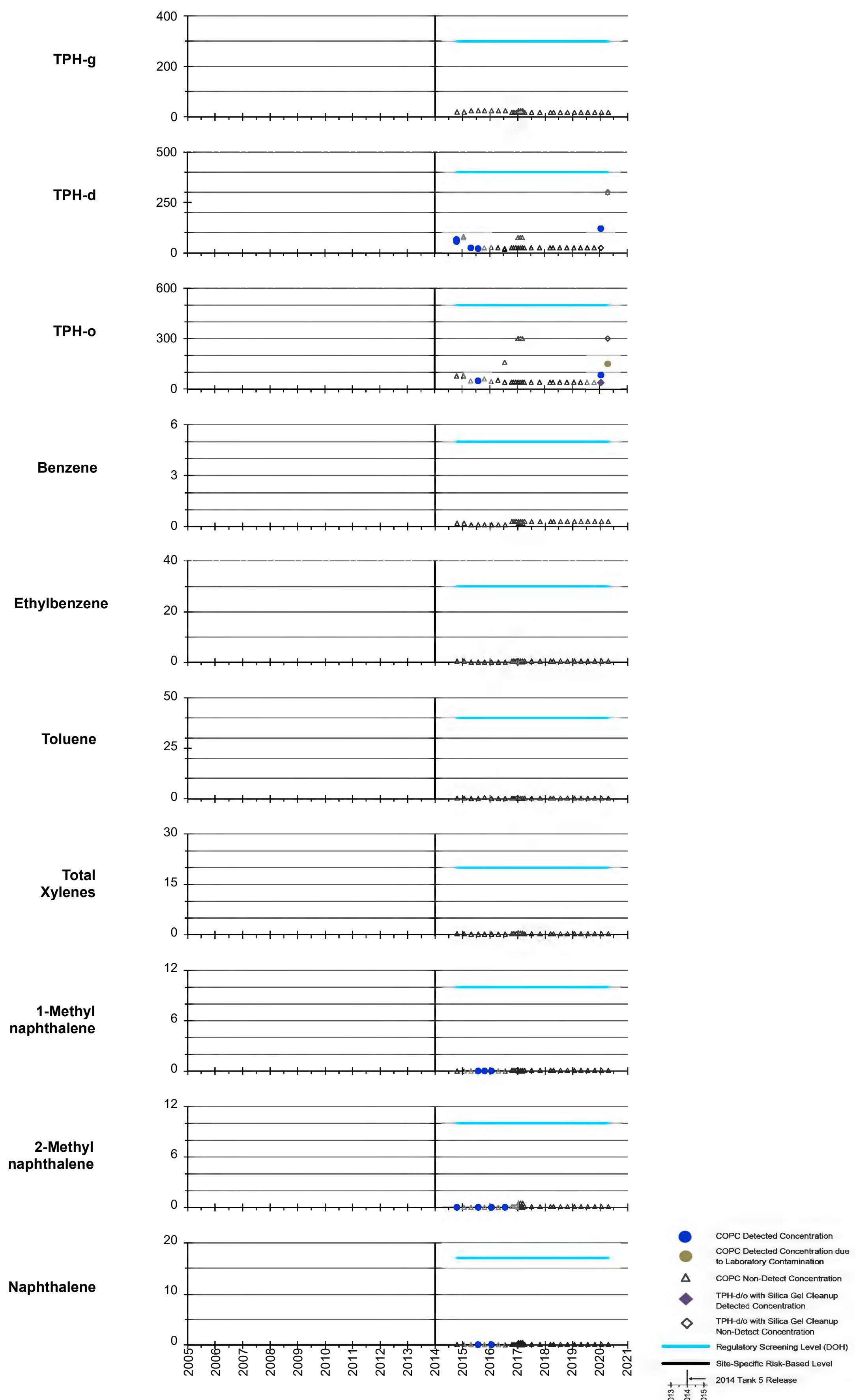

All results in micrograms per liter (µg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.

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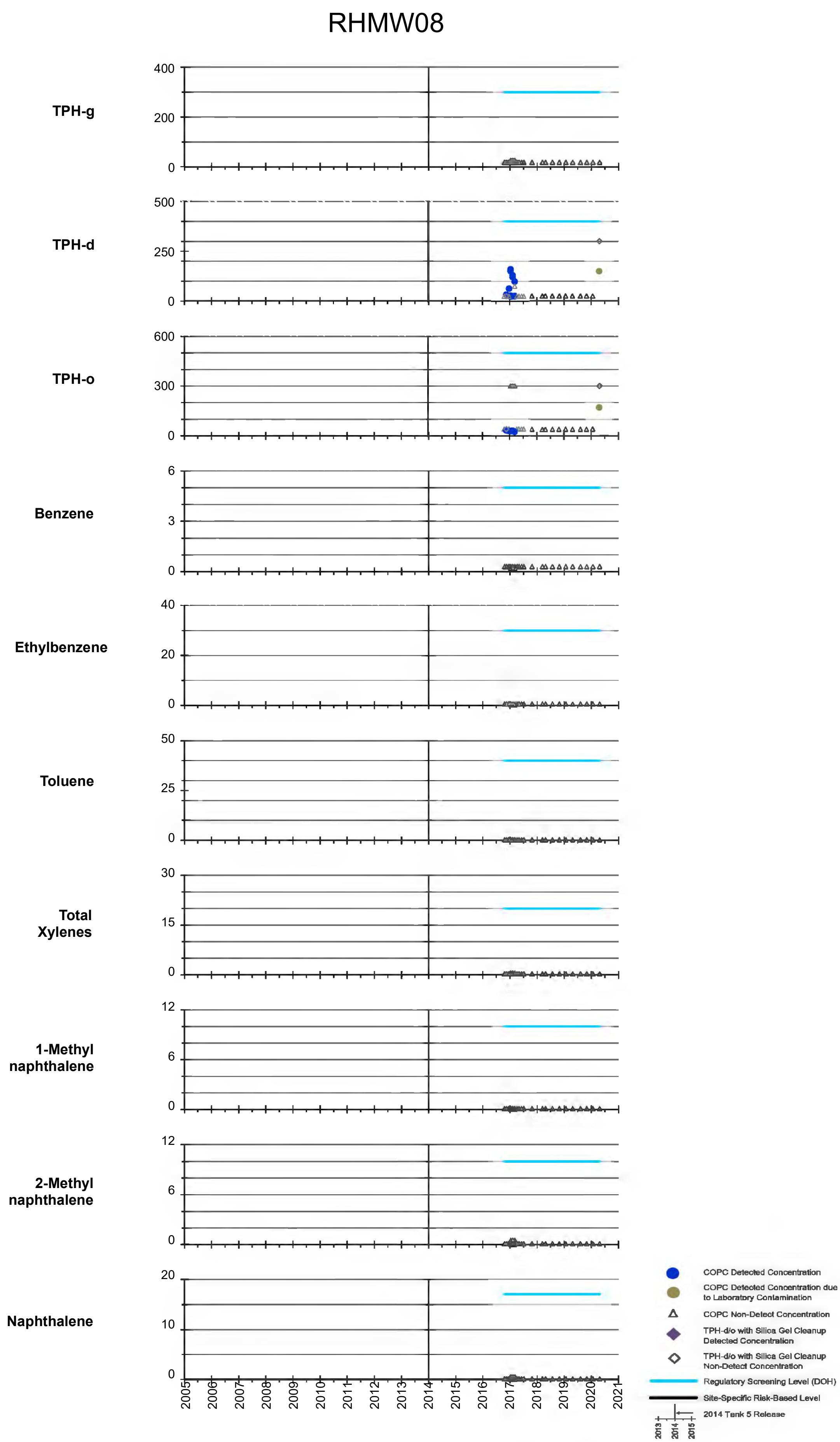

All results in micrograms per liter (µg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.

Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

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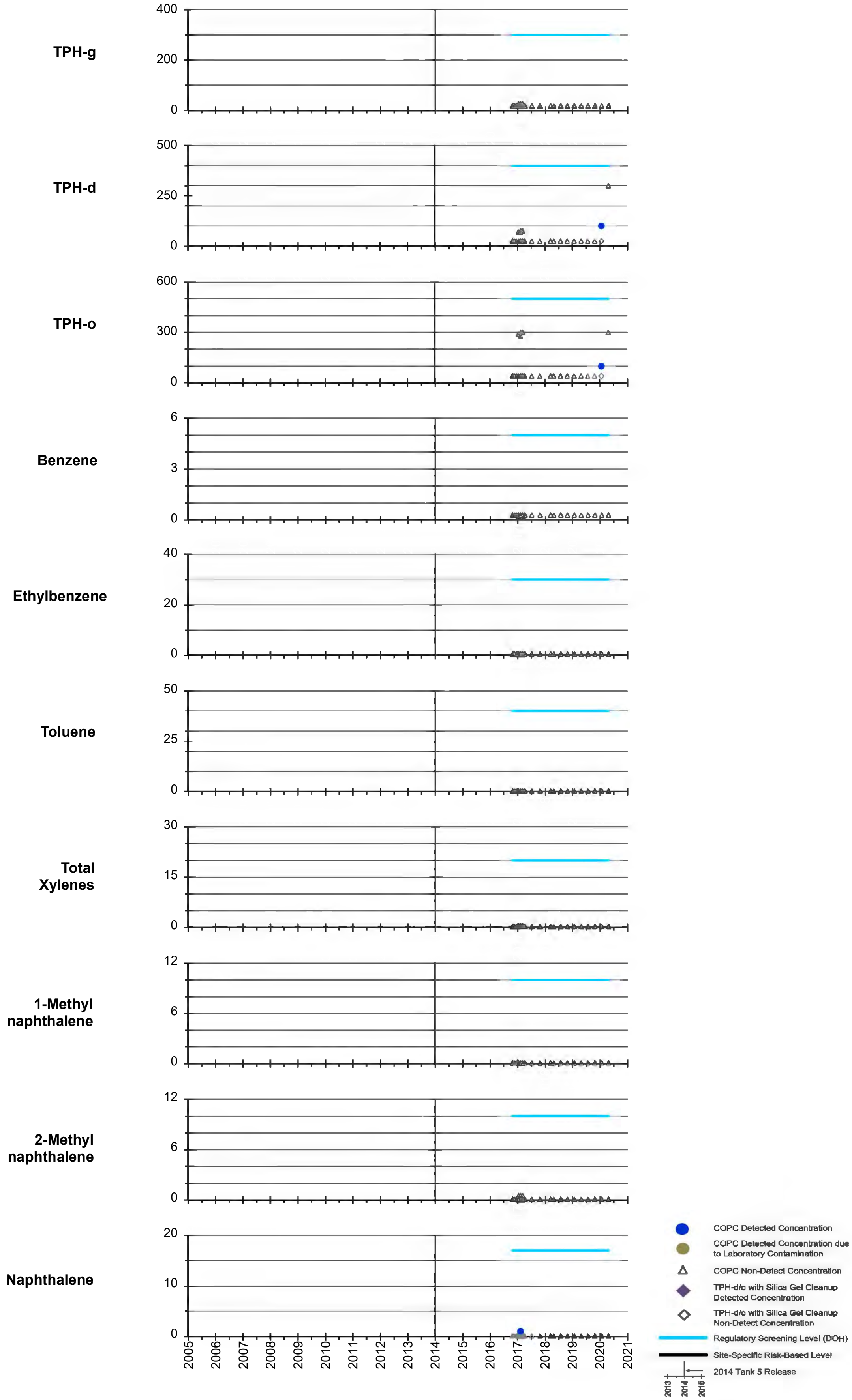

All results in micrograms per liter (µg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.

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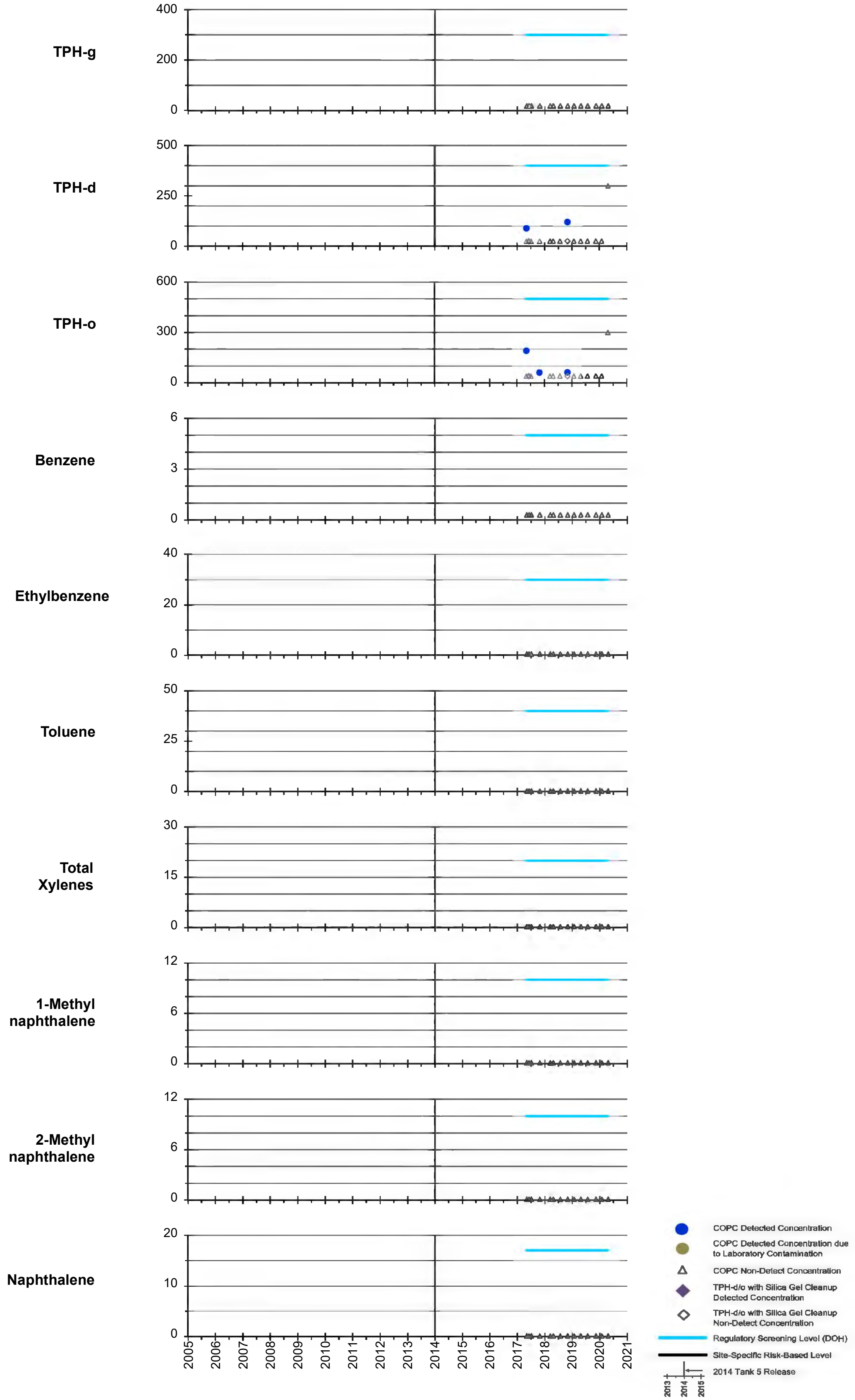

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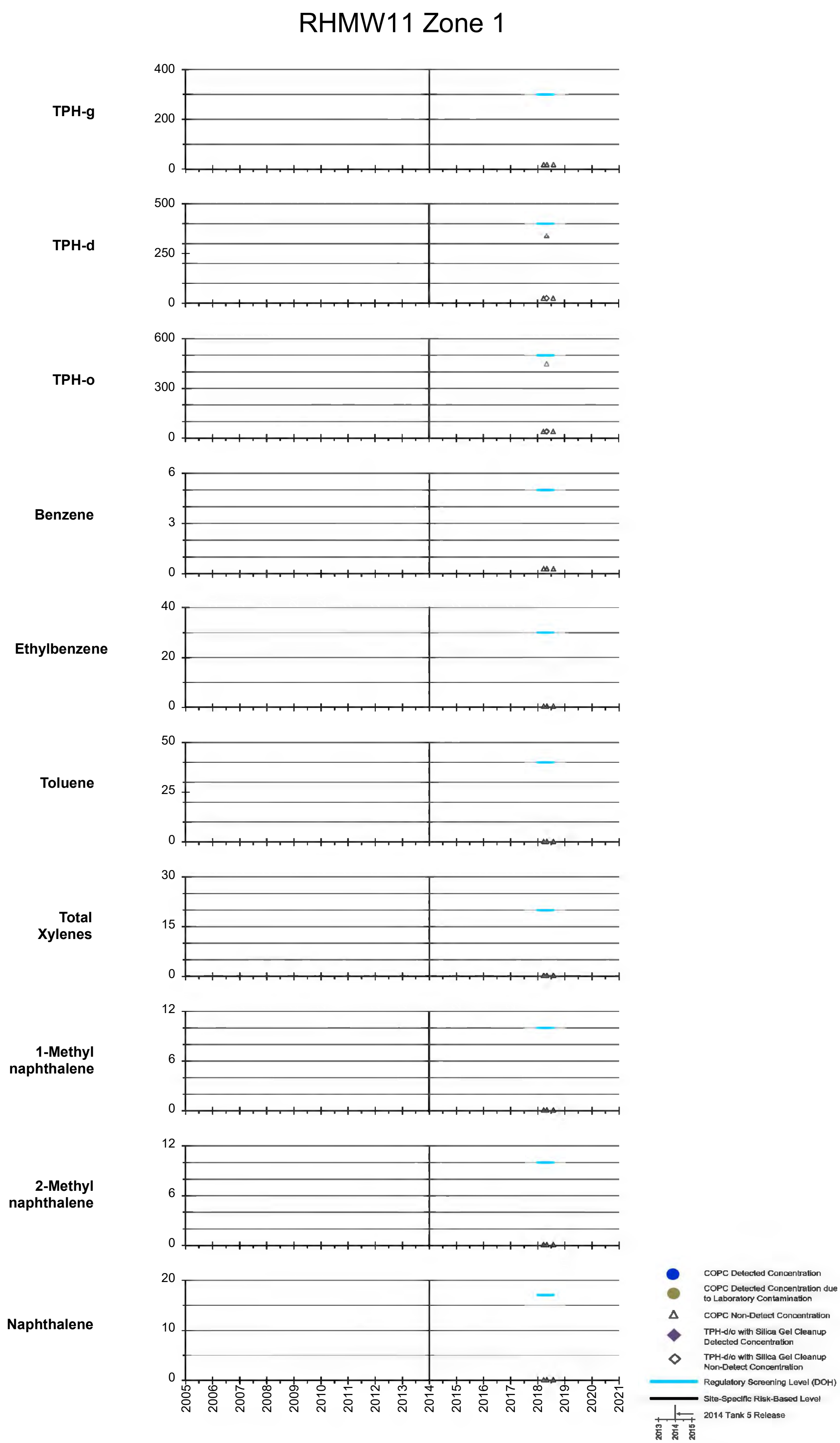

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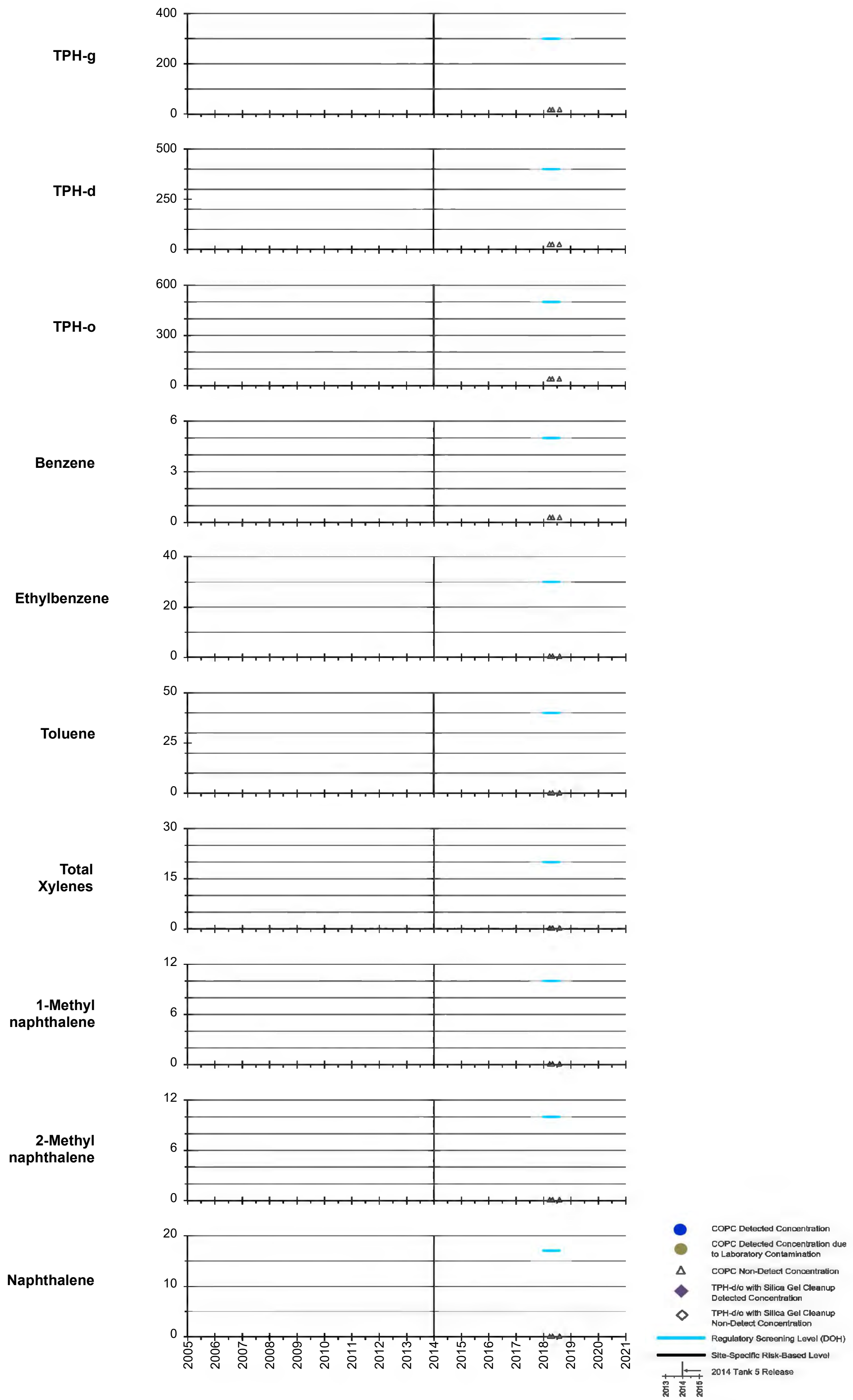
RHMW11 Zone 2



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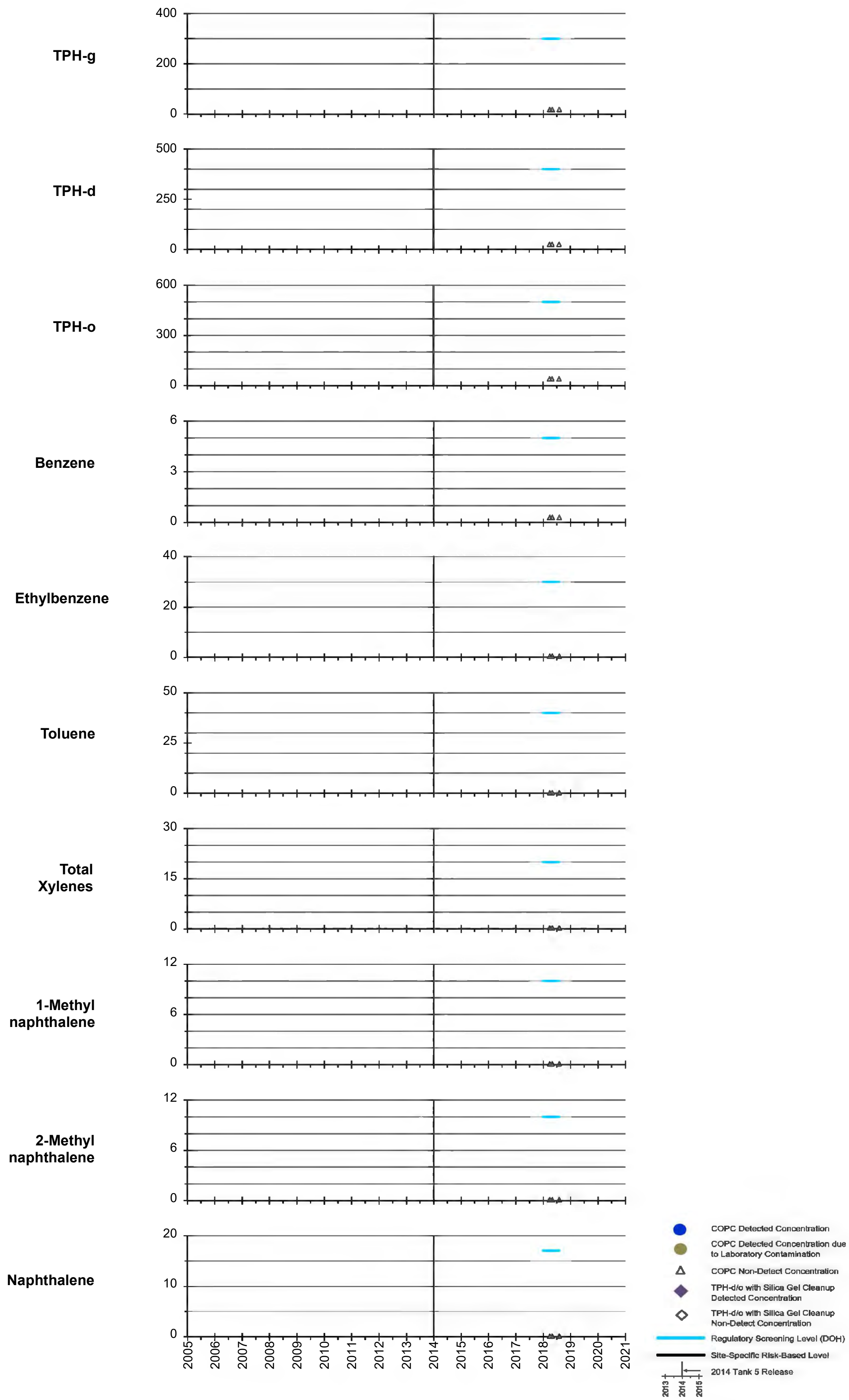
RHMW11 Zone 3



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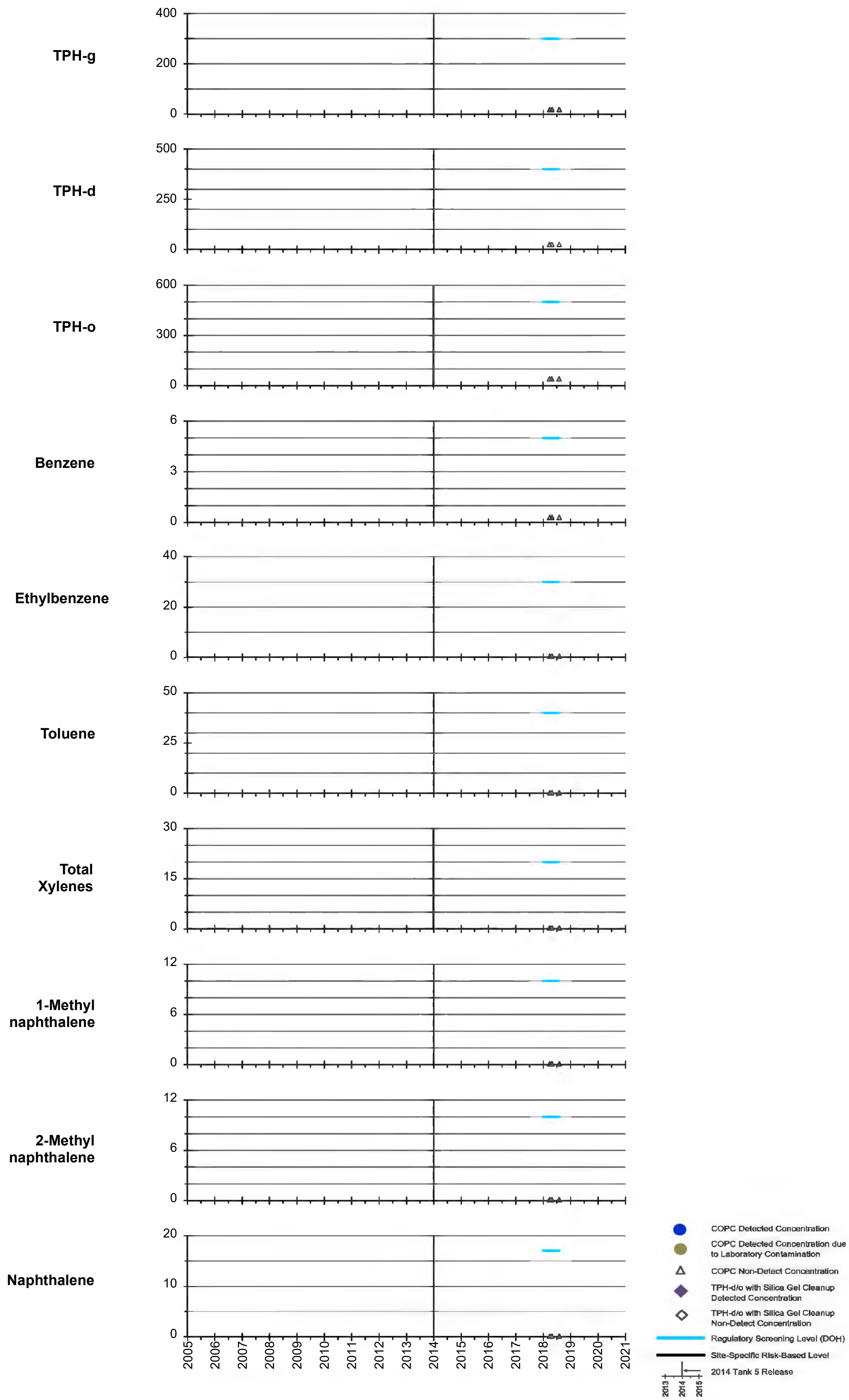

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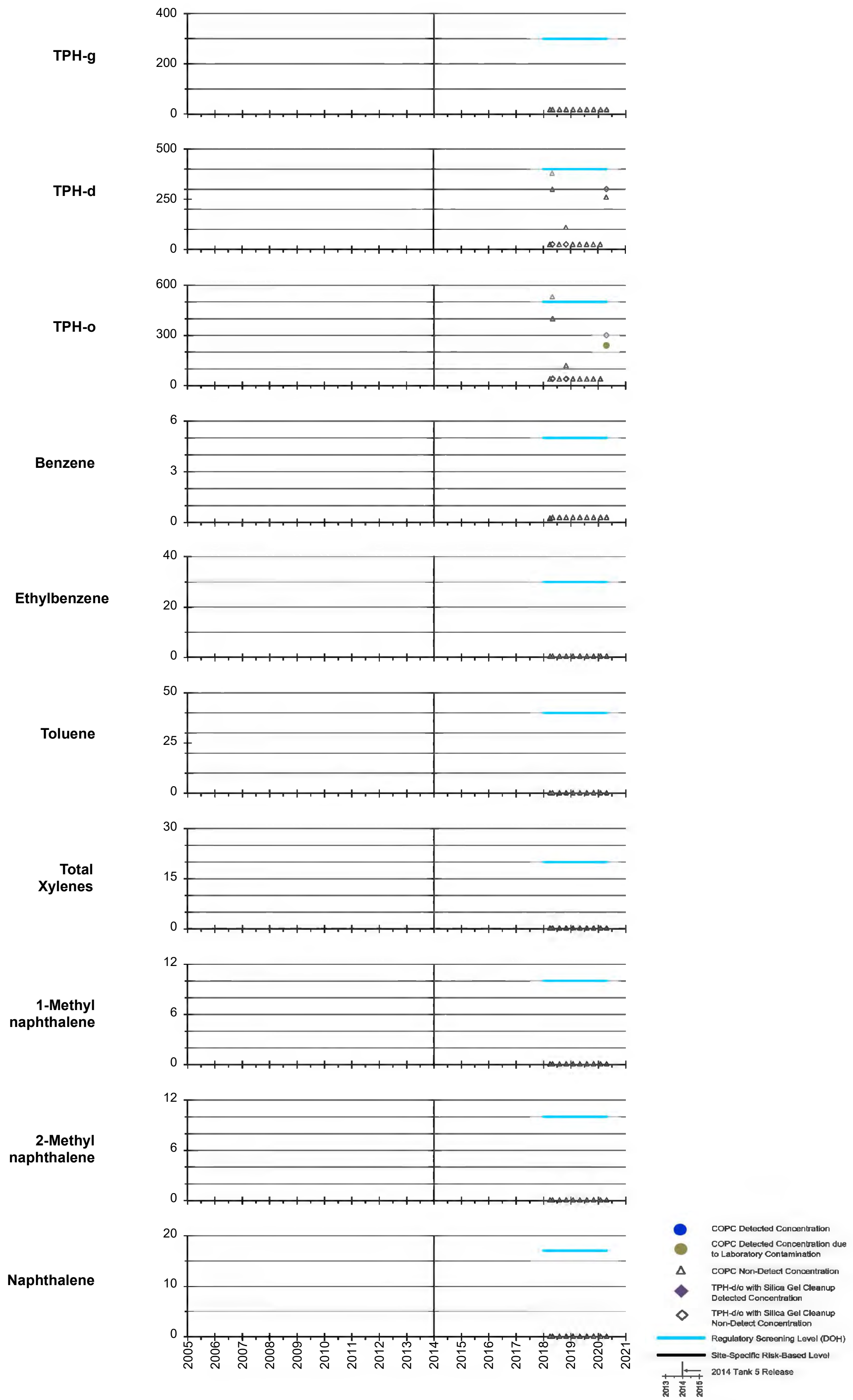
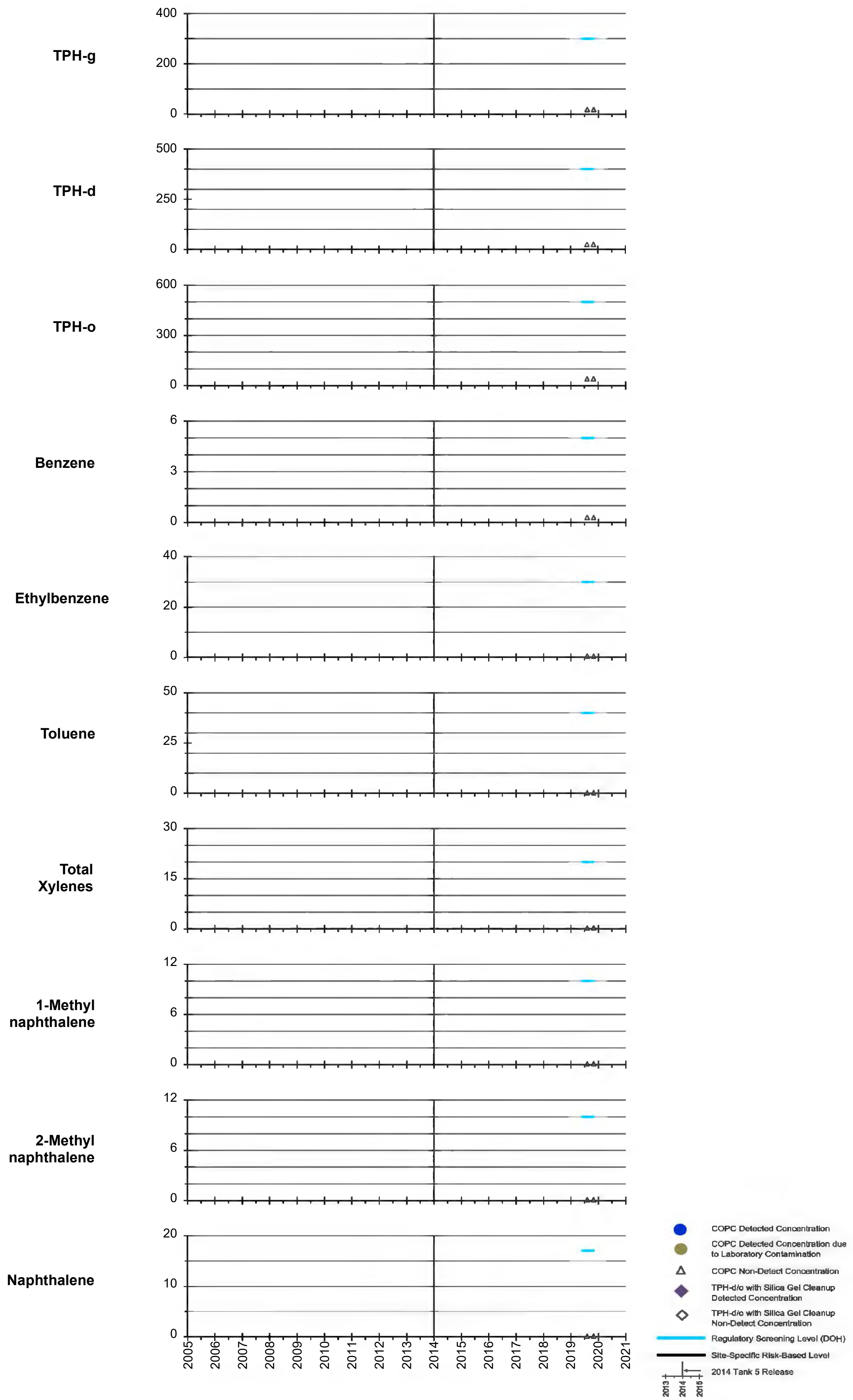
RHMW11 Zone 5



All results in micrograms per liter (µg/L or parts per billion).

Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

RHMW11 Zone 7



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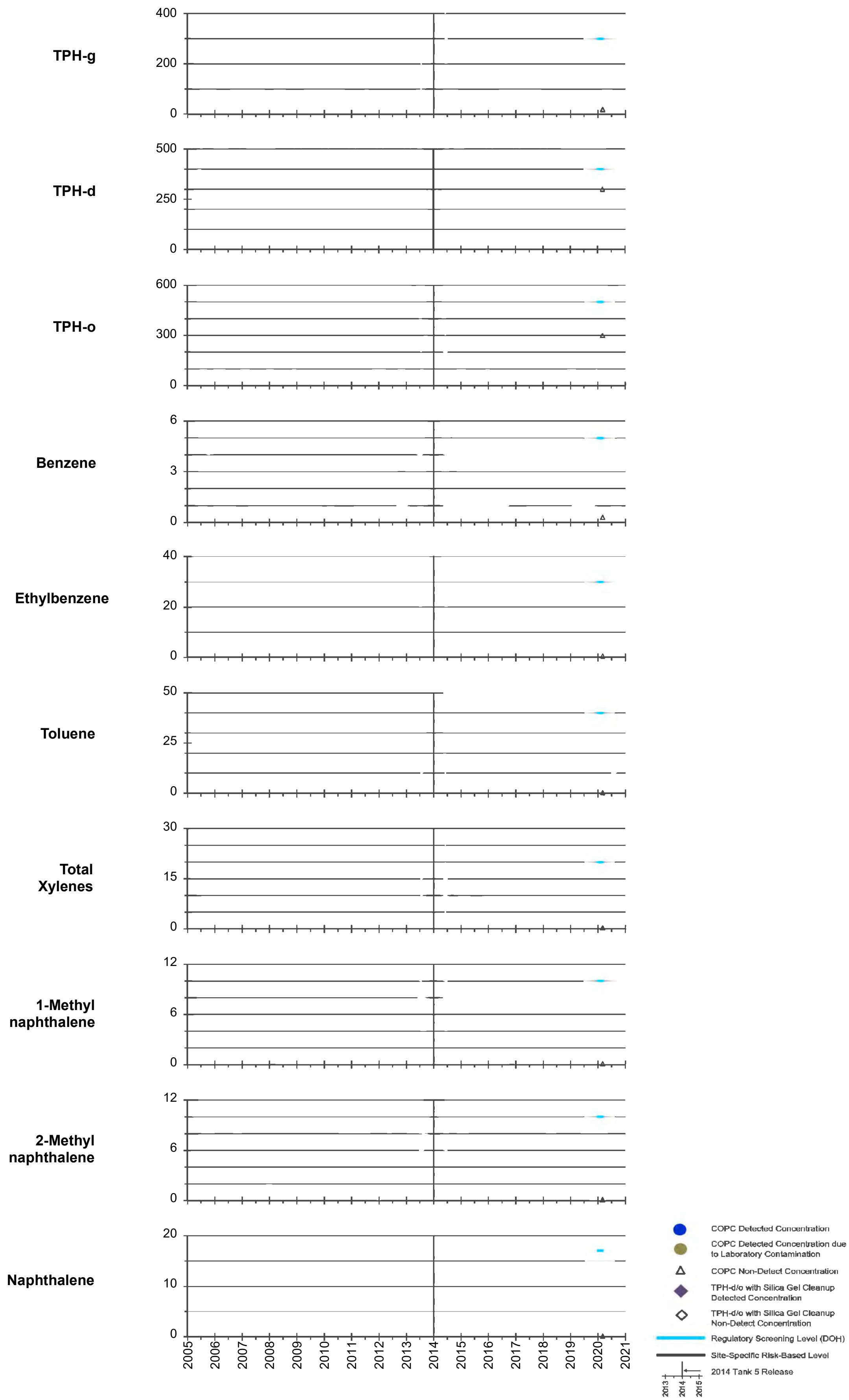
RHMW13 Zone 1



All results in micrograms per liter (µg/L or parts per billion).

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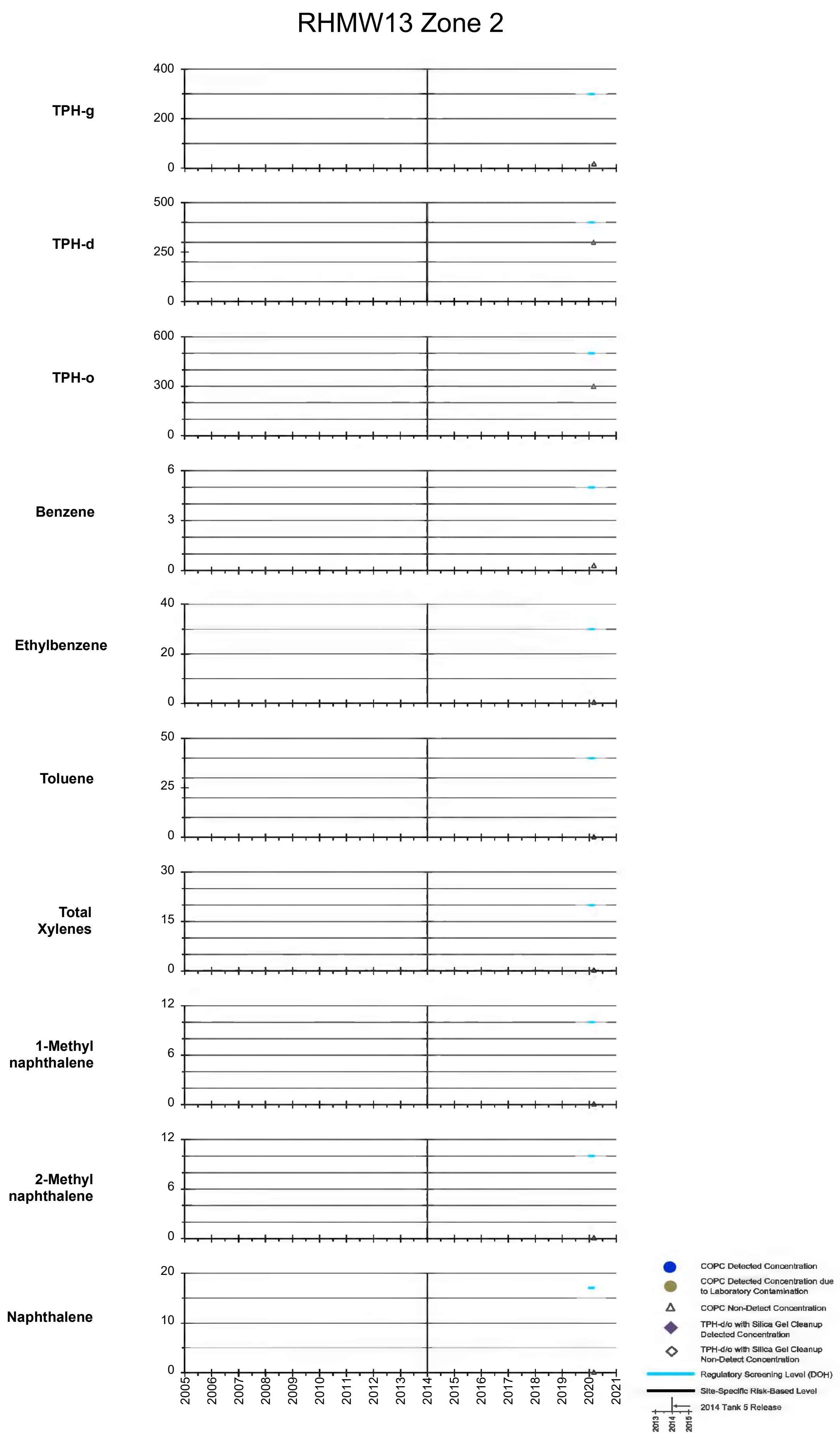

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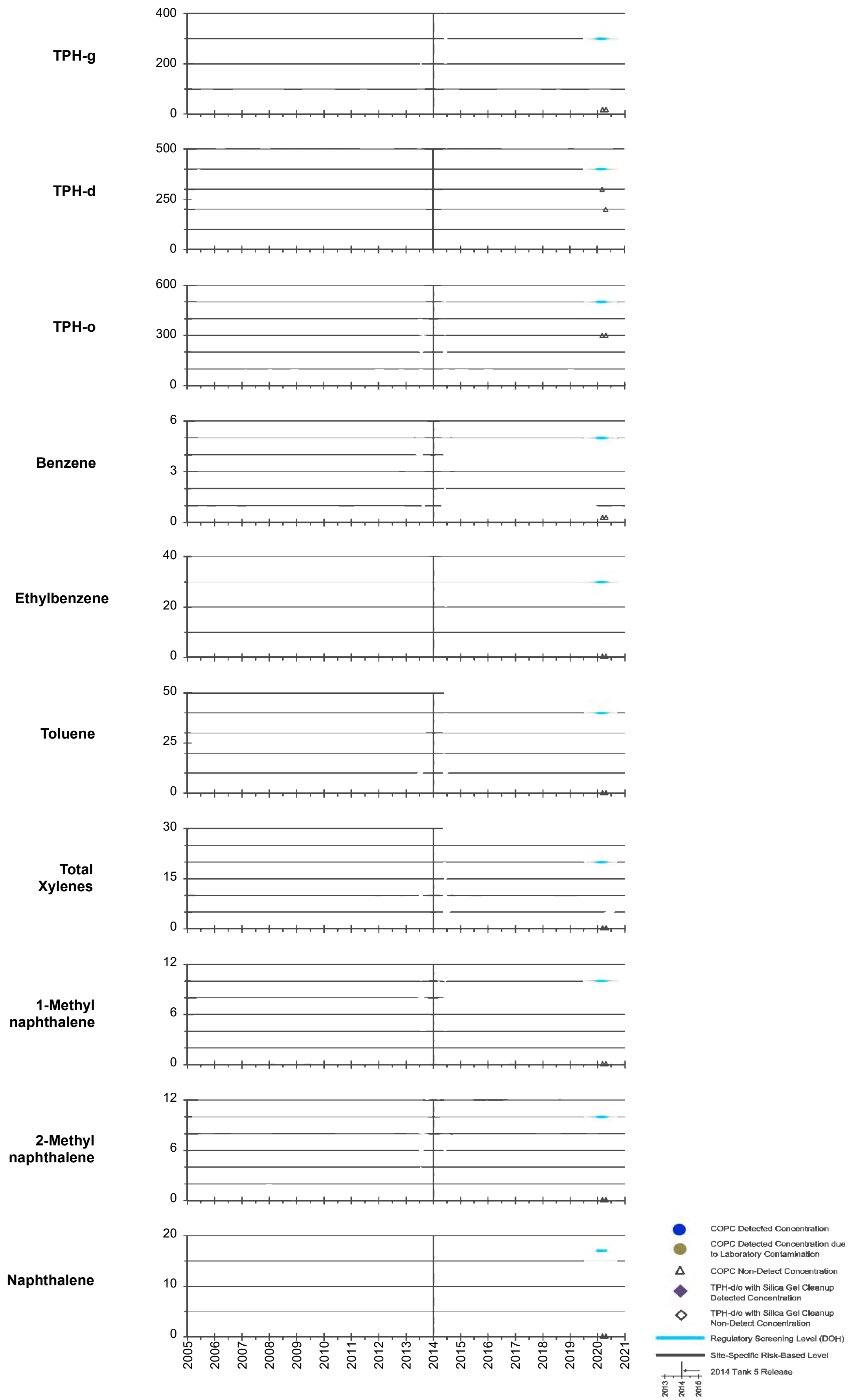
RHMW13 Zone 3



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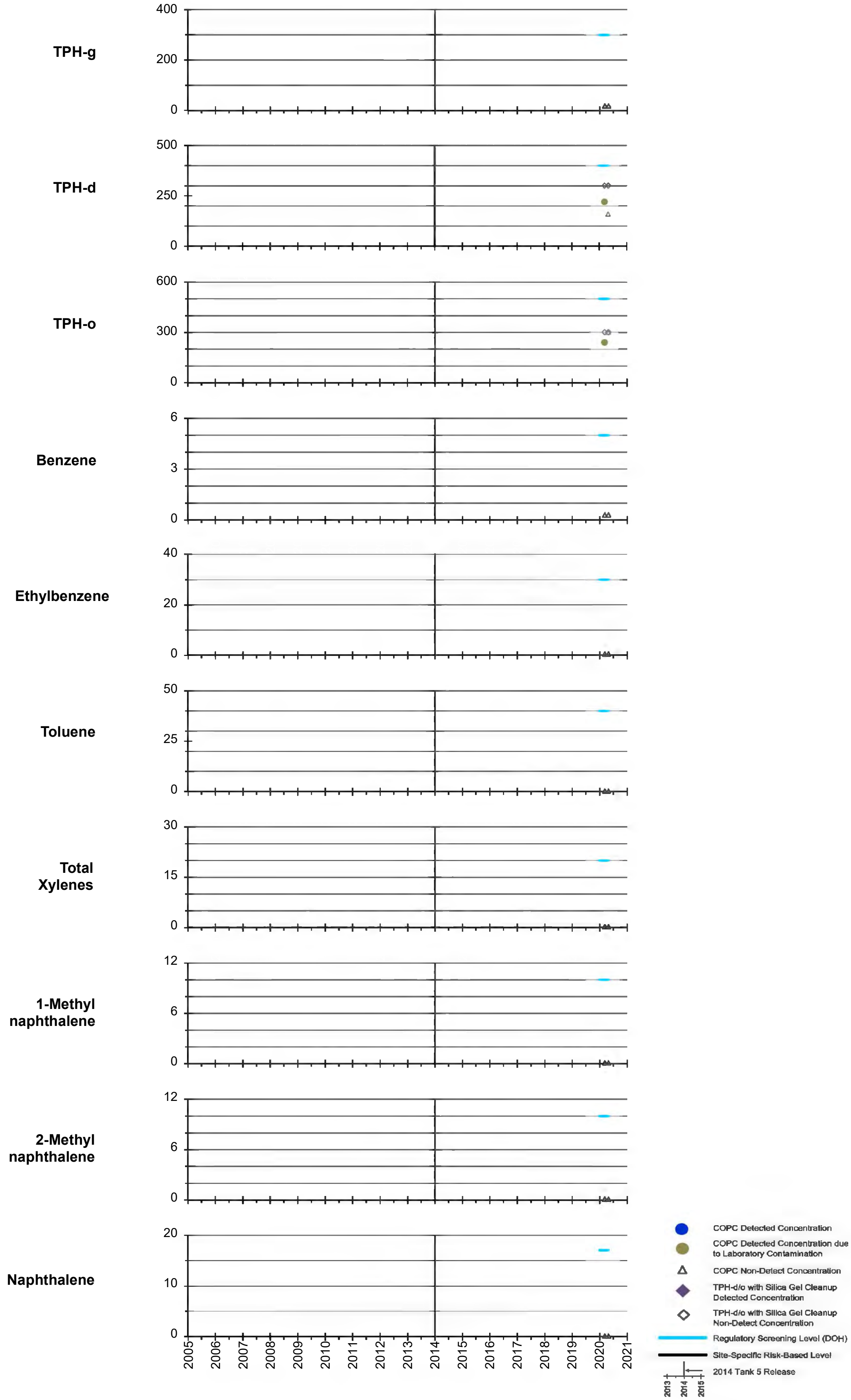
RHMW13 Zone 4



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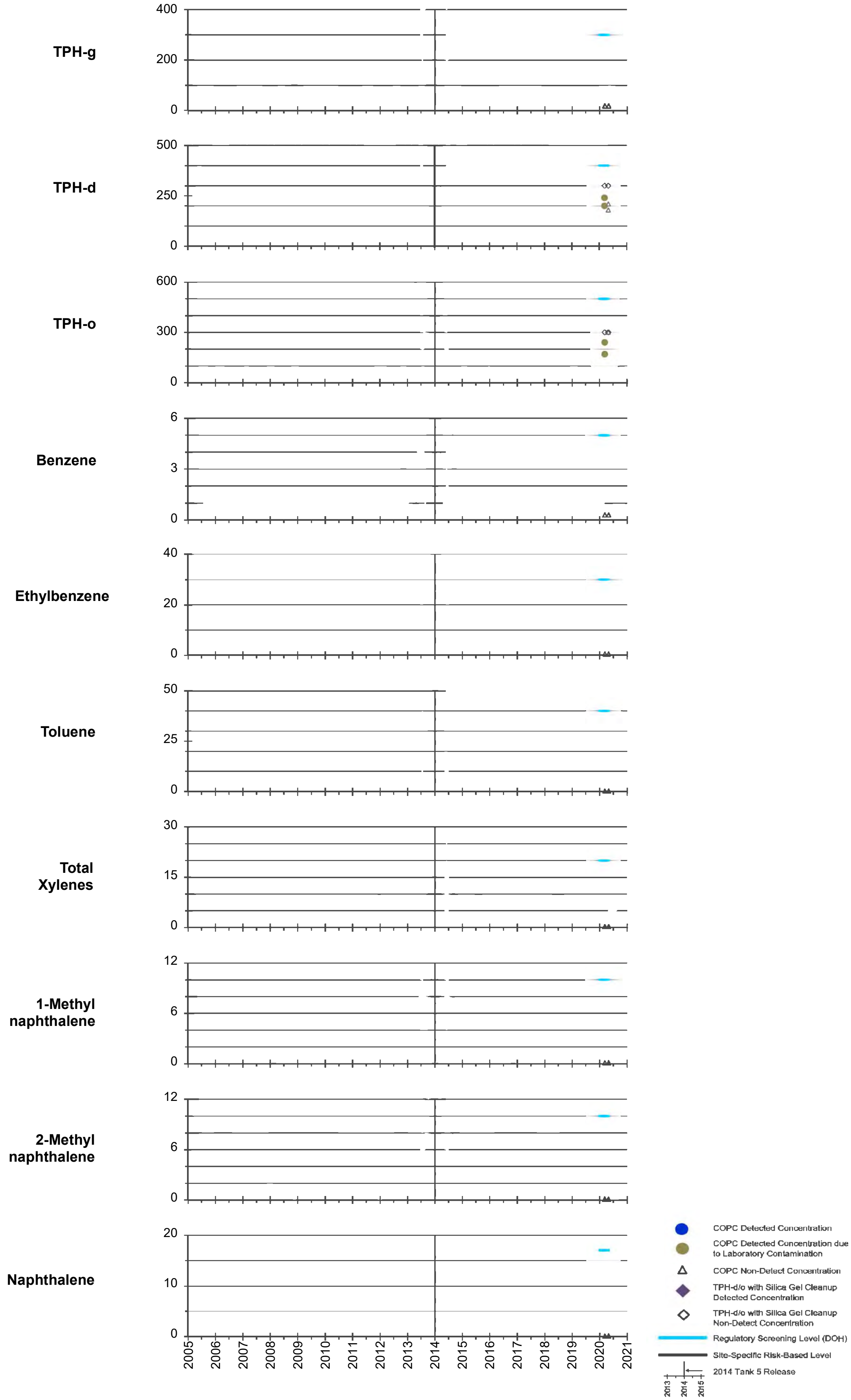
RHMW13 Zone 5



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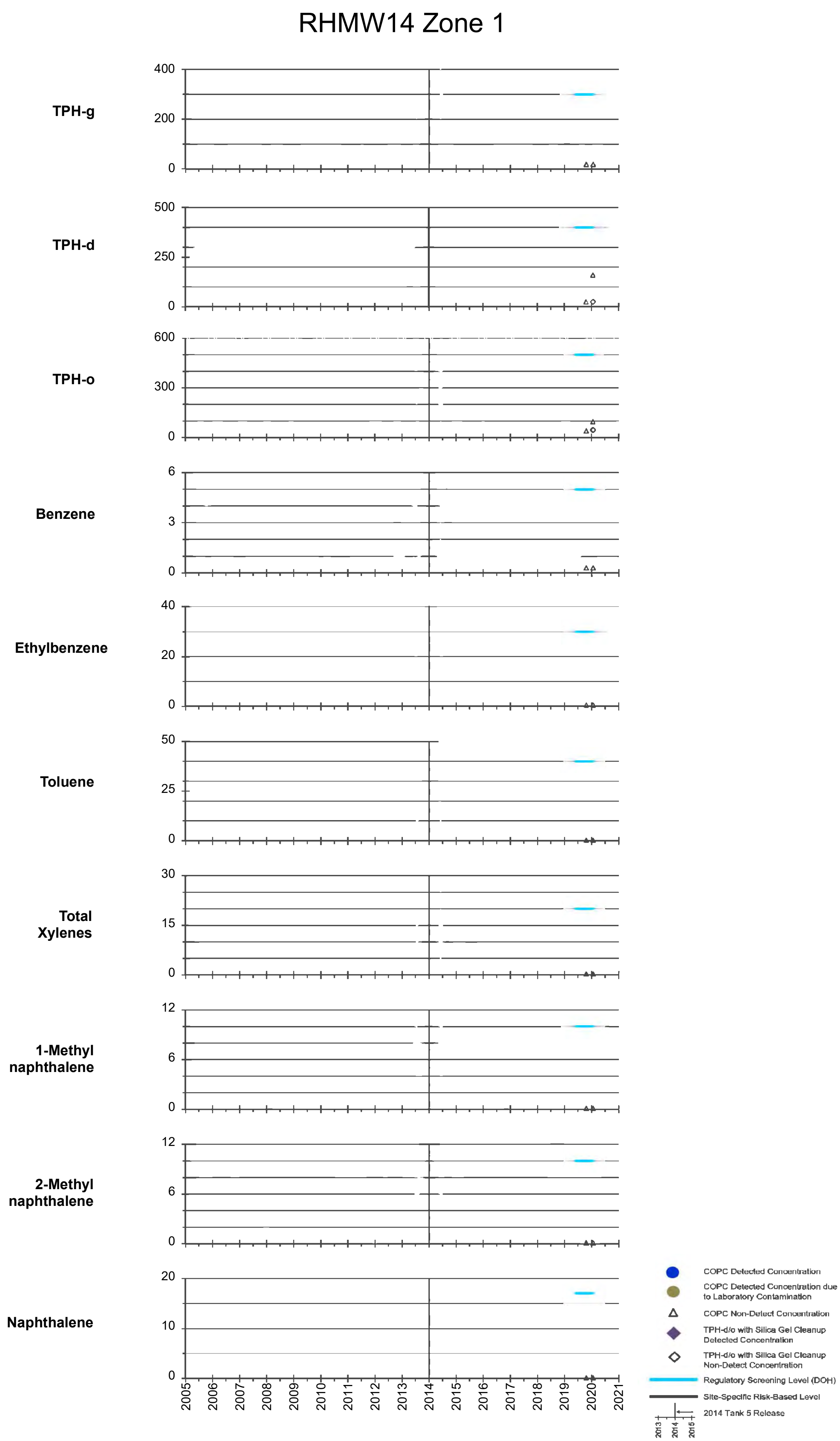

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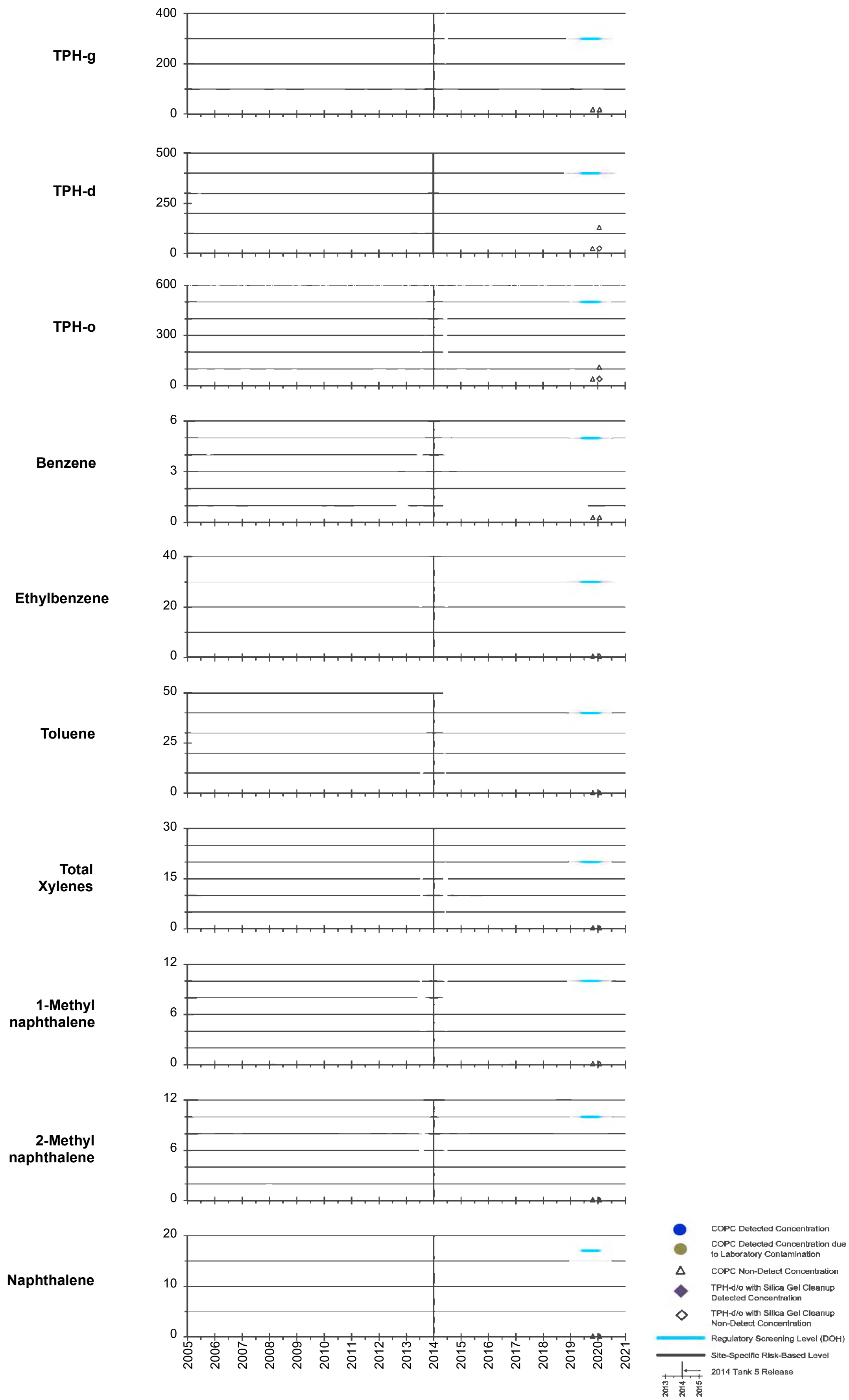
RHMW14 Zone 2



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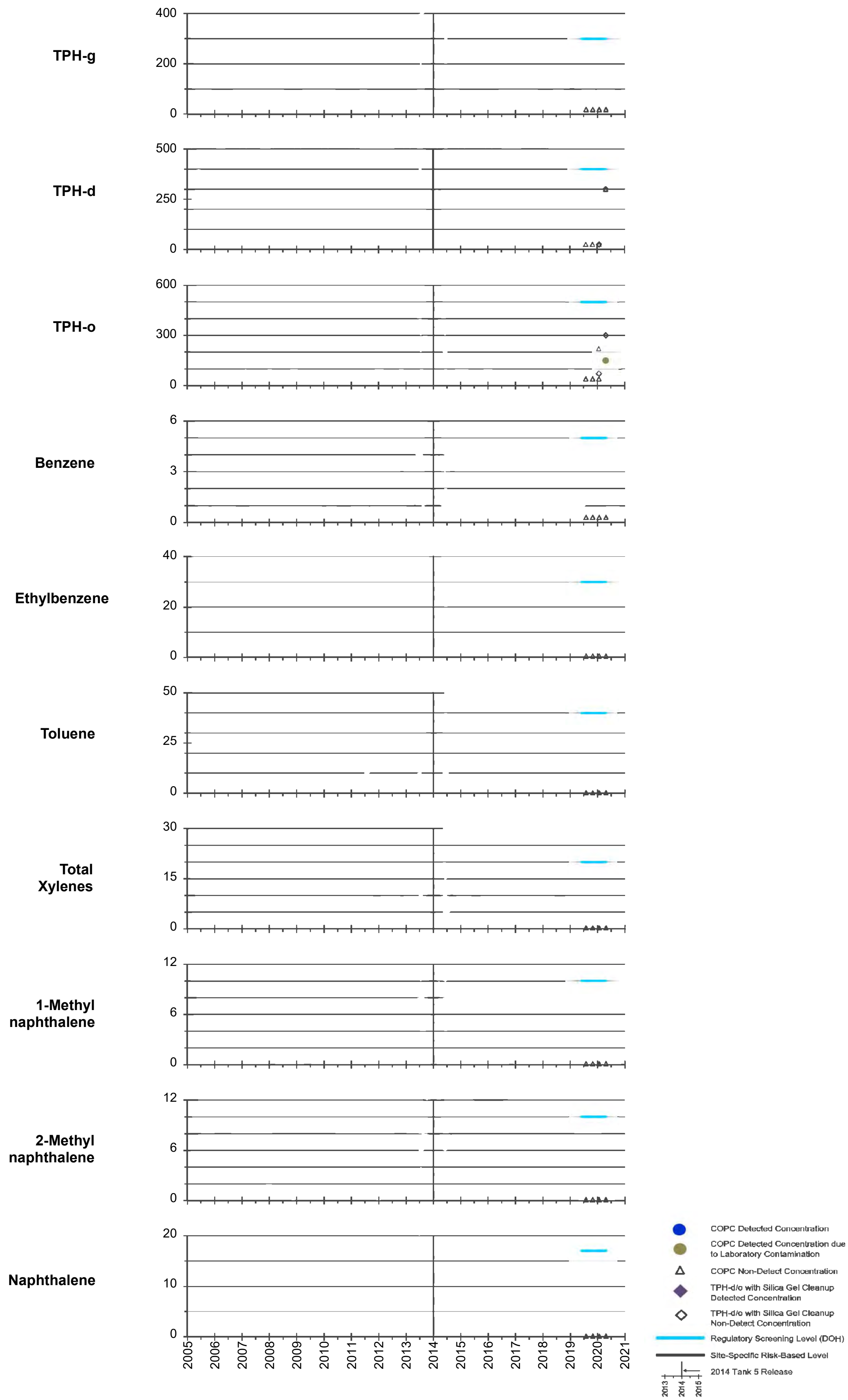
RHMW14 Zone 3



All results in micrograms per liter (µg/L or parts per billion).

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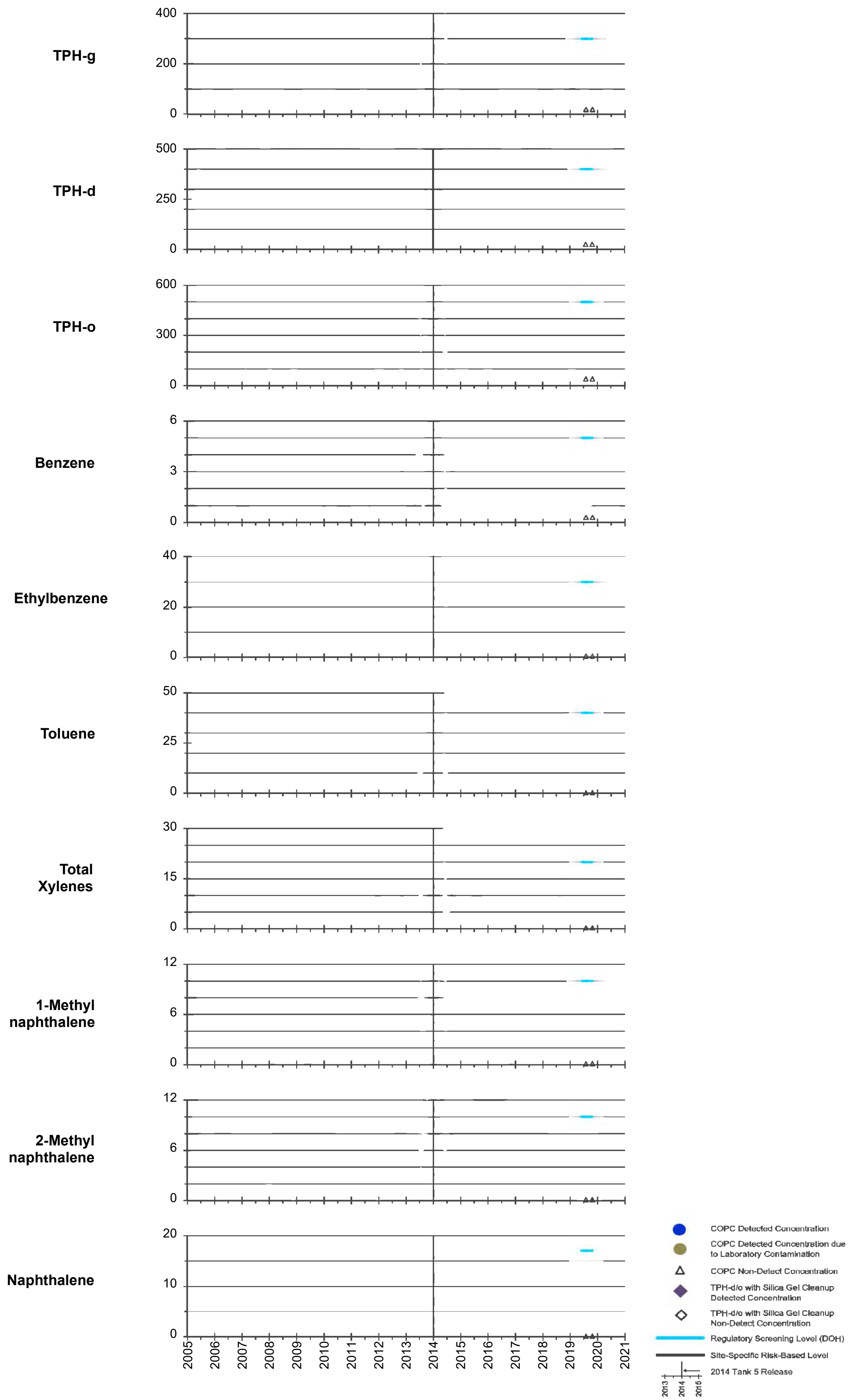
RHMW14 Zone 4



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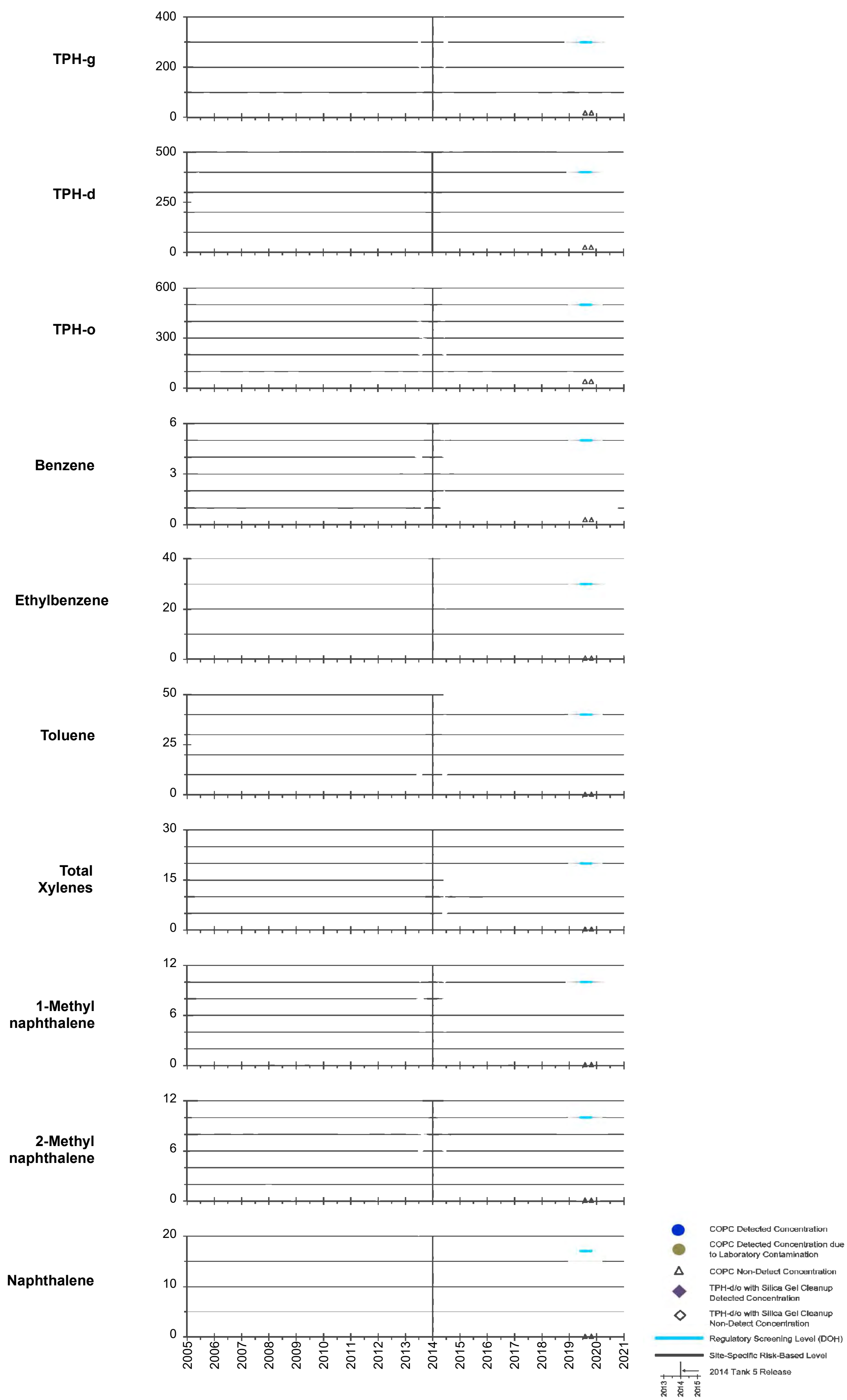
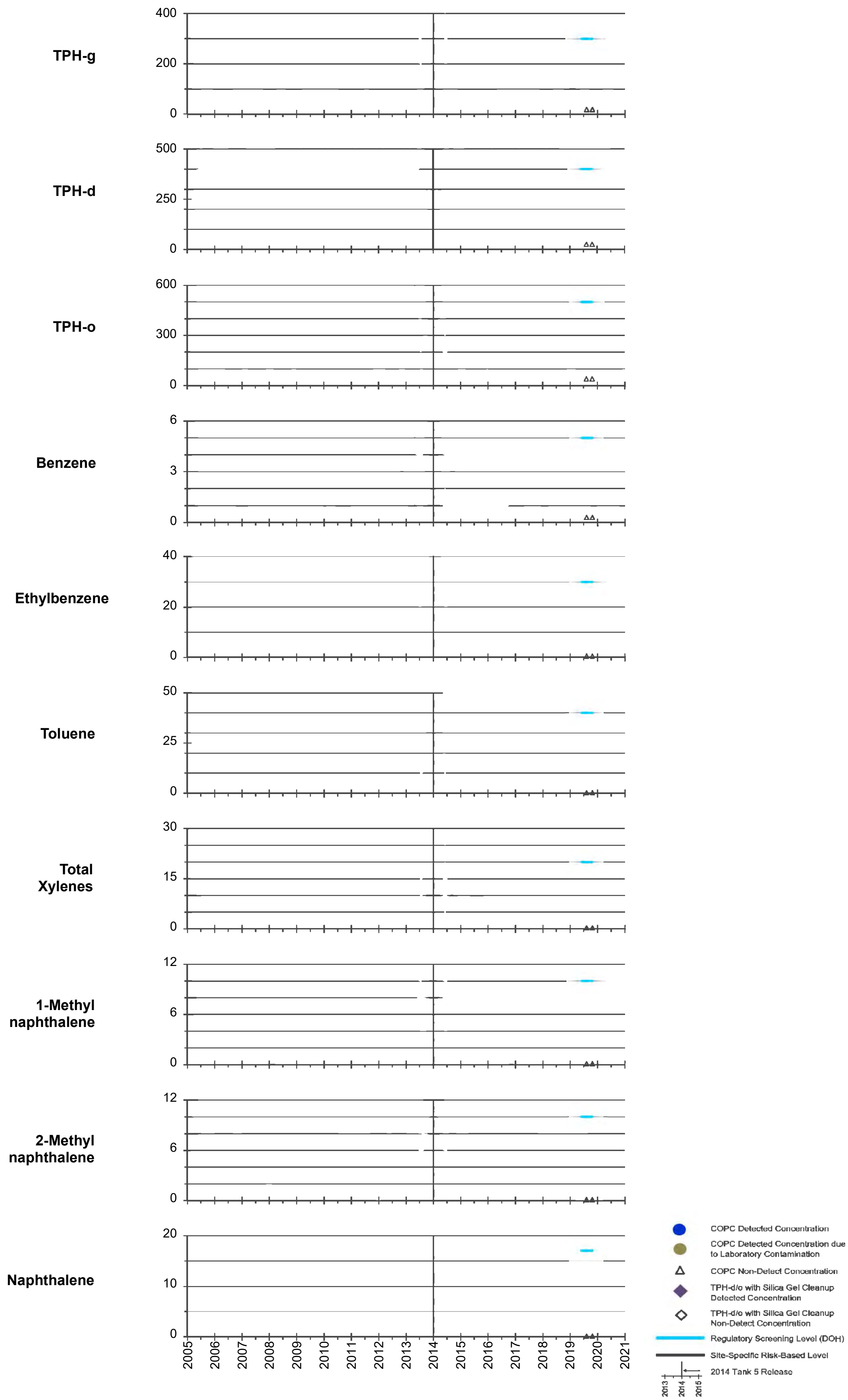
RHMW14 Zone 5

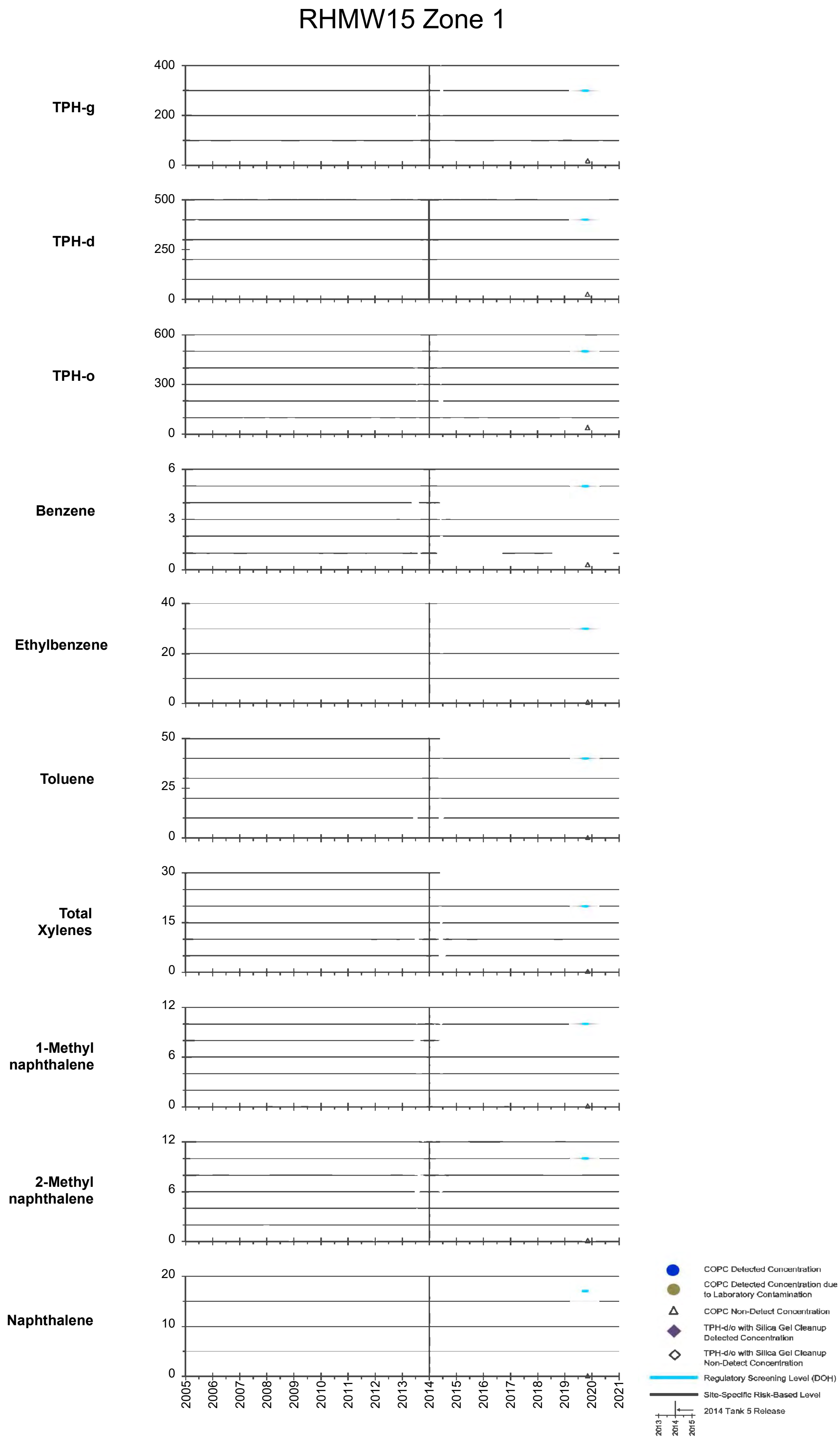


All results in micrograms per liter (µg/L or parts per billion).

RHMW14 Zone 7



All results in micrograms per liter (µg/L or parts per billion).



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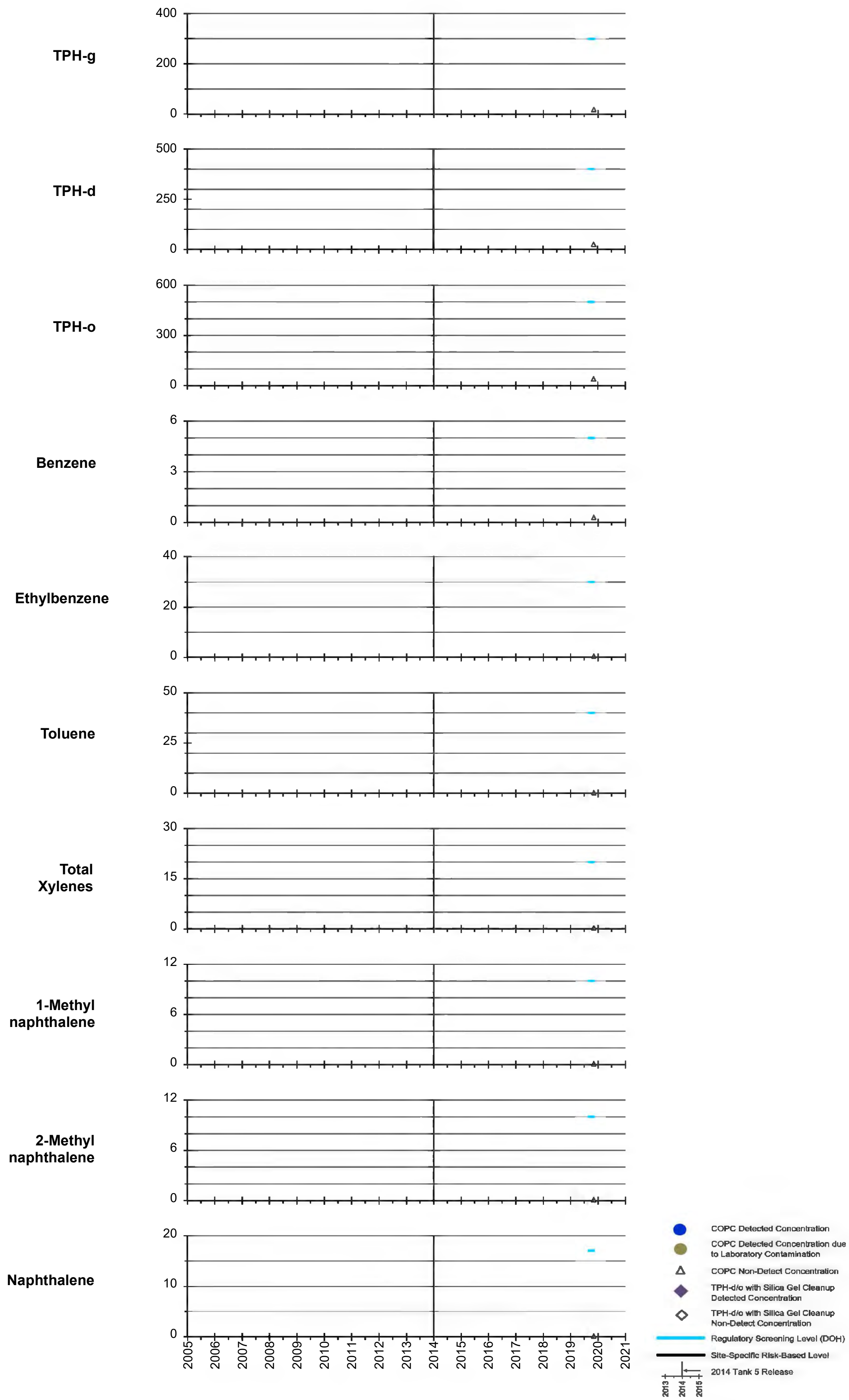

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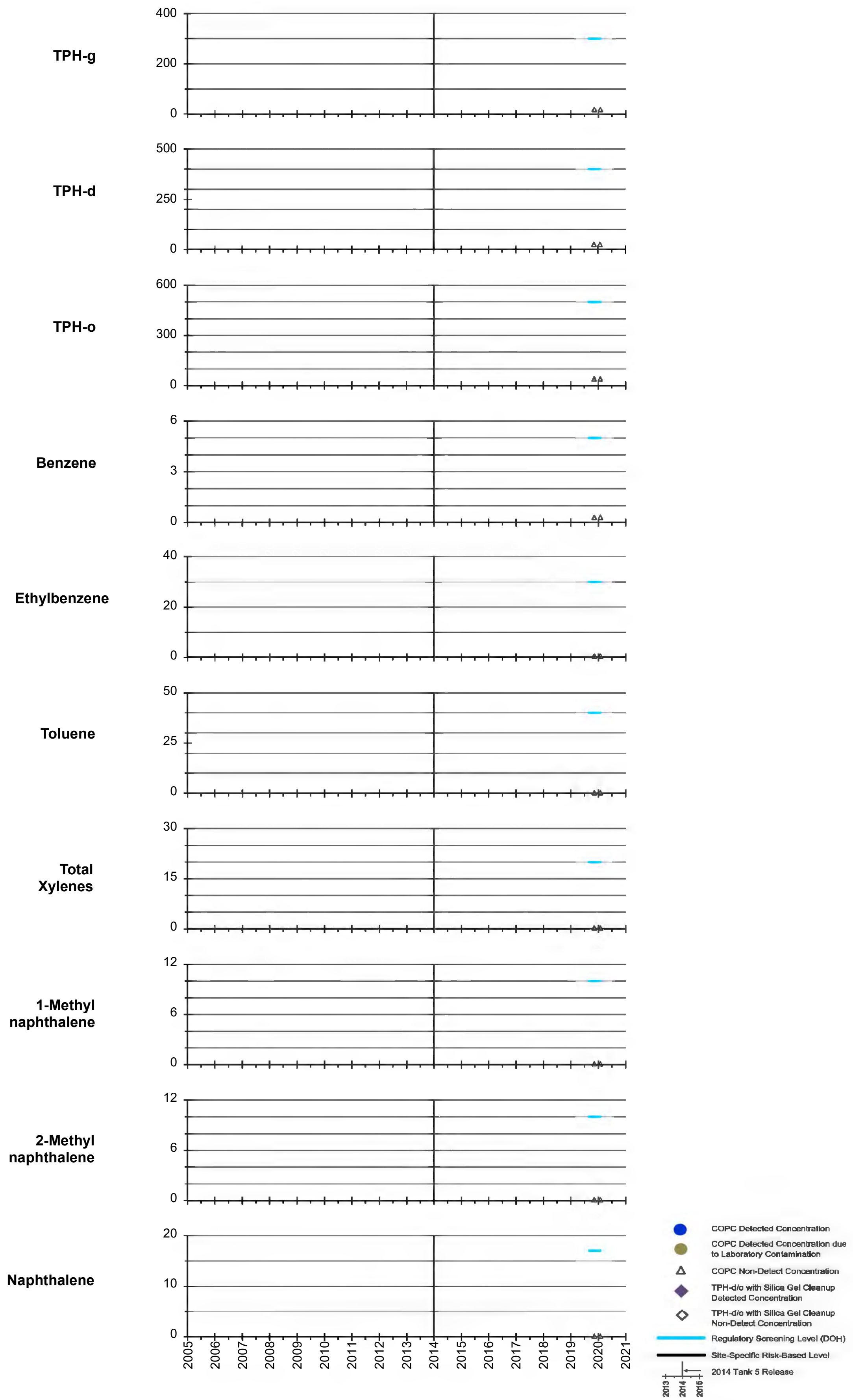
RHMW15 Zone 3



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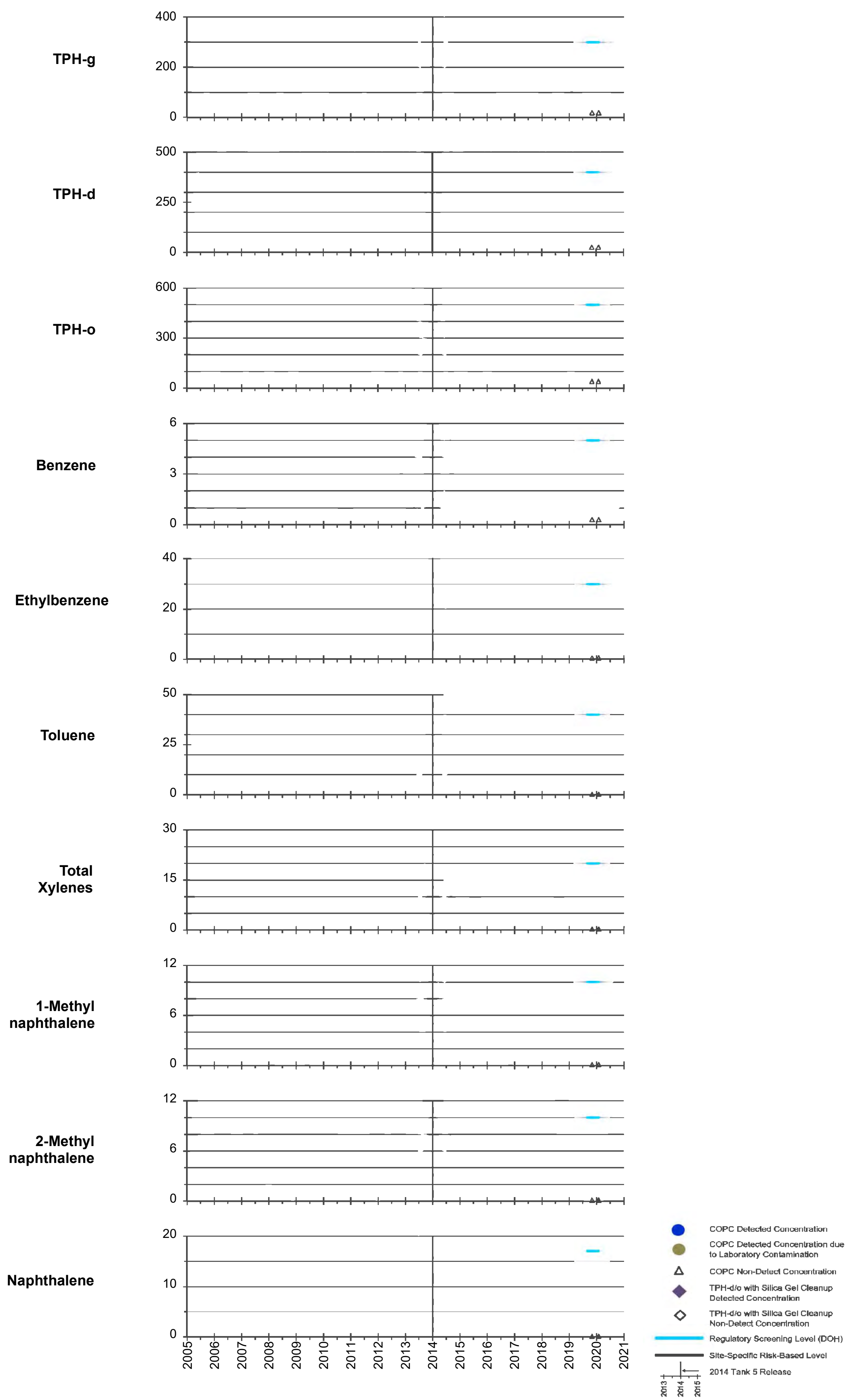

All results in micrograms per liter (µg/L or parts per billion).

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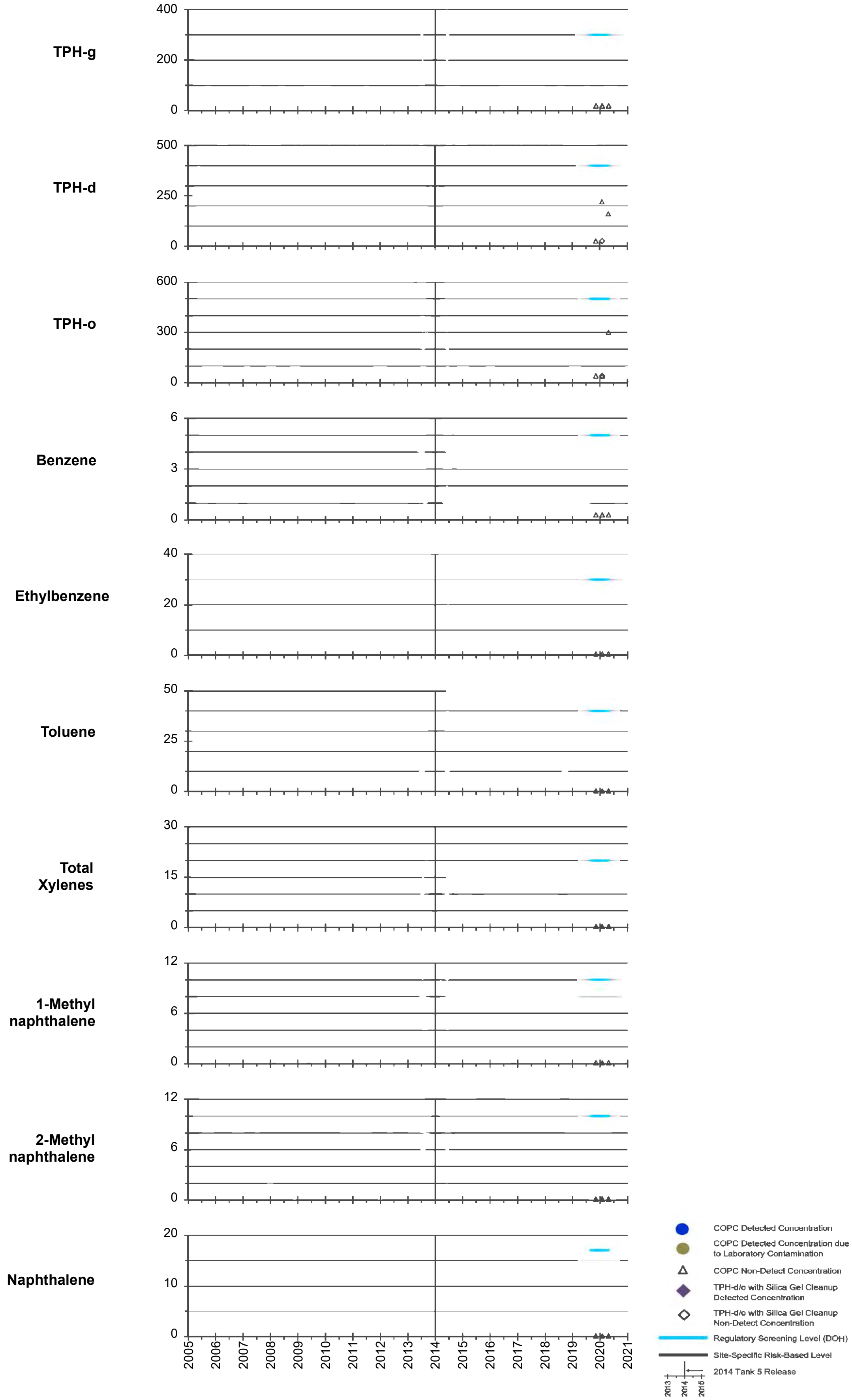
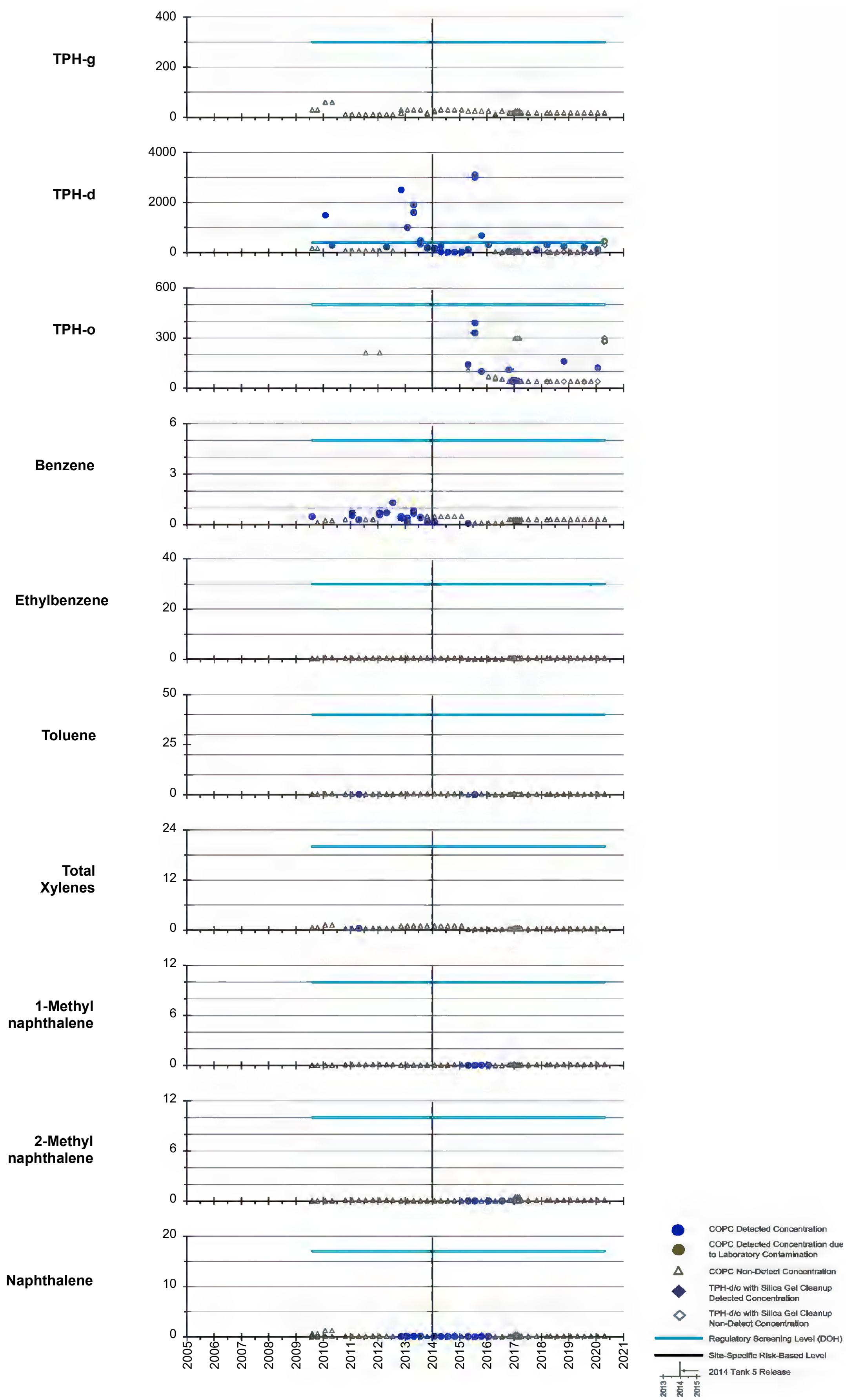


All results in micrograms per liter (µg/L or parts per billion).

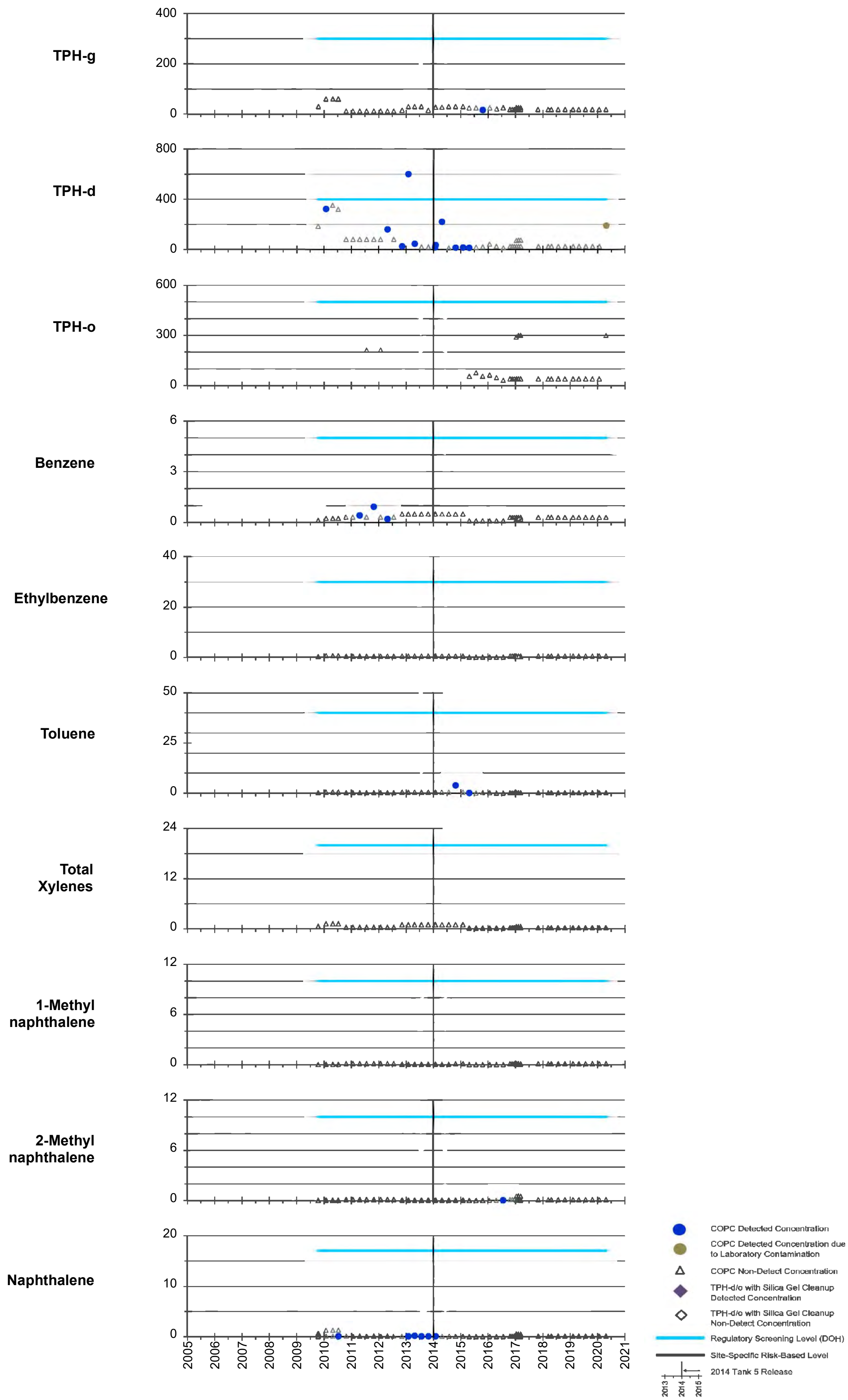
Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

OWDFMW01



All results in micrograms per liter (µg/L or parts per billion).
EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.
Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

HDMW2253-03



All results in micrograms per liter (μg/L or parts per billion).

EPA Region 9 Laboratory split sampling data from First to Third Quarters 2017 included in the graphs.

Laboratory reporting limits for TPH-d and TPH-o were raised in March 2020 in accordance with the most current DoD QSM (2019), TNI Manual (2016), and 40 CFR Part 136 (Methods Update Rule 2017).

Exhibit K

5.1.7 Red Hill Geologic Framework Model

A geologic framework model was generated using CTECH's Earth Volumetric Studio (EVS) software. The lithologic information used to generate the model was derived from available borehole lithology and from a series of geologic cross sections in the vicinity of Red Hill. Interpolation of lithologic contacts from borehole lithology and cross sections was achieved via adaptive indicator kriging. The framework model was used to visualize the extent of clinker beneath the water table. Groundwater data from the November 2016 synoptic gauging event was incorporated into the model to serve as an upper domain relative to the model's geologic block.

The geologic framework model was also used to compute the estimated volume of clinker and pahoehoe within user-specified domains. The EVS volumetric module was used to compute the volume of clinker and pāhoehoe within each zone against the overall geometric volume to achieve a percent total. In addition to use in groundwater modeling, this geologic evaluation was also incorporated into the holding capacity analysis included in the *Groundwater Protection and Evaluation Considerations* report (DON 2018h).

Details are presented in Appendix E.

5.1.8 3D Regional Geologic Model

Geologic information from borehole logs, seismic profiles, developed cross sections, and relevant publications were incorporated into the development of a 3D regional geologic model of Red Hill and surrounding environs including North and South Hālawa Valleys, Moanalua Valley, the Salt Lake area, and Pearl Harbor. The model encompasses both the vadose and saturated zones and includes the various rock types present: unweathered basalt (undifferentiated), pyroclastic deposits, caprock deposits, and weathered basalt or saprolite. The 3D regional geologic model was developed to provide stratigraphic support for the Red Hill groundwater flow model; the model extent mirrored the extent of the groundwater flow model domain.

Several data sources were used to develop the 3D regional geologic model. These sources included:

- USGS caprock thickness structural contour data sets
- Regional geologic cross sections
- Geophysical investigation study
- Volcanic tuff and pyroclastic mapping
- Marine sediment mapping
- South Hālawa Valley base of saprolite interpretations

Details are presented in Appendix E.

5.1.9 Assessment of Subsurface Heterogeneity

Geologic logs and photographs of basalt cores from the Red Hill area show that the vadose zone surrounding the fuel tanks is composed of a heterogeneous series of layered basalt flows. Both types of basalt, pāhoehoe and a'ā, are present.

Within the heterogeneous layered basalt formation that composes the vadose zone surrounding the fuel tanks, the spatial distribution of interconnected pore spaces (effective porosity) is the result of the basalt lava flow genesis and subsequent sub-aerial weathering that may occur prior to the next flow.

Appendix E:
Geologic Framework Model

CONTENTS

ATTACHMENTS

FIGURES

TABLE

ACRONYMS AND ABBREVIATIONS

3D	three-dimensional
EVS	Earth Volumetric Studio
ft	foot/feet
GIS	geographic information system
USGS	United States Geological Survey

1. Red Hill Geologic Framework Model

A geologic framework model was generated using CTECH's Earth Volumetric Studio (EVS) software. The lithologic information used to generate the model was derived from two primary sources and housed in a Microsoft Access database. The first data source came from available borehole lithology where lithologic contacts were pulled from borehole logs and tabulated in a simple flat-file format for inclusion into the lithology database. The second lithology source was derived from a series of geologic cross sections in the vicinity of Red Hill and several others throughout the groundwater flow model domain (Figure E-1). These cross sections were subdivided into a series of artificial boreholes with a horizontal spacing of 100–500 feet (ft). Lithologic contacts from these artificial boreholes were tabulated in a flat-file format and incorporated into the lithology database for interpolation.

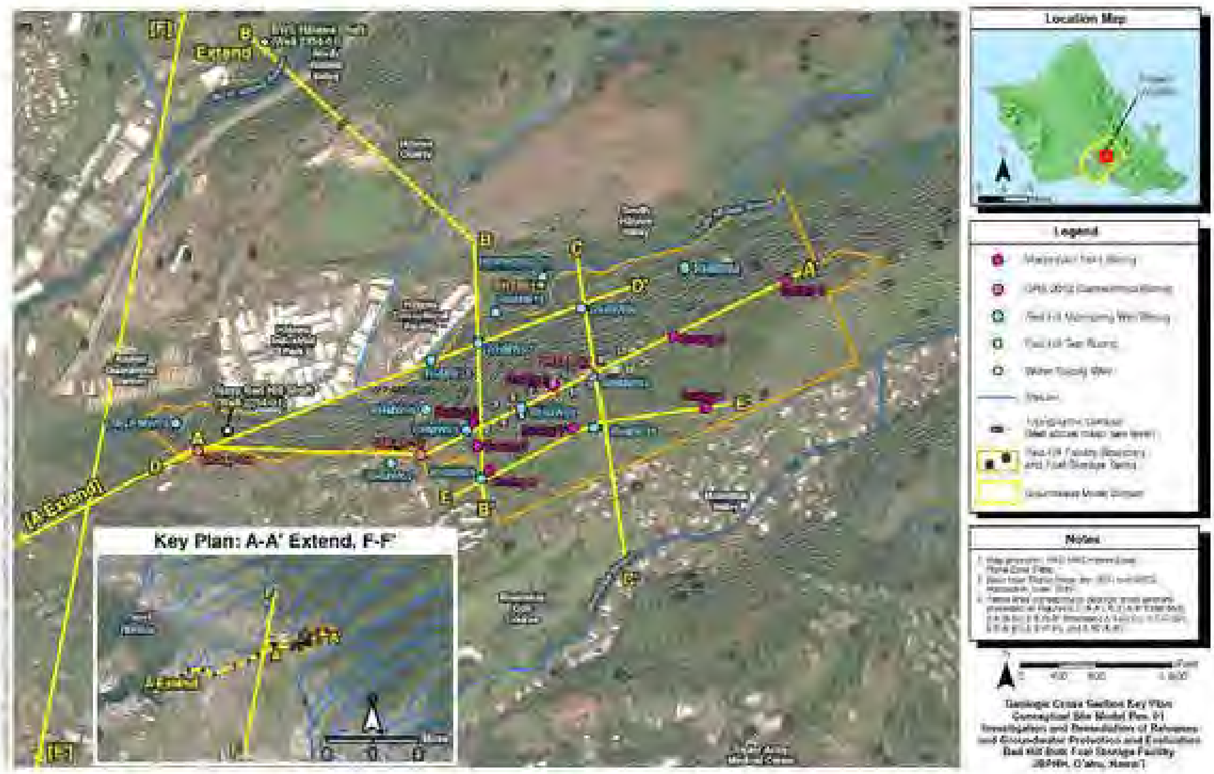


Figure E-1: Red Hill Geologic Cross Section Location Map

Interpolation of the lithologic contacts was achieved via adaptive indicator kriging. Adaptive indicator kriging applies kriging to a user-defined external grid and further refines it by splitting whole cells along boundaries between two or more materials to create smoother surfaces. The external grid used for the geologic framework model had an approximate horizontal cell size of 165 ft × 165 ft with 280 cells along the x-axis and 190 cells along the y-axis. Proportional gridding was used to establish the vertical thickness where a z-axis resolution of 100 was specified. Finally, the horizontal/vertical anisotropy was set at 100 (Figure E-2).

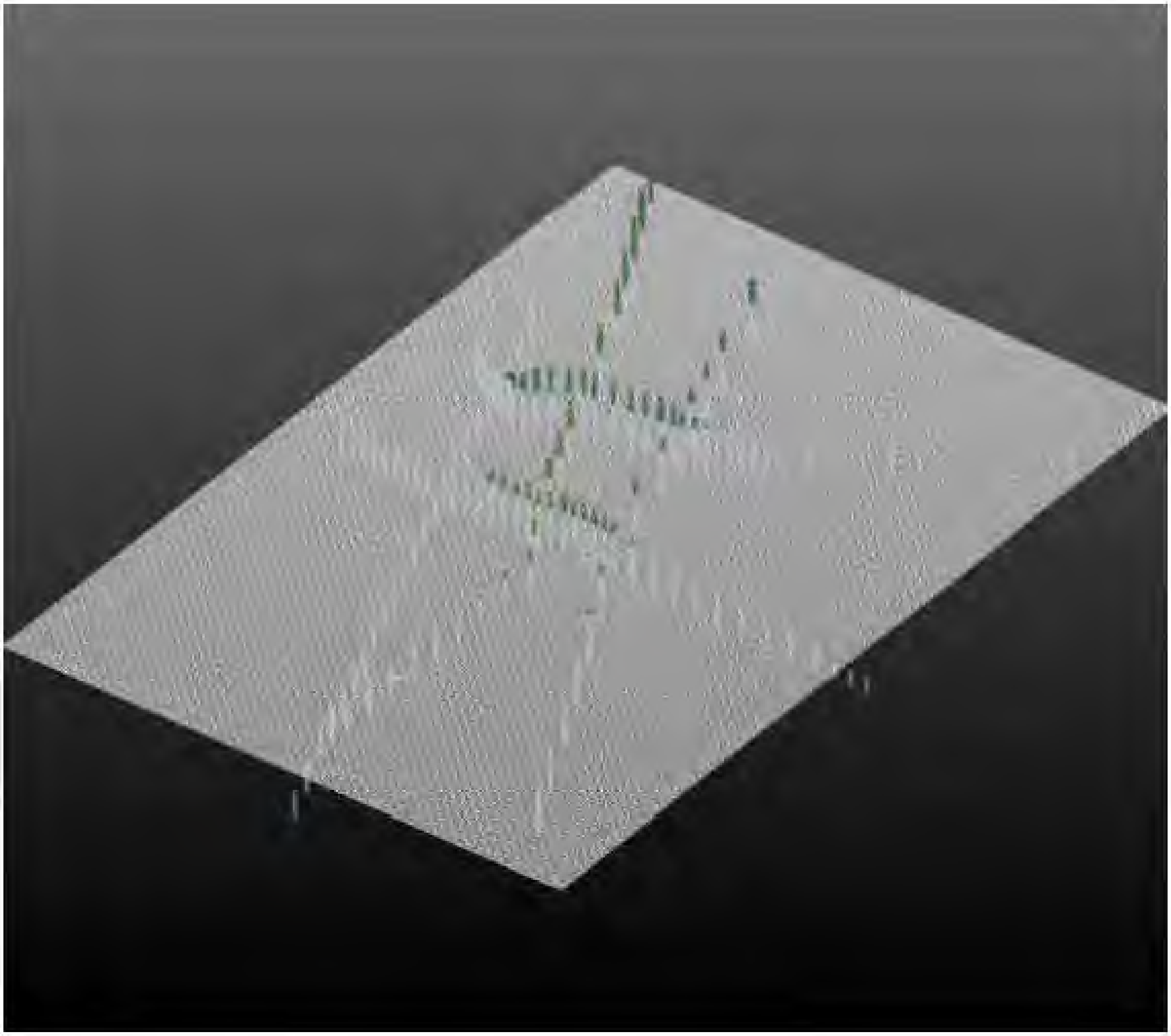


Figure E-2: External Grid (oblique view)

The resulting interpolation yielded a geologic block consisting of the following five primary soil/rock types: alluvium, saprolite, massive a'ā basalt, a'ā clinker, and pāhoehoe (Figure E-3).

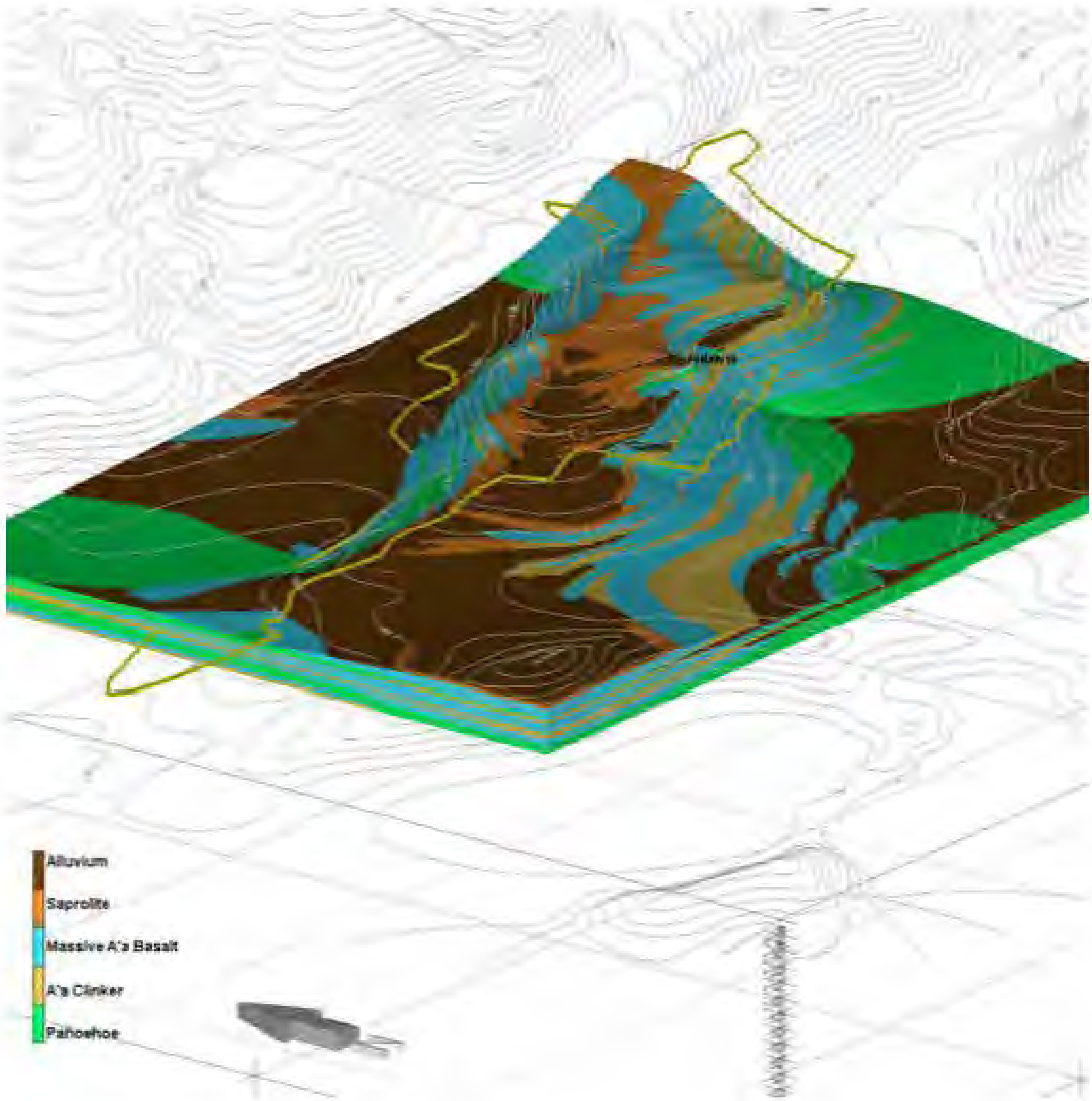


Figure E-3: Red Hill 3D Geologic Block Diagram

Various work products were developed from the geologic block. Specifically, fence diagrams in a variety of orientations along with volume calculations of specific material types from user-specified domains. A groundwater elevation surface was also introduced to visualize soil/rock types in the vadose zone versus saturated zone.

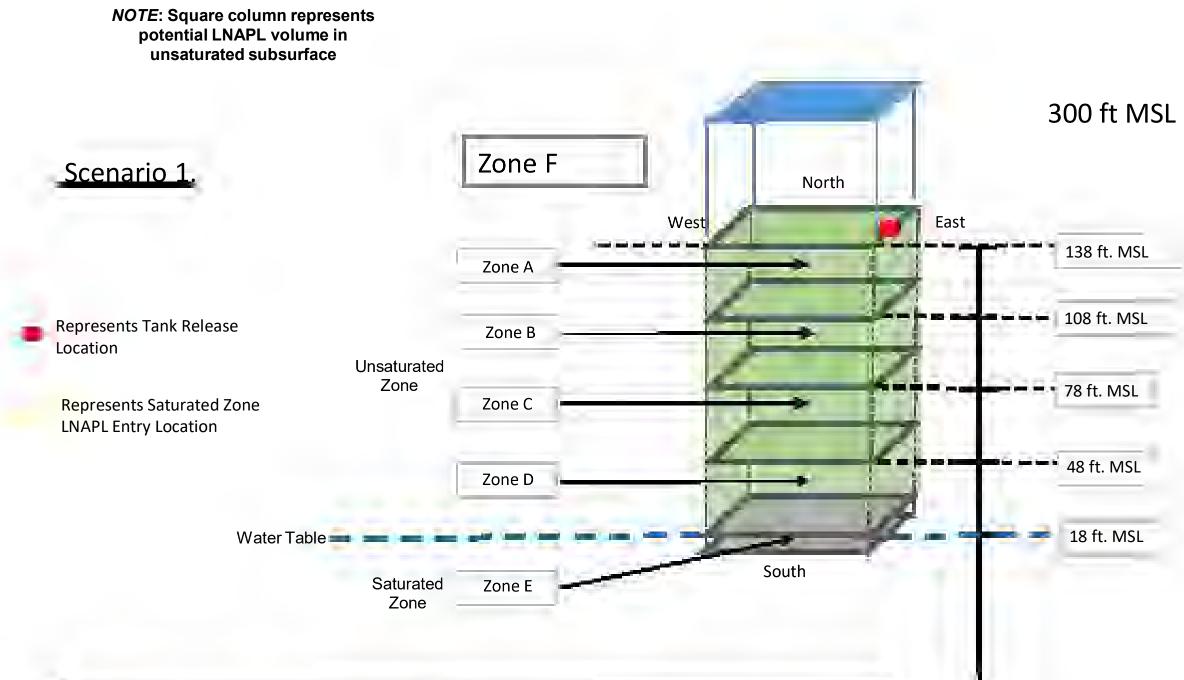
1.1 SATURATED CLINKER EVALUATION

The geologic framework model was used to visualize the extent of clinker beneath the water table. Groundwater data from the November 2016 synoptic gauging event was incorporated into the model to serve as an upper domain relative to the model's geologic block. The five soil/rock types that compose the geologic block were turned off with exception of the clinker rock type to reveal its extent below the water table (Figure E-4).

Figure E-4: Extent of Saturated Clinker (oblique view to the northeast)

1.2 CLINKER/PĀHOEHOE VOLUME EVALUATION

The geologic framework model was used to compute the estimated volume of clinker and pahoehoe within user specified domains. Two cells (1,600 ft × 1,600 ft and 720 ft × 720 ft) with specific elevation intervals (i.e., zones; Figure E-5) were specified domains for these volume computations. The EVS volumetric module was used to compute the volume of clinker and pāhoehoe within each zone against the overall geometric volume to achieve a percent total (see Table E-1). In addition to use for groundwater modeling, this geologic evaluation was also incorporated into the holding capacity analysis that was part of the *Groundwater Protection and Evaluation Considerations* report (DON 2018b).



Geometric Summary						
Dimension	**Zone A**	**Zone B**	**Zone C**	**Zone D**	**Zone E**	*Unit*
Length	1,600	1,600	1,600	1,600	1,600	feet
Width	1,600	1,600	1,600	1,600	1,600	feet
Thickness	30	30	30	30	2	feet
Top Area	2,560,000	2,560,000	2,560,000	2,560,000	2,560,000	sq.ft.
Bottom Area	2,560,000	2,560,000	2,560,000	2,560,000	2,560,000	sq.ft.

Figure E-5: Scenario Zone Designations

Table E-1: Clinker / Pāhoehoe Percent Volume Results

Zone	Elevation Interval (ft)	Total Volume (cu. ft.)	Clinker Volume (cu. ft.)	Pāhoehoe Volume (cu. ft.)	% Clinker	% Pāhoehoe
Scenario 1 (1,600 ft × 1,600 ft Cell)						
F	300–138	4.15E+08	1.04E+08	4.54E+07	25%	11%
A	138–108	7.68E+07	9.93E+06	3.88E+07	13%	50%
B	108–78	7.68E+07	1.48E+06	4.43E+07	2%	58%
C	78–48	7.68E+07	1.94E+06	5.73E+07	3%	75%
D	48–18	7.68E+07	3.02E+06	6.40E+07	4%	83%
E	18–16	5.12E+06	5.68E+04	4.98E+06	1%	97%
Scenario 2 (720 ft × 720 ft Cell)						
F	300–138	8.40E+07	2.16E+07	8.82E+06	26%	11%
A	138–108	1.56E+07	1.11E+06	1.10E+07	7%	70%
B	108–78	1.56E+07	5.74E+03	9.78E+06	0.04%	63%
C	78–48	1.56E+07	2.49E+05	1.25E+07	2%	80%
D	48–18	1.56E+07	0.00E+00	1.45E+07	0%	93%
E	18–16	1.04E+06	0.00E+00	1.04E+06	0%	100%

2. Three-Dimensional (3D) Regional Geologic Model

In addition to the Red Hill-specific geologic model, a 3D regional geologic model was developed to provide stratigraphic support for the groundwater flow model. The model extent mirrored the extent of the groundwater flow model domain, which is approximately 9 miles along the northeast/southwest and approximately 6 miles in the northwest/southeast direction (Figure E-6).

Figure E-6: Extent of 3D Regional Geologic Model

2.1 Regional Geologic Model Data Sets

Several data sources were used to develop the 3D regional geologic model. These sources included:

- United States Geological Survey (USGS) caprock thickness structural contour data sets
- Regional geologic cross sections
- Geophysical investigation study
- Volcanic tuff and pyroclastic mapping
- Marine sediment mapping
- South Hālawa Valley base of saprolite interpretations

2.1.1 USGS Caprock Thickness Data Sets

On July 20, 2017, the USGS provided the Navy with two preliminary spatial data sets depicting the thickness of the Caprock hydrogeological unit and the structural surface elevation contours of the underlying undifferentiated basalt. These data sets were provided as geographic information system (GIS) shapefiles and served as the basis of the 3D regional geologic model as it relates to caprock thickness and surface elevation of the undifferentiated basalt.

2.1.2 Regional Geologic Cross Sections

Regional geologic cross sections were incorporated into the model to provide additional lithologic detail beyond what was provided in the USGS data sets. Cross-section locations are shown on Figure E-7; the cross-section diagrams are presented in Attachment E.1. Specifically, the geologic cross sections provided lithologic contact elevations for undifferentiated basalt, saprolite, alluvium, tuff, and marine deposits. These cross sections were subdivided into a series of artificial boreholes with a horizontal spacing of 500–1,000 ft. Lithologic contacts from these artificial boreholes were tabulated in a flat-file format and incorporated into the lithology database for interpolation.

Figure E-7: Regional Geologic Cross-Section Location Map

2.1.3 Geophysical Investigation

A geophysical investigation was performed to better understand the extent of saprolite in the valleys adjacent to the Red Hill site. A seismic refraction and reflection survey was performed along a series of transects located on Red Hill and in North/South Hālawa and Moanalua Valleys. Findings from the seismic study (DON 2018a) were incorporated into the regional geologic cross sections used in development of the 3D model (Figure E-8).

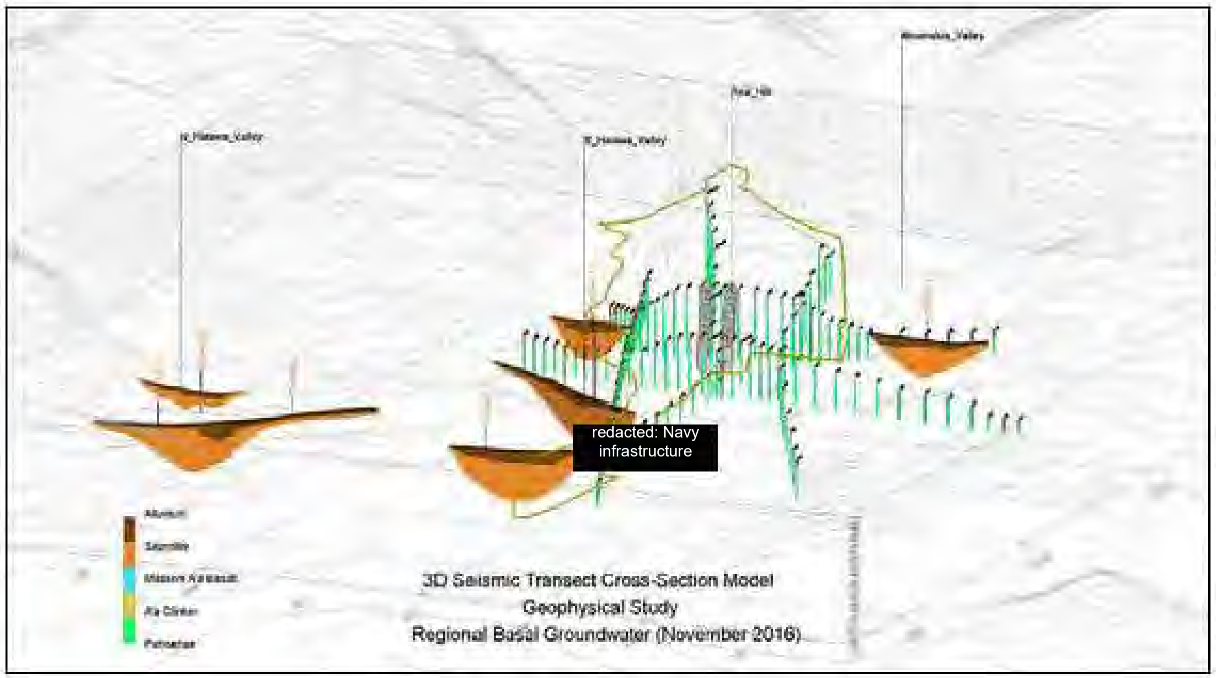


Figure E-8: Geophysical Investigation 3D Rendering

2.1.4 Volcanic Tuff Mapping

A series of pyroclastic craters and associated surface tuff deposits were incorporated into the 3D model based on a study of the Salt Lake Area by Pankiwskyj (1972). Figures from this study were used to delineate the crater rims and surface tuff extent through georeferencing in a GIS software platform. These features were then subsequently transferred into the 3D model for interpolation (Figure E-9 and Figure E-10).

Figure E-9: Surface Tuff and Crater Rim Extent

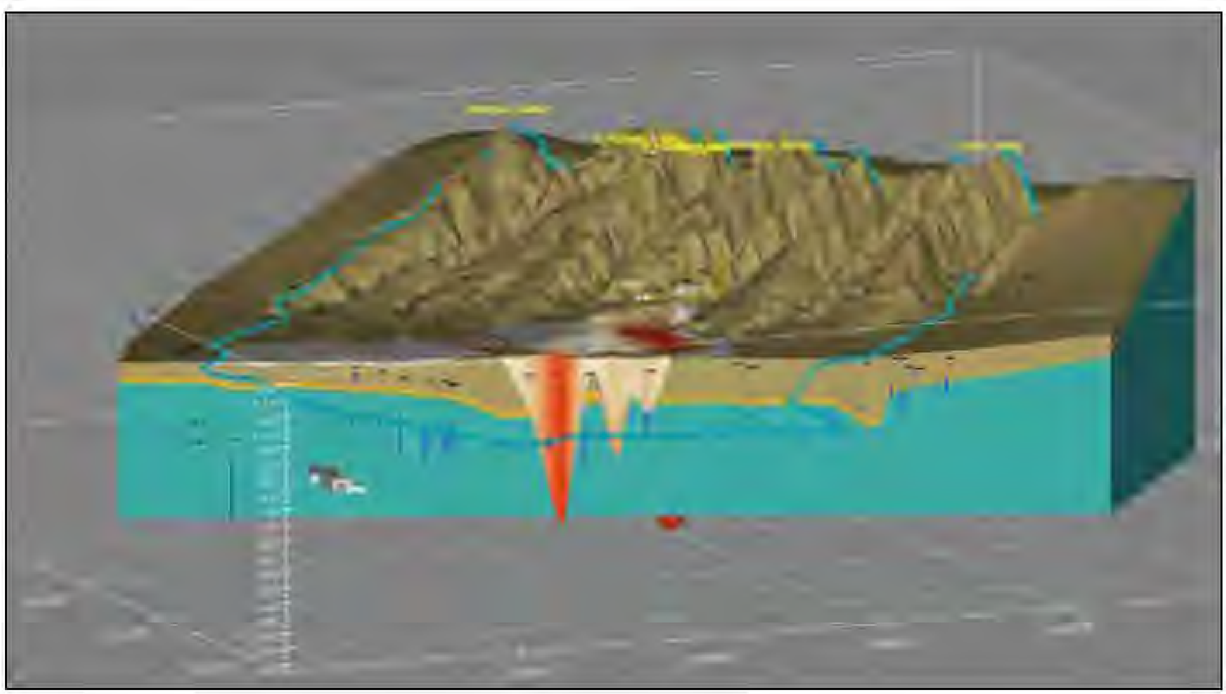


Figure E-10: 3D Block Diagram of Tuff Complex

2.1.5 Marine Sediments

Marine sediments were conceptually incorporated into the model and spatially situated based on available geologic mapping. The marine sediment lithology database and subsequent interpolation was generated in a fashion to show a transgression/regression pattern indicative of a coastal sediment depositional environment (Figure E-11).

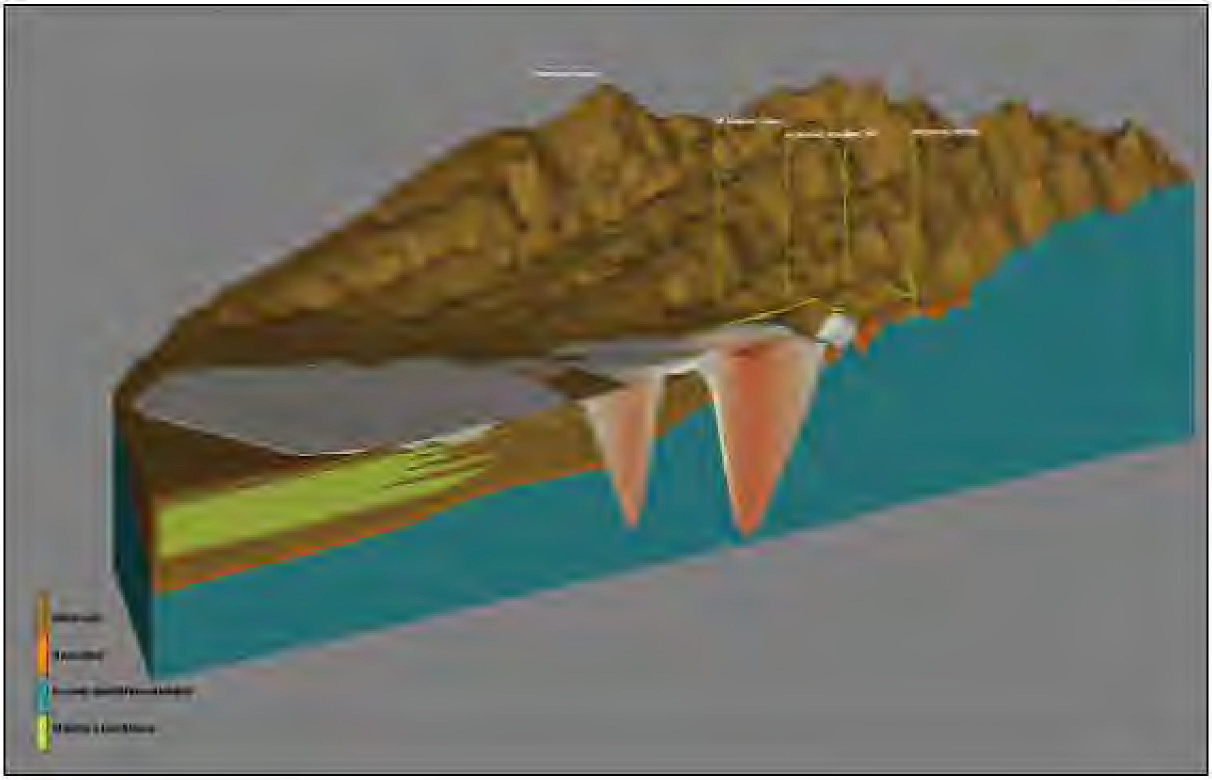


Figure E-11: 3D Block Diagram of Marine Sediments and Tuff Crater

2.1.6 South Hālawa Valley Base of Saprolite Interpretations

Two cross-section interpretations, an upper bound and a lower bound, situated along the South Hālawa Valley resulted in two versions of the 3D geologic model. These interpretations relate to the base of saprolite contact elevation with one version having a saprolite contact depth approximately 50 ft lower. As a result, two dedicated stand-alone geologic models were generated as the "Navy" and "DOH" interpretations (Figure E-12 and Figure E-13, respectively).

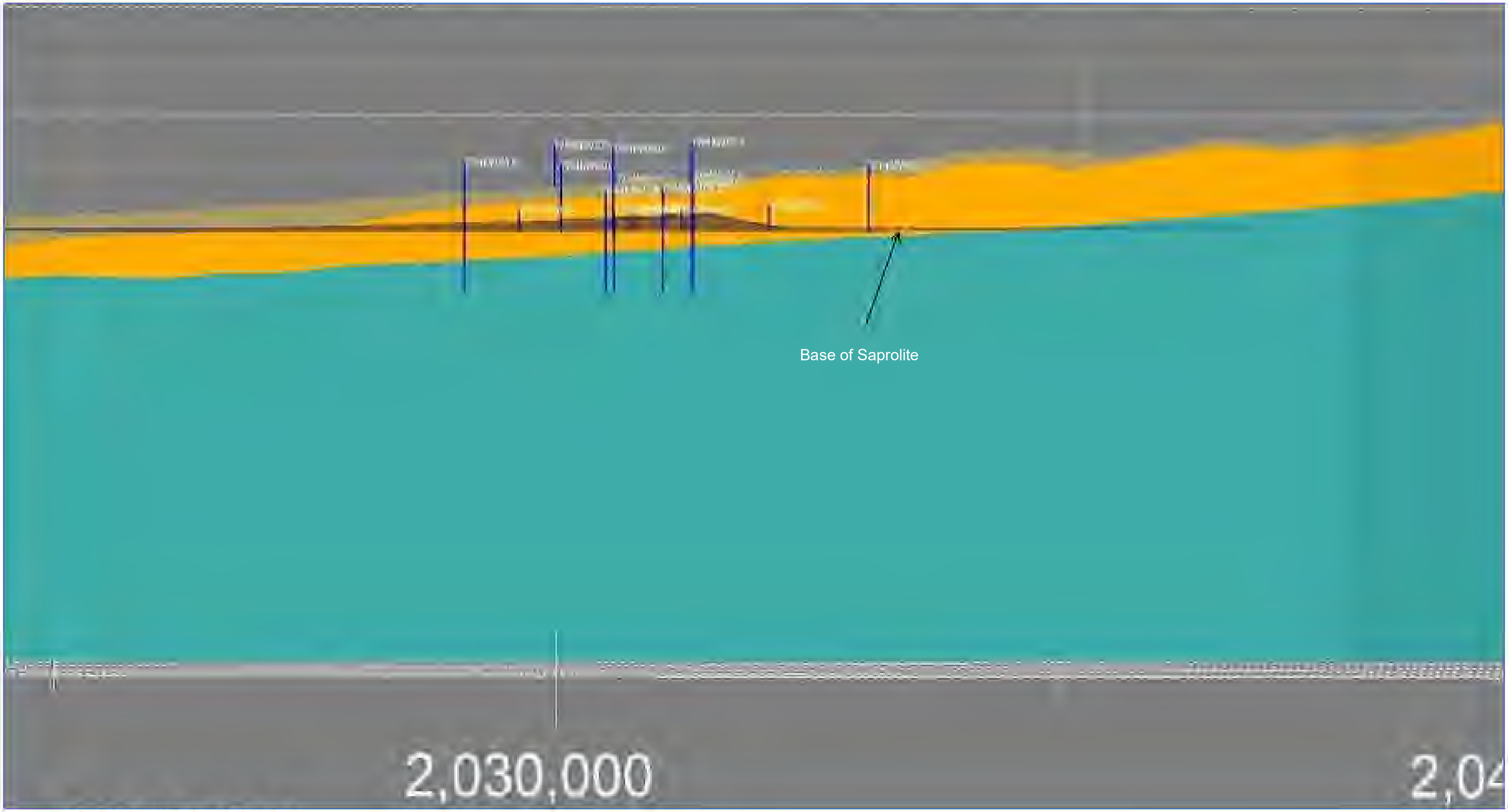


Figure E-12 South Halawa Valley Base of Saprolite (lower bound interpretation)

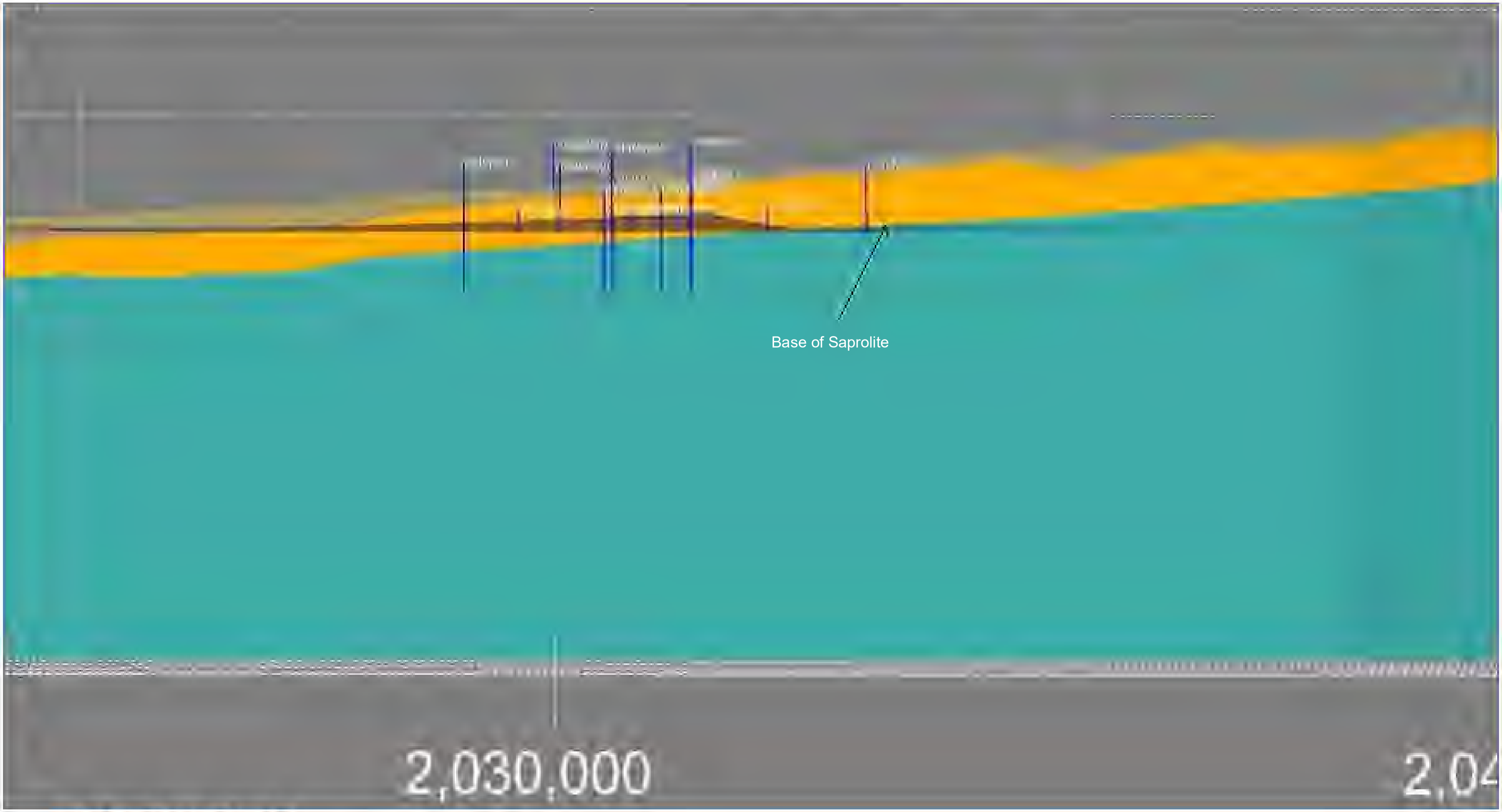


Figure E-13: South Halawa Valley Base of Saprolite (upper bound interpretation)

2.2 MODEL INTERPOLATION

Pertinent geologic contacts from the aforementioned data sets were tabulated and housed in a Microsoft Access database consisting of 2,909 spatial data points. Each point represents the location of discrete geologic contacts (up to five depending on geology at that location). A higher concentration of data points resides in the nearby North/South Hālawa and Moanalua Valleys due to a variety of subsurface investigations in those areas (see Figure E-14). Interpolation of this spatial data set was performed in EVS via the krig_3D_geology module. This module interpolates data into a series of geologic horizons where each elevation represents a geologic surface at that point in space. Several kriging estimation methods within the krig_3D_geology module are available for use. The Natural Neighbors kriging estimation method was used to generate the 3D geologic block diagram.

Figure E-14: 3D Regional Geologic Model Spatial Data Set

3. References

Department of the Navy (DON). 2018a. *Seismic Profiling to Map Hydrostratigraphy in the Red Hill Area, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, Hawai‘i; March 30, 2018, Revision 00.* Prepared by Lee Liberty and James St. Claire, Boise State University, Boise, ID, for AECOM Technical Services, Inc., Honolulu, HI. Boise State University Technical Report BSU CGISS 18-01. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

Attachment E.1: Regional Geologic Cross Sections

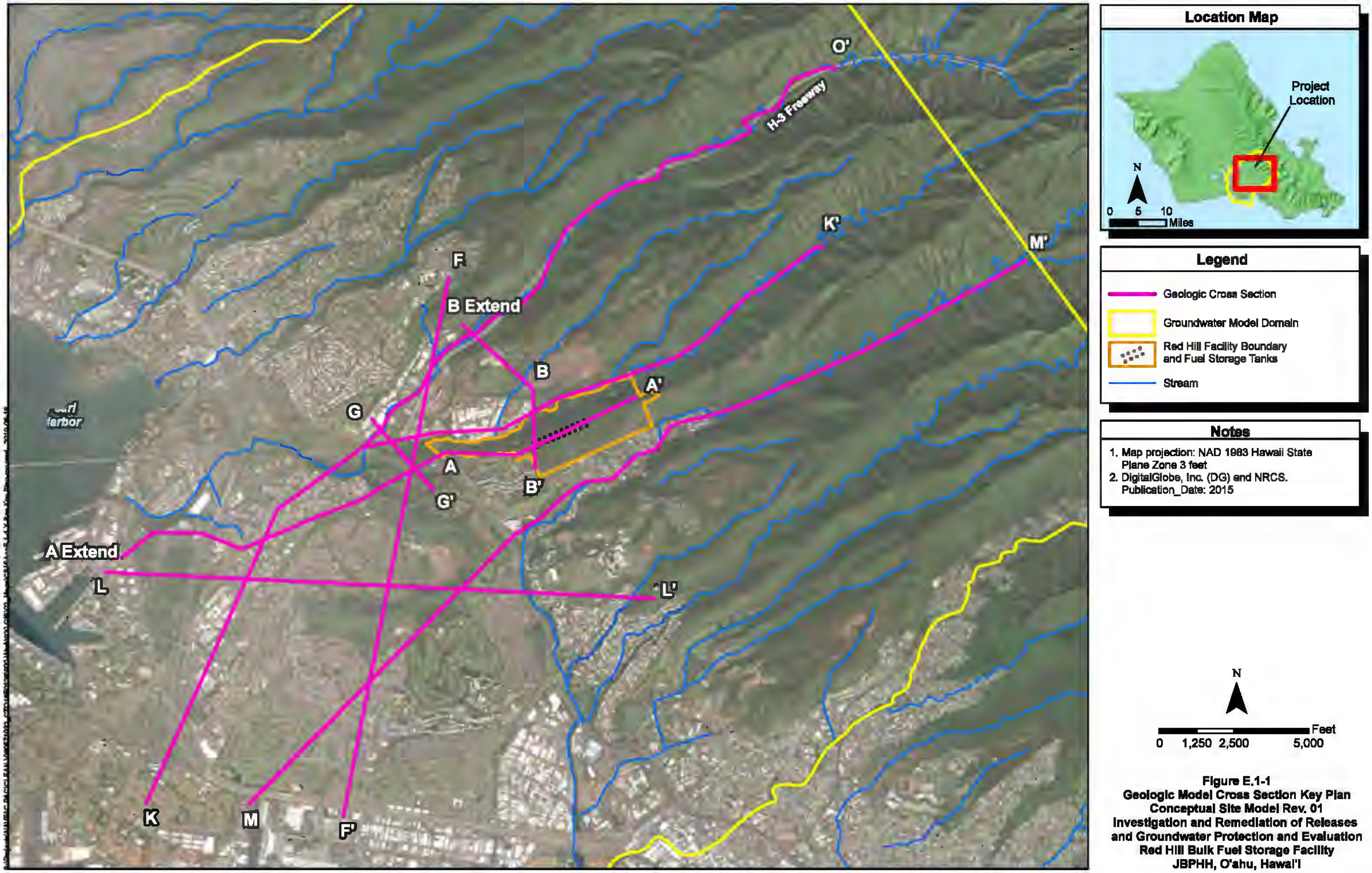
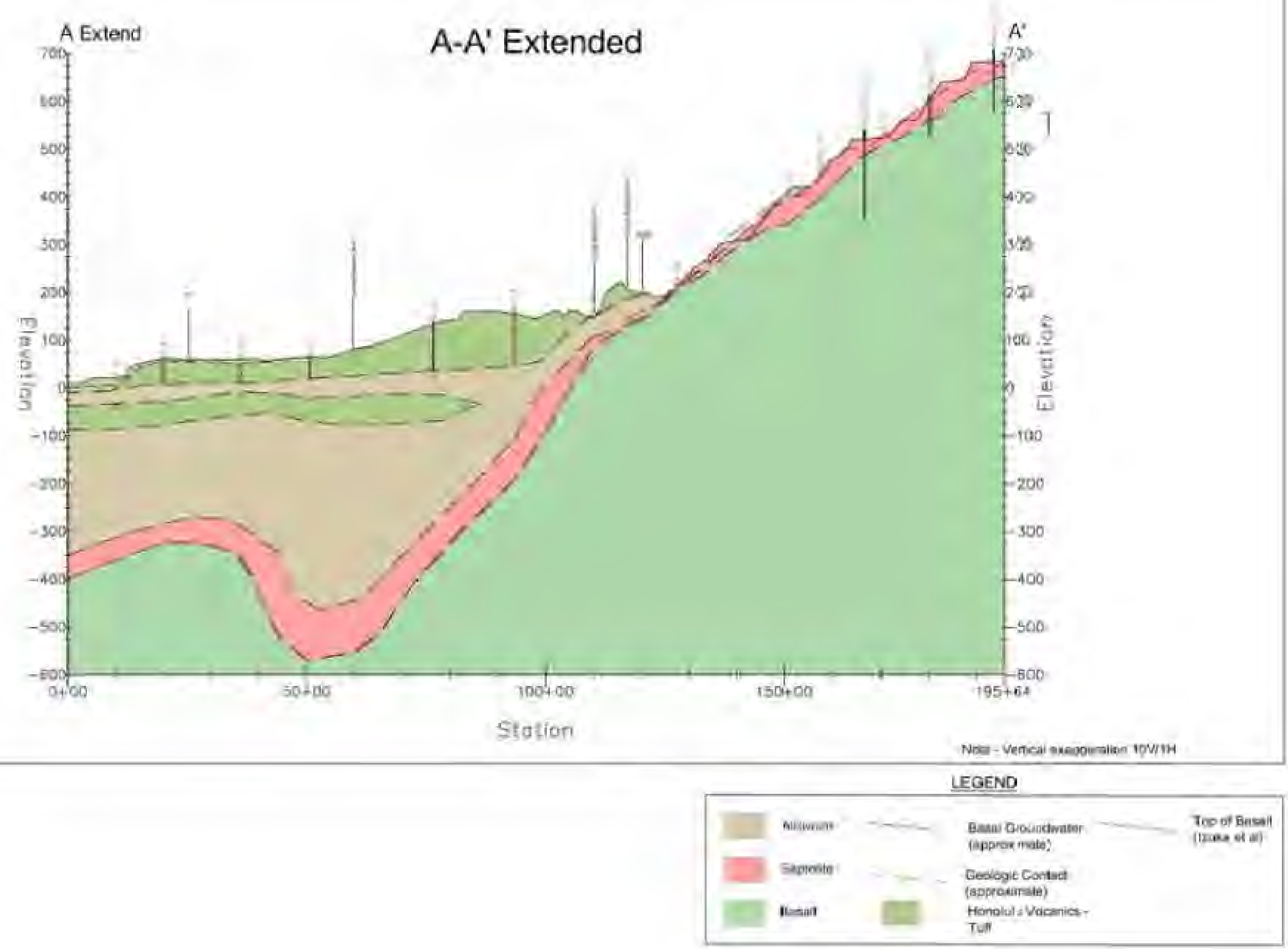
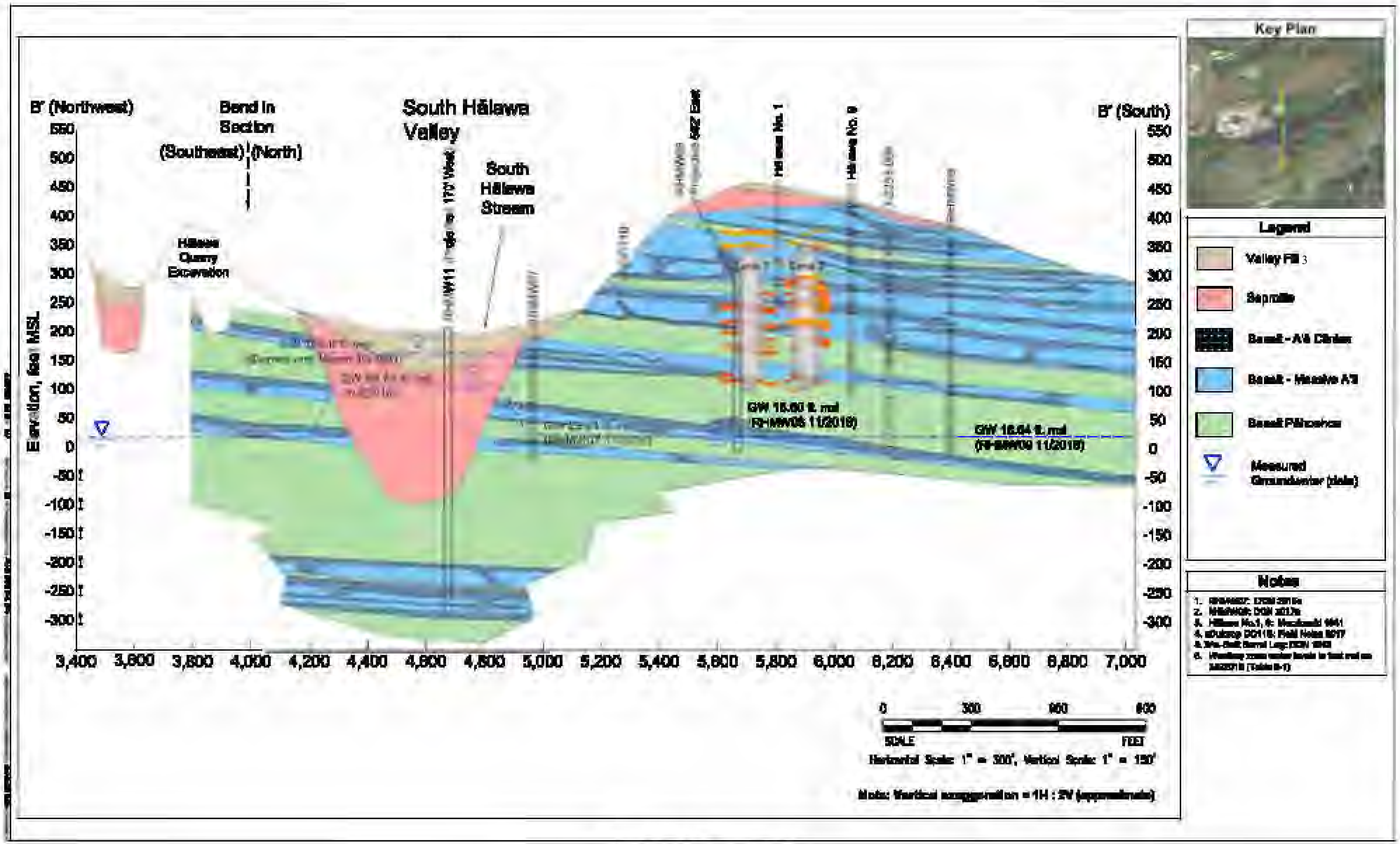
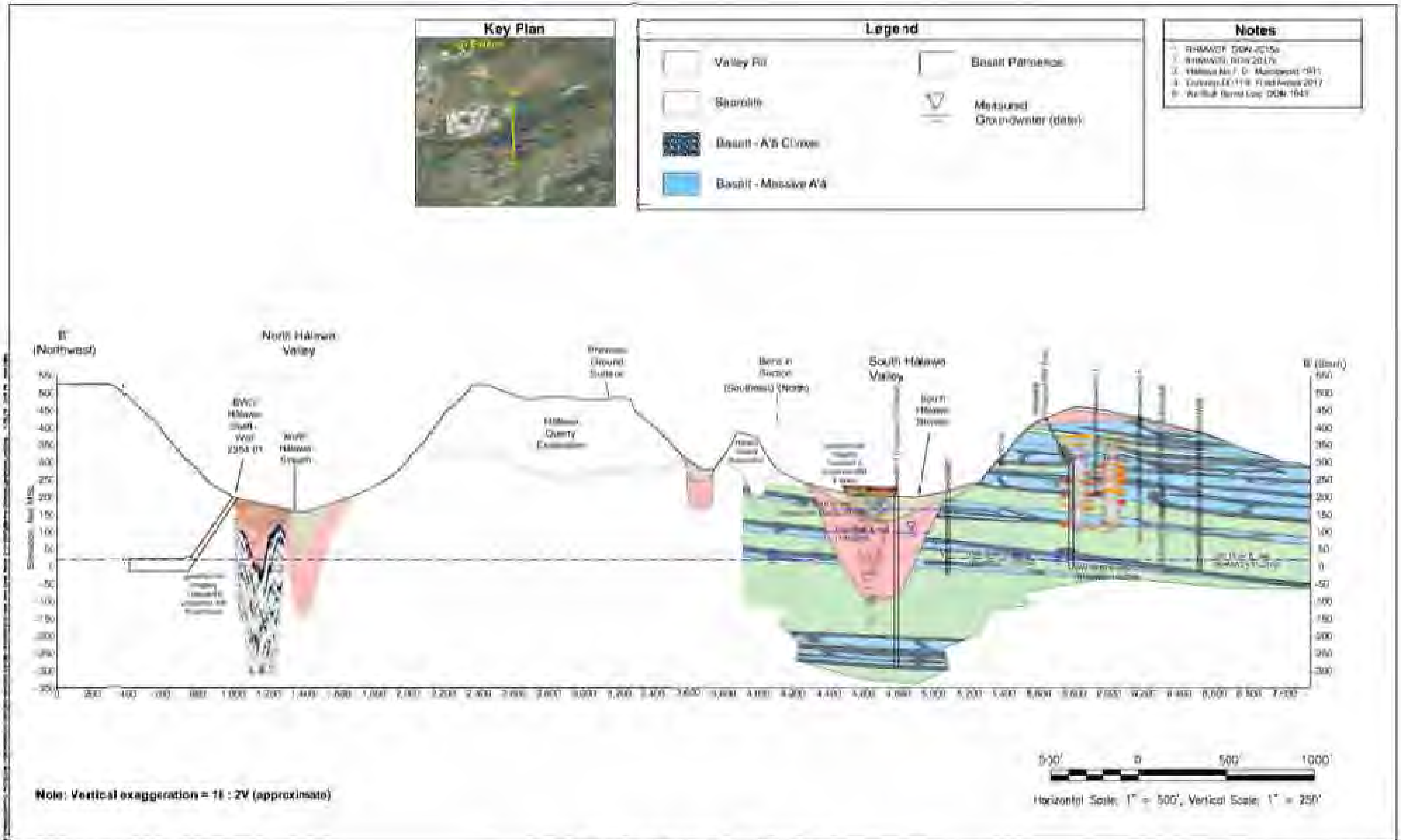


Figure E.1-1
Geologic Model Cross Section Key Plan
Conceptual Site Model Rev. 01
Investigation and Remediation of Releases and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

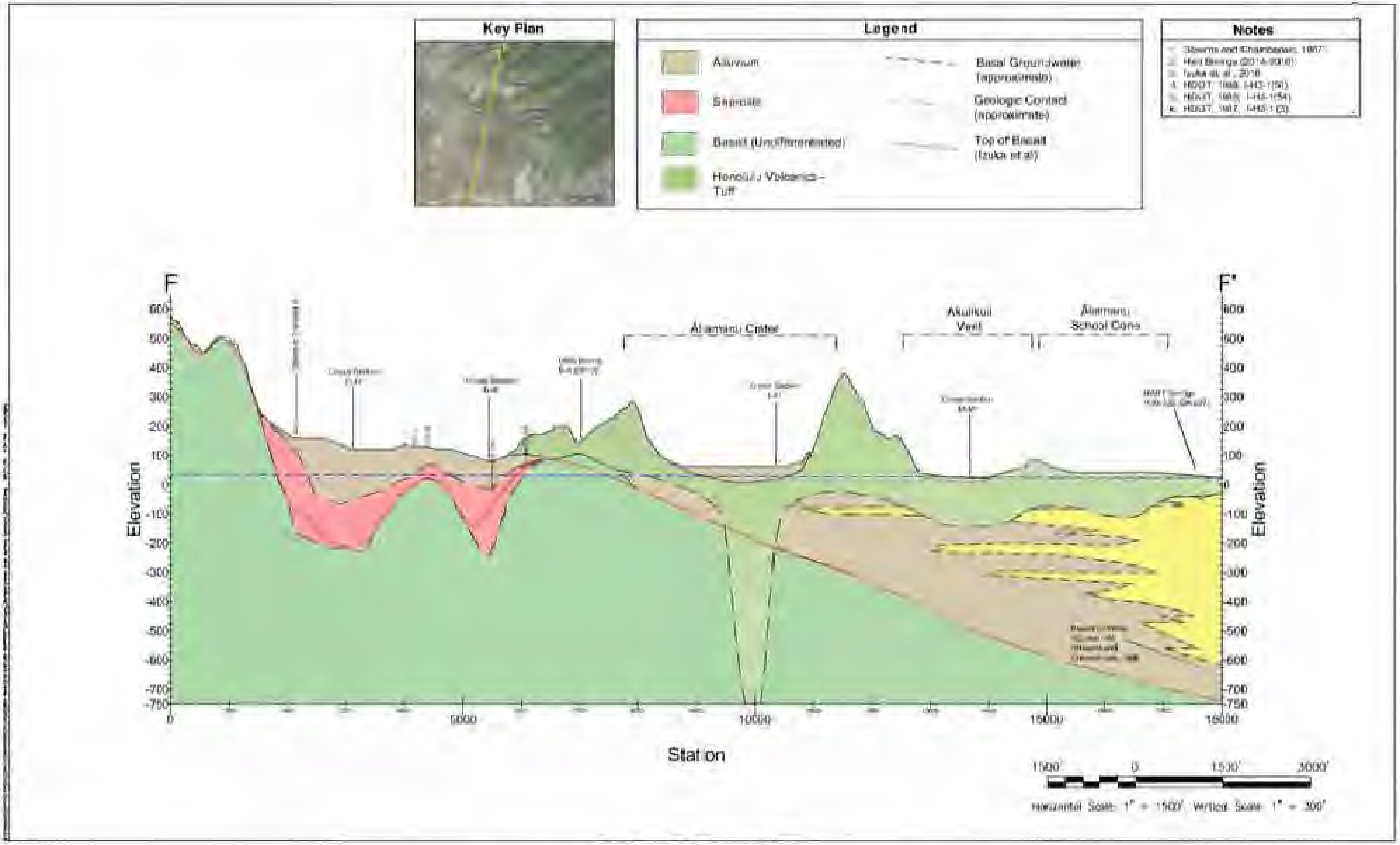

A-A' Extended
A Extend
A'
Elevation
Station
0+00
50+00
100+00
150+00
195+64
Note - Vertical exaggeration 10V/1H
LEGEND
Alluvium
Saprolite
Basalt
Basal Groundwater (approximate)
Geologic Contact (approximate)
Honolulu Volcanics - Tuff
Top of Basalt (Izuka et al)



Cross Section B-B' (View Looking East)
Conceptual Site Model Revision 01
Investigation and Remediation of Releases and Groundwater Protection and Evaluation Red Hill Bulk Fuel Storage Facility, JBPHH, O'ahu, Hawai'i

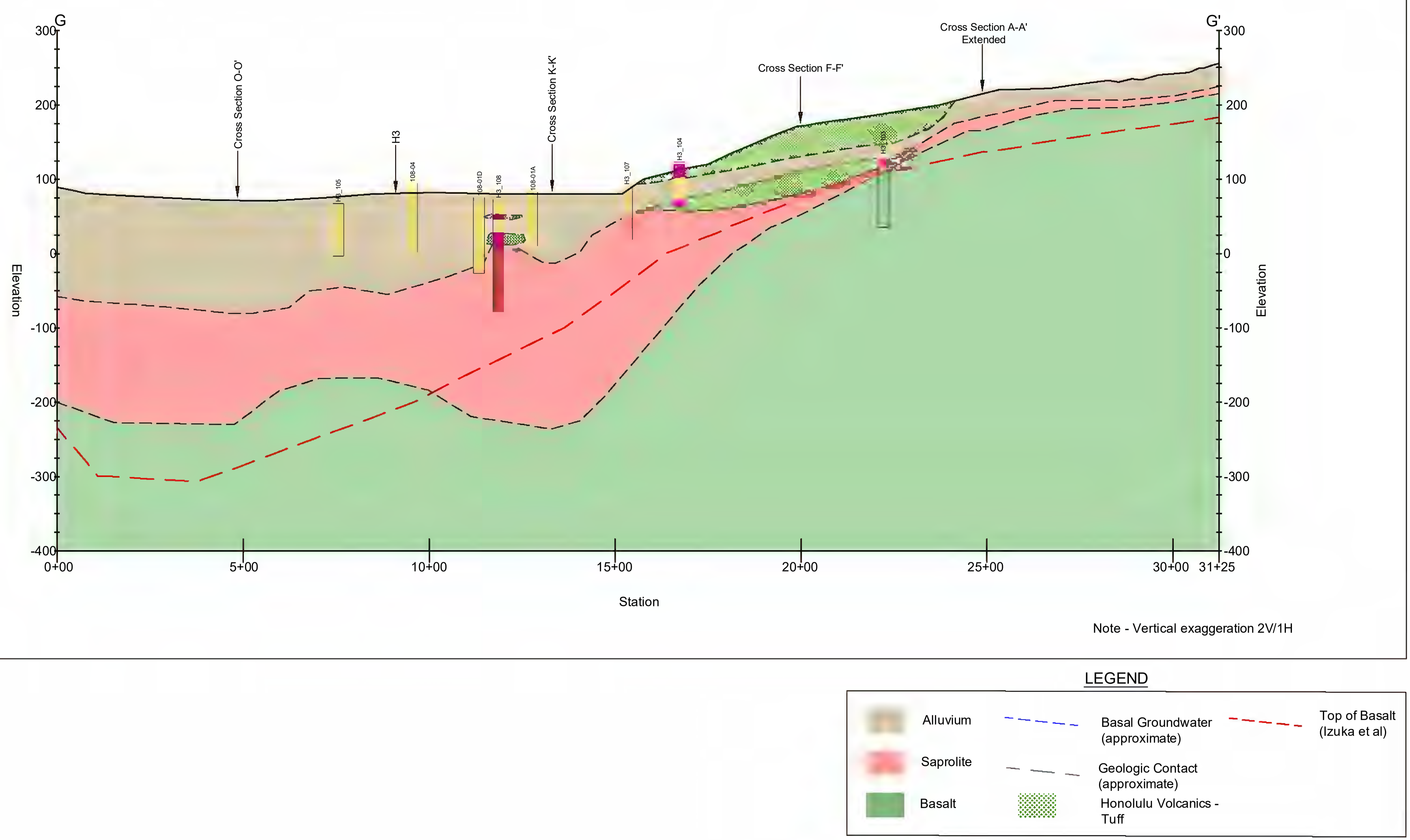


Cross Section B-B' Extended (View Looking East)
Conceptual Site Model Revision 01
Investigation and Remediation of Releases and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility, JBPHH, O'ahu, Hawai'i



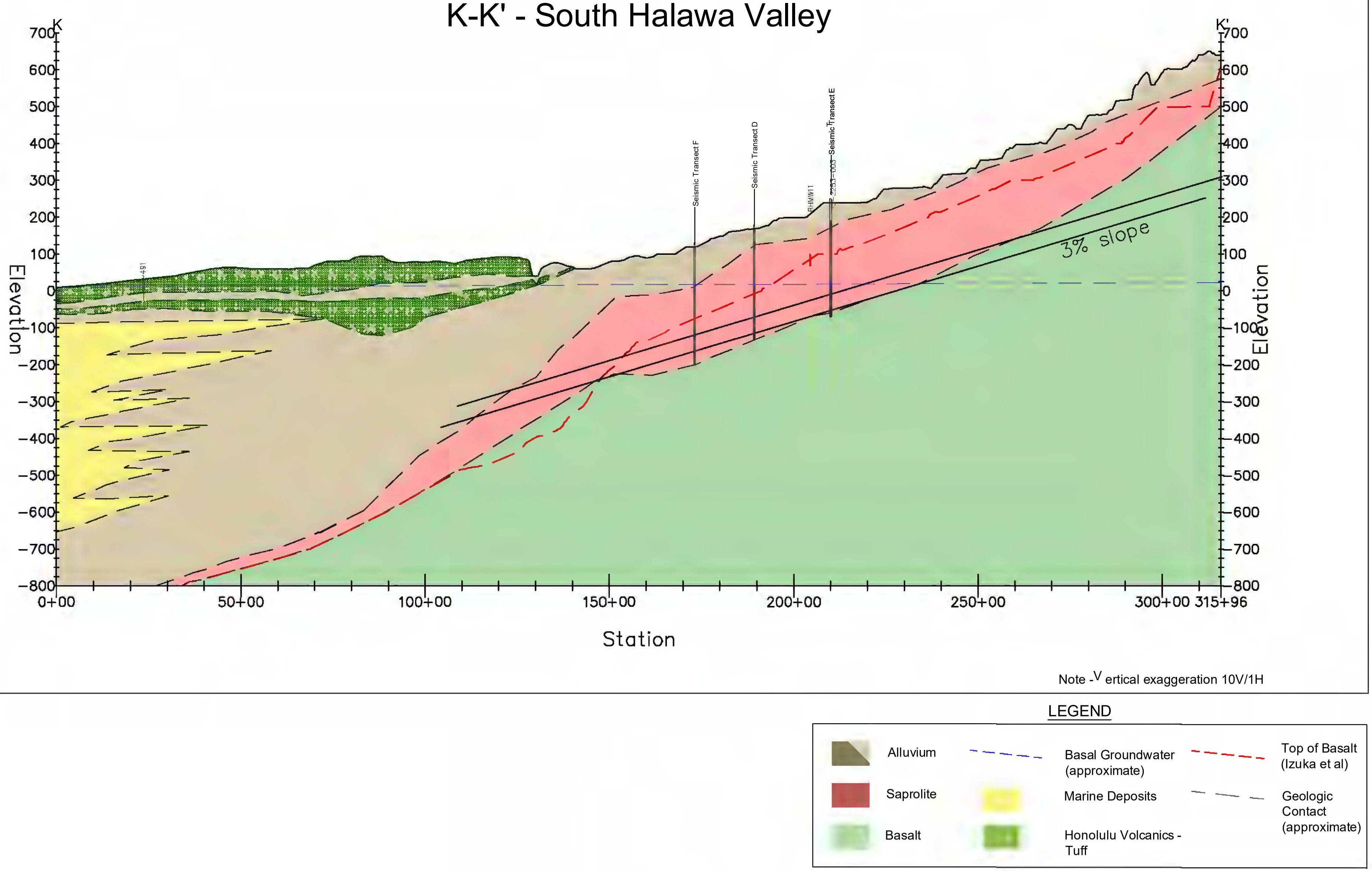
Cross Section F-F' Āliamanu Crater Section
Conceptual Site Model Revision 01
Investigation and Remediation of Releases and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility, JBPHH, O'ahu, Hawai'i

G-G' - H3 interchange



C:\Users\Mark.Higley\Documents\Autodesk\model area surface contours_180910.dwg 9/11/2018 7:39 AM Mark.Higley

K-K' - South Halawa Valley



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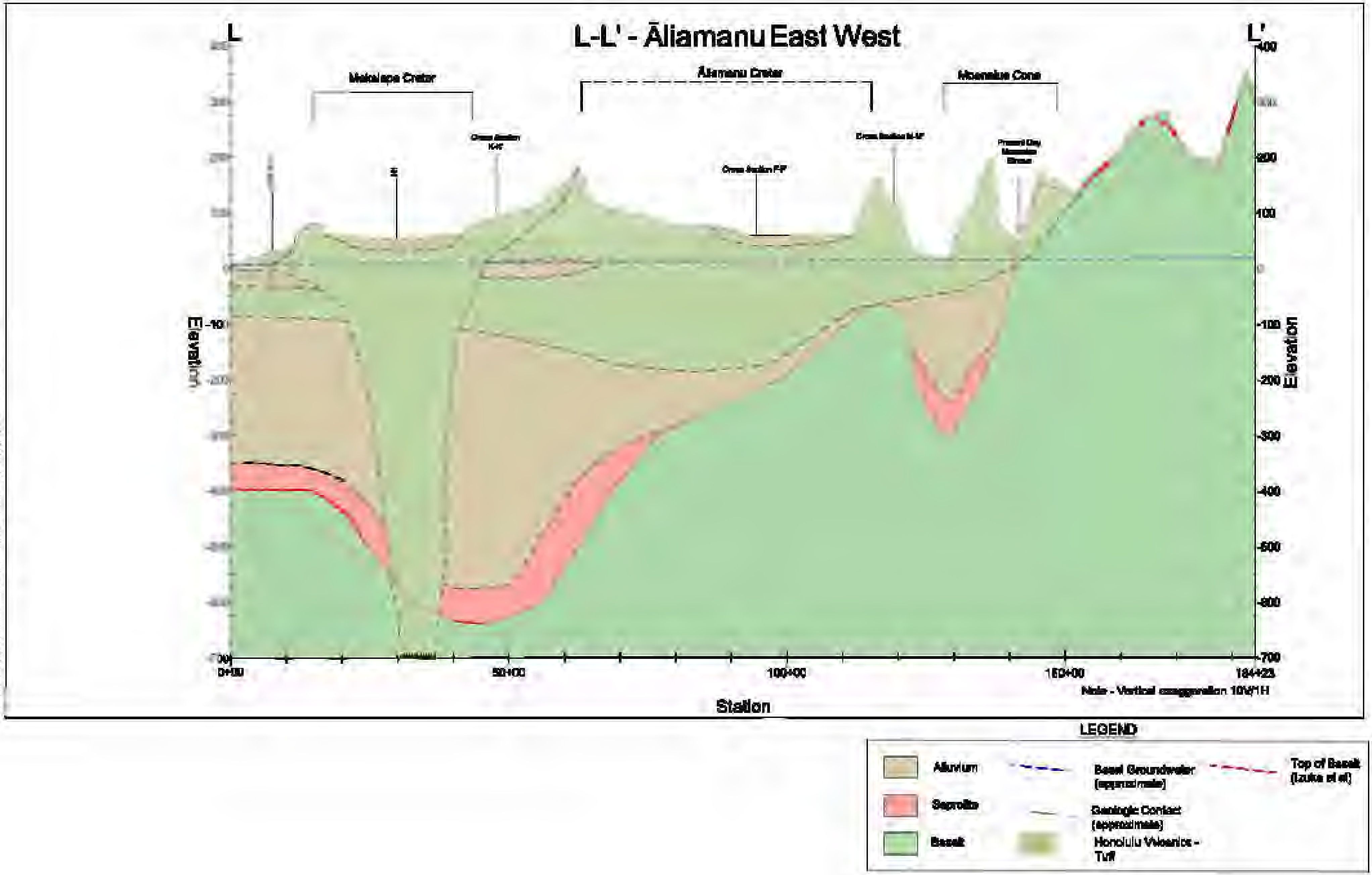
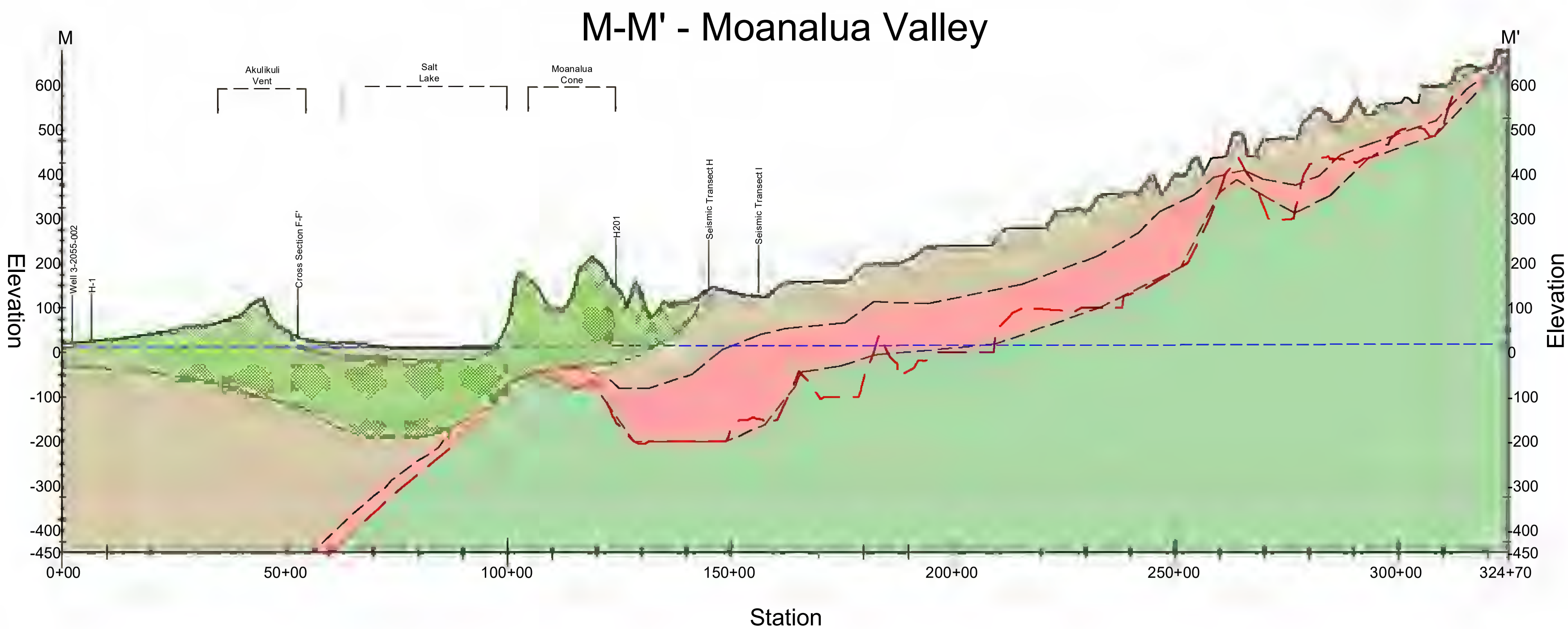


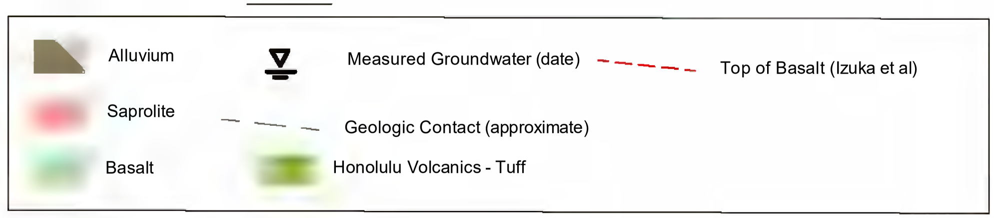
L-L' - Āliamanu East West
L
L'
Makalapa Crater
Āliamanu Crater
Moanalua Cone
Cross Section F-F'
Cross Section M-M'
Elevation
Station
0+00
50+00
100+00
150+00
184+23
Note - Vertical exaggeration 10V/1H
LEGEND
Alluvium
Saprolite
Basalt
Basal Groundwater (approximate)
Geologic Contact (approximate)
Honolulu Volcanics - Tuff
Top of Basalt (Izuka et al)

M-M' - Moanalua Valley



Note - Vertical exaggeration 10V/1H

LEGEND



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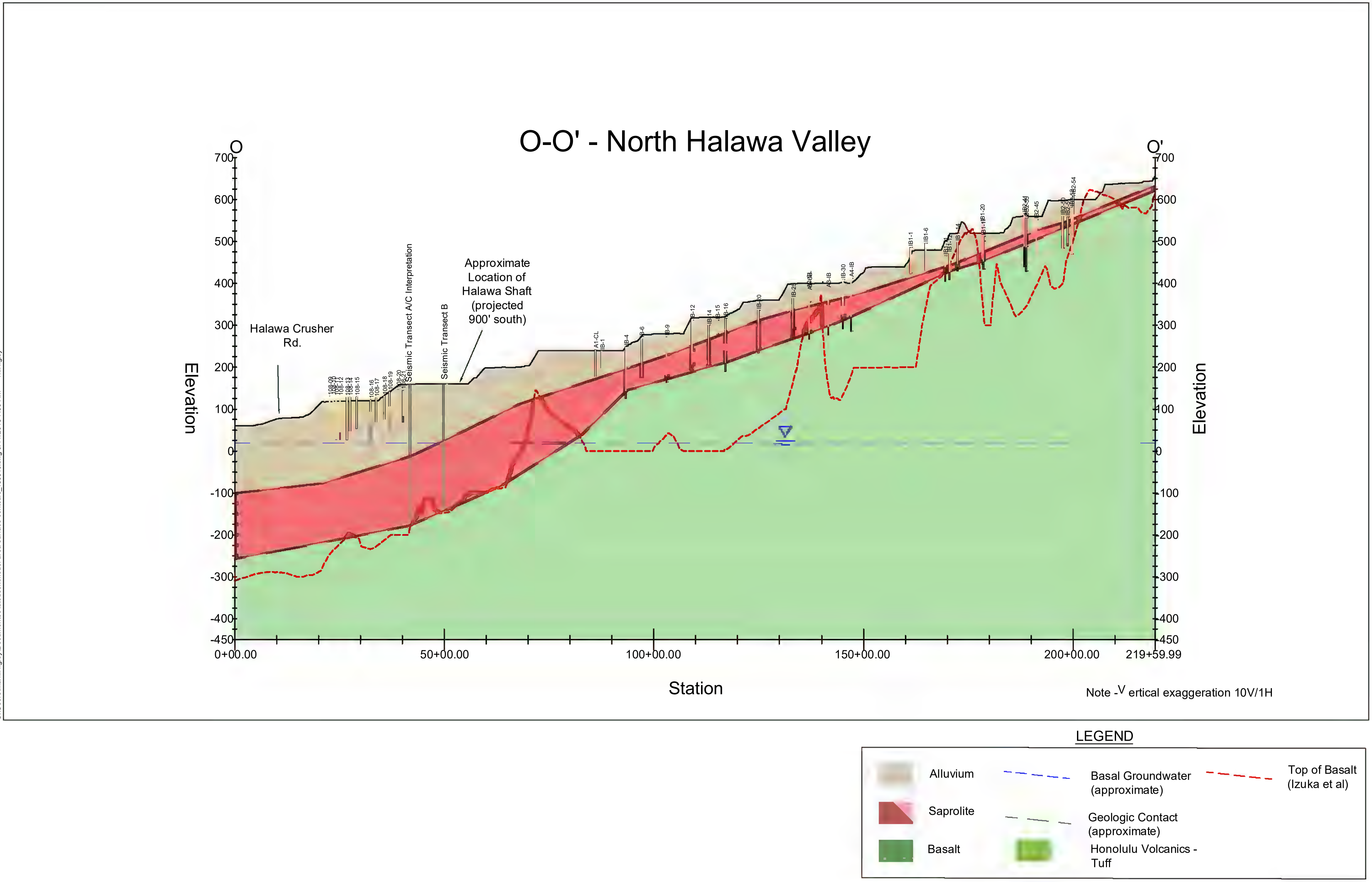

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Exhibit L

Macdonald (1941) writes: "*The pahoehoe flows are fed by lava moving through tubes in the interior of the flow, most of them only a foot or two across but a few reaching diameters of tens of feet. Sometimes the liquid lava drains away from these tubes leaving them partly or entirely empty.*" In highly weathered basalt and saprolite sequences, such as those found below valley fill deposits in South Hālawa Valley, lava tube structures, if present, would generally fail and collapse. Based on the drilling of thousands of feet through similar volcanic materials on Hawai‘i Island, the occurrence of lava tubes was described as "rare" (D. Thomas, UH Hilo and DOH, pers. comm. 2018). Lava tubes are constrained by the width of the lava flow they are contained within. With that, it is highly unlikely that there may be lava tubes from Red Hill area that would provide a conduit or pathway toward Hālawa Shaft (i.e., the unlikely geometry that would allow a lava tube somewhere near the water table under the Red Hill Facility to be oriented all the way across [under or around] the saprolite in modern day North and South Hālawa Valleys, and then extend all the way to Hālawa Shaft).

5.1.2 Geologic Cross Sections and Mapping

Geologic cross sections have been prepared from available geologic logs of rock cores and from field mapping (Figure 5-1 through Figure 5-9). Geologic logs from the Red Hill groundwater monitoring network, from Macdonald (1941), and from Stearns (1943) (Figure 5-10) were used to correlate the stratigraphy of the basalt flows at Red Hill. Barrel logs developed during construction of the tanks also depict the stratigraphy of the rock formation (Figure 5-11). These logs encompass the 150-ft-tall cylinder interval of the tanks below the base of the upper dome and above the top of the lower dome, i.e., the middle 150 ft of the 250-ft-tall tanks.

In general, the upper stratigraphic section in Red Hill is composed predominantly of a‘ā flows with some interbedded pāhoehoe flows (Figure 5-2). Field mapping also indicated a predominance of a‘ā flows in exposed cliff-forming outcrops that correlate with the upper stratigraphic section. The lower section is composed primarily of thinner bedded pāhoehoe flows (see Photo 5-1). Correlation of boring logs at Red Hill indicates the presence of one or more intervals of a‘ā flows (composed of several flows with a‘ā clinker layers) within the pāhoehoe section that are approximately 30–60 ft thick.

A 1943 Navy as-built drawing, "Plan of Lava Tubes Cut by Tank 18," maps lava tubes connecting from Tank 20 to Tank 18 that were compass-surveyed (Figure 5-12). The survey shows these lava tubes are oriented downgradient in a south-southwest direction ranging from 187 to 241 degrees. These bounding orientations have a middle orientation of 214 degrees. Kriging correlation of lava tube and loose rock from barrel log data also presents similar orientations to the south-southwest (Figure 5-13).

Geologic mapping indicates the predominant dip direction (i.e., dip azimuth) is toward the south-southwest in the Red Hill area. Regionally, flows commonly dip 3–10 degrees from horizontal (i.e., dip magnitude) in the direction away from the eruptive axis of the volcano (Hunt Jr. 1996), and the dip direction is generally to the southwest. The average dip directions from geologic mapping in the Red Hill area are:

- Hālawa side of Red Hill: 194 degrees
- Active pit at Hālawa Quarry: 194 degrees
- Moanalua Water Tunnel: 206 degrees
- Moanalua side of Red Hill and Moanalua Golf Course: 209 degrees
- Moanalua side of Red Hill from Tripler Ridge and Moanalua Valley: 186 degrees

Geostatistical evaluation of dip azimuth and magnitude data collected during geologic mapping included generation of rose diagrams and Gaussian mixing models. To derive true dip, data included discrete field dip azimuth and dip magnitude (true dip) measurements as well as common plane-derived measurements using two apparent dips measured in the field (see Appendix C). Discrete measurements were collected from the Hālawa side of Red Hill, Moanalua Water Tunnel, Moanalua side of Red Hill, and Moanalua Golf Course (Figure 5-14).

Apparent dip data were collected in the active pit area at Hālawa Quarry and from the Moanalua side of Red Hill from Tripler Ridge and Moanalua Valley. Additional apparent dip azimuth and magnitude data were derived from clinker correlation, kriging correlation, and a Lower Beds correlation feature between Tanks 9–16 developed from models of three-dimensional (3D) barrel log data. Additionally, one dip azimuth and dip magnitude value was provided by DOH.

Weighting was applied to the mapping data as follows:

- All discrete field measurements (Hālawa side, Moanalua side, and Golf Course, Moanalua Tunnel) were weighted 1 point each (39 measurements).
- Common Plane measurements in Hālawa Quarry were weighted 10 points each (6 measurements).
- Common Plane measurements of Moanalua side of Red Hill from Tripler Ridge and Moanalua Valley were weighted 3 points each (9 measurements).
- Common Plane measurement of barrel log clinker correlation was weighted 5 points (1 measurement).
- Common Plane measurement of barrel log kriging correlation was weighted 5 points (1 measurement).
- Common Plane measurement of barrel log Lower Beds Tanks 9–16 was weighted 3 points (1 measurement).
- DOH dip azimuth and dip magnitude was weighted 10 points (1 measurement).

All data using weighting factors yielded an average dip azimuth of 197.4 degrees and an average dip magnitude of 6.5 degrees. With the objective to derive a range of dip azimuth and magnitude data and a best-estimate value, further review of that data set shows multiple dip-azimuth populations. Rose diagram plots of these data show what appear to be approximately 217- and 183-degree dip azimuths—an indication of a bi-modal distribution (Figure 5-14).

These azimuths have a slightly farther spread than what Gaussian distributions indicate (Section 5.1.3).

5.1.3 Gaussian Mixture Model

At least two subpopulations of dip azimuth were apparent in histograms of field measurements, and those two subpopulations appeared to overlap, preventing the separation of readings so that the mean dip azimuth of each subpopulation could be computed. Weighted pairs of dip azimuth and dip magnitude were analyzed using two-dimensional Gaussian Mixture Modeling (GMM), which estimates a separate mean and standard deviation for each subpopulation, in addition to evaluating the number of subpopulations present in the data. A common statistical analysis package was used to complete the analysis of the dip measurements (scikit-learn, implemented in Python at https://scikit-learn.org/stable/modules/mixture.html).

An evaluation of the GMM results indicated that the simplest combination of Gaussian models that fit the dip field measurements had three components, two of which were visually apparent when examining histograms of site data (Figure 5-16). The three components composing the GMM were (mean +/- standard deviation):

- Dip azimuth of 184.6 +/- 7.1 degrees, with a dip magnitude of 5.9 +/- 1.4 degrees
- Dip azimuth of 213.6 +/- 4.8 degrees, with a dip magnitude of 2.9 +/- 0.5 degrees
- Dip azimuth of 200.5 +/- 29.7 degrees, with a dip magnitude of 11.2 +/- 5.2 degrees

These components are illustrated on a polar plot of the GMM data analysis, Figure 5-17. The probability that dip azimuth will take a particular value is shown as unitless (see "p(Dip Azimuth)" on Figure 5-17); integrating under the blue curve will sum to a total probability of 1.0. The first two contributors to the GMM showed tall, narrow peaks with relatively small standard deviations, and the third component was a minor contributor with a broad peak (i.e., a comparatively large standard deviation) (Figure 5-16).

The bi-modal separation between the two major components (184.6 and 213.6 degrees) of the GMM is 29.0 degrees (see Figure 5-11 and Figure 5-17).

5.1.4 Assessment of Potential Preferential Pathways Related to Historical Lava Flow

Random walk modeling was performed using a recently developed probabilistic model, MrLavaLoba (Vitturi and Tarquini 2018), to evaluate the potential historical lava flow paths passing through the vicinity of the Red Hill tank farm. The purpose was to evaluate the likelihood of a flow path present from the tank farm area to Red Hill Shaft. Results are presented in Appendix D.

The model parameters used were based on Vitturi and Tarquini (2018) for simulating a Kilauea volcano eruption. The downslope was represented by a digital elevation model generated based on a dip orientation with an azimuth of 213.6 degrees and a dip angle of 2.9 degrees. A fractal dimension range between 1.13 and 1.23 was adopted (Bruno et al. 1992) to simulate pāhoehoe lava flow. The lava flow pathlines were simulated from a location upgradient from the tank farm.

A total of 10,000 Monte Carlo simulations of random lava flow pathlines were generated. Of these 10,000 simulated pathlines, 3,635 pathlines passed through the tank farm area with fractal dimensions in the range of 1.13–1.23. None of the pathlines through the tank farm area passed through the Red Hill Shaft area. Even if a pathline passes through the tank farm area and the Red Hill Shaft area, it might not pass through the elevation intervals of concern. In addition, a lava flow path does not imply a continuous channel that forms a preferential pathway for contaminant transport. Therefore, the results indicate that a preferential pathway occurring between the tank farm area and the Red Hill Shaft area in relation to historical lava flow is unlikely.

5.1.5 Overall Occurrence of Rock Types

The presence of nearly horizontal to gently dipping lava flows with layers (i.e., beds) of alternately greater and lesser resistance to erosion at the site were observed during rock coring for installation of Red Hill groundwater monitoring wells and site reconnaissance activities. No dikes were apparent in recovered cores or in observed outcrops at Red Hill.

Erosion of the less-resistant beds, such as a'ā clinker, has resulted in undercutting of the more resistant massive a'ā and pāhoehoe flows (Photo 5-2). Thinner bedded pāhoehoe flows are less resistant than

Appendix C:
Strike and Dip Data

Gaussian Mixed Model Evaluation Coordinates

	Strike	Dip Azimuth	Dip	Location	Notes	Formatted for Python	Latitude	Longitude
1	280	190	12	Halawa 1 pt		[190, 12],	21.375420	-157.890790
2	290	200	13	Halawa 1 pt		[200, 13],	21.374760	-157.892380
3	280	190	10	Halawa 1 pt		[190, 10],	21.375350	-157.891100
4	280	190	12	Halawa 1 pt		[190, 12],	21.375190	-157.891270
5	280	190	10	Halawa 1 pt		[190, 10],	21.374790	-157.892330
6	280	190	10	Halawa 1 pt		[190, 10],	21.370678	-157.900642
7	300	210	12	Halawa 1 pt		[210, 12],	21.370523	-157.901076
8	270	180	15	Halawa 1 pt		[180, 15],	21.373212	-157.895076
9	290	200	12	Halawa 1 pt		[200, 12],	21.373150	-157.896178
10	296	206	10	Halawa 1 pt		[206, 10],	21.373070	-157.896440
11	240	150	4	Halawa 1 pt		[150, 4],	21.373243	-157.896563
12	285	195	10	Halawa 1 pt		[195, 10],	21.373244	-157.896820
13	290	200	15	Halawa 1 pt		[200, 15],	21.373331	-157.896207
14	280	190	12	Halawa 1 pt		[190, 12],	21.373320	-157.896238
15	295	205	20	Halawa 1 pt		[205, 20],	21.372797	-157.897625
16	295	205	12	Halawa 1 pt		[205, 12],	21.372668	-157.897876
17	285	195	14	Halawa 1 pt		[195, 14],	21.372681	-157.898084
18	300	210	15	Halawa 1 pt		[210, 15],	21.371783	-157.899378
19	290	200	15	Halawa 1 pt		[200, 15],	21.371273	-157.901096
20	270	180	12	Halawa 1 pt		[180, 12],	21.370979	-157.902171
21	20	290	2	Moanalua 1 pt		[290, 2],	21.368495	-157.895831
22	300	210	10	Moanalua 1 pt		[210, 10],	21.365717	-157.895783
23	300	210	10	Moanalua 1 pt		[210, 10],	21.365783	-157.898400
25	320	230	10	Moanalua 1 pt		[230, 10],	21.365933	-157.898283
26	325	235	12	Moanalua 1 pt		[235, 12],	21.365933	-157.898283
27	290	200	5	Moanalua 1 pt		[200, 5],	21.368317	-157.896033
28	260	170	12	Moanalua 1 pt		[170, 12],	21.368317	-157.896033
29	280	190	12	Moanalua 1 pt		[190, 12],	21.368317	-157.896033
30	270	180	15	Moanalua 1 pt		[180, 15],	21.368300	-157.896133
31	265	175	8	Moanalua 1 pt		[175, 8],	21.368300	-157.896133
32	232	142	5	Moanalua Tunnel 1 pt		[142, 5],	04+45[1]	
33	265	175	8	Moanalua Tunnel 1 pt		[175, 8],	06+00[1]	
34	270	180	15	Moanalua Tunnel 1 pt		[180, 15],	10+25[1]	
35	390	300	30	Moanalua Tunnel 1 pt		[300, 30],	23+85[1]	
36	330	240	4.5	Moanalua Tunnel 1 pt		[240, 4.5],	25+65[1]	
45	310	220	4.5	Moanalua Tunnel 1 pt		[220, 4.5],	26+45[1]	
47	325	235	5.5	Moanalua Tunnel 1 pt		[235, 5.5],	28+38[1]	
48	275	185	13	Moanalua Tunnel 1 pt		[185, 13],	21.370741	-157.905226
49	272	182	20	Moanalua Tunnel 1 pt		[182, 20],	21.370741	-157.905226
50	307	217	3.085	Barrel log - Clinker Evaluation 2017 Weighted 5 pts		[217, 3.085],	n/a	n/a
51	307	217	3.085	Barrel log - Clinker Evaluation 2017 Weighted 5 pts		[217, 3.085],	n/a	n/a
52	307	217	3.085	Barrel log - Clinker Evaluation 2017 Weighted 5 pts		[217, 3.085],	n/a	n/a
53	307	217	3.085	Barrel log - Clinker Evaluation 2017 Weighted 5 pts		[217, 3.085],	n/a	n/a
54	307	217	3.085	Barrel log - Clinker Evaluation 2017 Weighted 5 pts		[217, 3.085],	n/a	n/a
55	309	219	2.732	Barrel log - Kriging Correlation 2018 Weighted 5 pts		[219, 2.732],	n/a	n/a
56	309	219	2.732	Barrel log - Kriging Correlation 2018 Weighted 5 pts		[219, 2.732],	n/a	n/a
57	309	219	2.732	Barrel log - Kriging Correlation 2018 Weighted 5 pts		[219, 2.732],	n/a	n/a
58	309	219	2.732	Barrel log - Kriging Correlation 2018 Weighted 5 pts		[219, 2.732],	n/a	n/a
59	309	219	2.732	Barrel log - Kriging Correlation 2018 Weighted 5 pts		[219, 2.732],	n/a	n/a

Gaussian Mixed Model Evaluation Coordinates (cont.)

	Strike	Dip Azimuth	Dip	Location	Notes	Formatted for Python	Latitude	Longitude
60	299.311	209.311	2.779	Barrel log - Kriging Correlation T9-16 2018 Weighted 3 pts		[209.311, 2.779],	n/a	n/a
61	299.311	209.311	2.779	Barrel log - Kriging Correlation T9-16 2018 Weighted 3 pts		[209.311, 2.779],	n/a	n/a
62	299.311	209.311	2.779	Barrel log - Kriging Correlation T9-16 2018 Weighted 3 pts		[209.311, 2.779],	n/a	n/a
63	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
64	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
65	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
66	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
67	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
68	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
69	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
70	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
71	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
72	307	217	2.732	DOH Weighted 10 pts		[217, 2.732],	n/a	n/a
73	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
74	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
75	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
76	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
77	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
78	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
79	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
80	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
81	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
82	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
83	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
84	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
85	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
86	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
87	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
88	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
89	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
90	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
91	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
92	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
93	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
94	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
95	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
96	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
97	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
98	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
99	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
100	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
101	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
102	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
103	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
104	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
105	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
106	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
107	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
108	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
109	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
110	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a

Gaussian Mixed Model Evaluation Coordinates (cont.)

	Strike	Dip Azimuth	Dip	Location	Notes	Formatted for Python	Latitude	Longitude
111	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
112	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
113	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
114	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
115	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
116	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
117	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
118	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
119	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
120	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
121	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
122	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
123	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
124	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
125	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
126	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
127	279.426	189.426	6	Quarry 10 pts		[189.426, 6],	n/a	n/a
128	284.347	194.347	6.017	Quarry 10 pts		[194.347, 6.017],	n/a	n/a
129	263.585	173.585	6.253	Quarry 10 pts		[173.585, 6.253],	n/a	n/a
130	274.772	184.772	6.025	Quarry 10 pts		[184.772, 6.025],	n/a	n/a
131	305.969	215.969	2.287	Quarry 10 pts		[215.969, 2.287],	n/a	n/a
132	296.366	206.366	3.838	Quarry 10 pts		[206.366, 3.838],	n/a	n/a
133	268	178	3.079	Moanalua Side, Weighted 3 pts		[178, 3.079],	n/a	n/a
134	297.5	207.5	3.129	Moanalua Side, Weighted 3 pts		[207.5, 3.129],	n/a	n/a
135	273	183	8.208	Moanalua Side, Weighted 3 pts		[183, 8.208],	n/a	n/a
136	273	183	7.356	Moanalua Side, Weighted 3 pts		[183, 7.356],	n/a	n/a
137	273	183	4.437	Moanalua Side, Weighted 3 pts		[183, 4.437],	n/a	n/a
138	272.4	182.4	4.27	Moanalua Side, Weighted 3 pts		[182.4, 4.27],	n/a	n/a
139	271.7	181.7	4.051	Moanalua Side, Weighted 3 pts		[181.7, 4.051],	n/a	n/a
140	267.1	177.1	3.09	Moanalua Side, Weighted 3 pts		[177.1, 3.09],	n/a	n/a
141	284	194	8.004	Moanalua Side, Weighted 3 pts		[194, 8.004],	n/a	n/a
142	268	178	3.079	Moanalua Side, Weighted 3 pts		[178, 3.079],	n/a	n/a
143	297.5	207.5	3.129	Moanalua Side, Weighted 3 pts		[207.5, 3.129],	n/a	n/a
144	273	183	8.208	Moanalua Side, Weighted 3 pts		[183, 8.208],	n/a	n/a
145	273	183	7.356	Moanalua Side, Weighted 3 pts		[183, 7.356],	n/a	n/a
146	273	183	4.437	Moanalua Side, Weighted 3 pts		[183, 4.437],	n/a	n/a
147	272.4	182.4	4.27	Moanalua Side, Weighted 3 pts		[182.4, 4.27],	n/a	n/a
148	271.7	181.7	4.051	Moanalua Side, Weighted 3 pts		[181.7, 4.051],	n/a	n/a
149	267.1	177.1	3.09	Moanalua Side, Weighted 3 pts		[177.1, 3.09],	n/a	n/a
150	284	194	8.004	Moanalua Side, Weighted 3 pts		[194, 8.004],	n/a	n/a
151	268	178	3.079	Moanalua Side, Weighted 3 pts		[178, 3.079],	n/a	n/a
152	297.5	207.5	3.129	Moanalua Side, Weighted 3 pts		[207.5, 3.129],	n/a	n/a
153	273	183	8.208	Moanalua Side, Weighted 3 pts		[183, 8.208],	n/a	n/a
154	273	183	7.356	Moanalua Side, Weighted 3 pts		[183, 7.356],	n/a	n/a
155	273	183	4.437	Moanalua Side, Weighted 3 pts		[183, 4.437],	n/a	n/a
156	272.4	182.4	4.27	Moanalua Side, Weighted 3 pts		[182.4, 4.27],	n/a	n/a
157	271.7	181.7	4.051	Moanalua Side, Weighted 3 pts		[181.7, 4.051],	n/a	n/a
158	267.1	177.1	3.09	Moanalua Side, Weighted 3 pts		[177.1, 3.09],	n/a	n/a
159	284	194	8.004	Moanalua Side, Weighted 3 pts		[194, 8.004],	n/a	n/a

[1] station along tunnel alignment

n/a dip azimuth and magnitude are derived from common plane calculations using apparent dip measurements taken at multiple locations

Halawa Quarry Active Pit Mapping - Outcrops used for Common Plane Analysis

	Start		End	
Outcrop	Lat	Long	Lat	Long
1	21.376207	-157.897226	21.376114	-157.897448
2	21.376114	-157.897448	21.375881	-157.897504
3	21.375796	-157.897416	21.375848	-157.896856

*Coordinates from google earth

Halawa Quarry - Active Quarry Pit

Common Plane - Azimuth & Plunge Pairs	Dip Direction	True Dip	Outcrop
190°/6° and 265°/1.5°	189.426	6	2,3
190°/6° and 265°/2°	194.347	6.017	2,3
190°/6° and 245°/2°	173.585	6.253	2,1
190°/6° and 245°/3°	184.772	6.025	2,1
245°/2° and 265°/1.5°	215.969	2.287	1,3
245°/3° and 265°/2°	206.366	3.838	1,3
True Average:	**194.0775**	**5.07**	

Moanalua side of Red Hill from Tripler Ridge and in Moanalua Valley Mapping - Outcrops used for Common Plane Analysis

	Start		End	
Outcrop	Lat	Long	Lat	Long
A	21.369935	-157.893144	21.369962	-157.892368
B	21.375157	-157.883559	21.375654	-157.882614
C	21.37105	-157.889755	21.372091	-157.888742
D	21.377935	-157.875661	21.378232	-157.874895

*Coordinates from google earth

Data collected looking at Moanalua side of Red Hill from Tripler Ridge and in Moanalua Valley

	View Direction	Plane Direction (perpendicular to View Direction, i.e., azimuth)	App Dip	Outcrop
3 from Tripler	3	93	0	A
4 from Tripler	4	94	0	A
5 from Moanalua	5	95	0	B
16 from Tripler	16	106	1	B
255 from Moanalua	255	165	7	C
286 from Moanalua	286	196	8	B
281 from Tripler	281	191	3	C
293 from Tripler	293	203	4	C
314 from Tripler	314	224	3	C
358 from Tripler	358	268	0	D

Common Plane - Azimuth & Plunge Pairs	**Dip Direction**	**True Dip**	
191°/3 and 268°/0°	178	3.079	C, D
191°/3° and 224/3°	207.5	3.129	C, C
93°/0° and 196°/8°	183	8.208	A, B
93°/0° and 165°/7°	183	7.356	A, C
93°/0° and 106°/1°	183	4.437	A, B
106°/1° and 203°/4°	182.4	4.27	B, C
106°/1° and 224°/3°	181.7	4.051	B, C
106°/1° and 191°/3°	177.1	3.09	B, C
165°/7° and 196°/8°	194	8.004	C, B
True Average:	**185.5222**	**5.0693**	

Exhibit M

CONTENTS

APPENDIXES (included on CD-ROM)

FIGURES (compiled at end of report)

■ FOIA §(b)(3), Critical Infrastructure

TABLES

apparent gradients in shallow Facility basalt wells all point uphill toward RHMW04 on Figure 3.1-5a. On Figure 3.1-5b, these apparent gradients all point away from RHMW01 in all directions as though that was an area of high recharge. Therefore, the Facility well water level differences should not be overinterpreted, due to the very small difference values that are within the error limits of water level measurements at any one well.

3.2 PUMPING

Pumping information for the domain was obtained largely during the interim modeling study (DON 2018, Appendix A). That same pumping information is used for the current model update except for Red Hill Shaft and Hālawa Shaft, which use specific calibration-related pumping rates associated with the 2017–2018 synoptic study. Modeled pumping well/shaft locations are provided on Figure 3.2-1. Pumping rates used in the model are shown in Table 3-1. The different stress periods for Red Hill Shaft and Hālawa Shaft pumping are discussed further in Section 4 under model development and calibration.

Table 3-1: Modeled Pumping Rates

Well ID	Well Name	Screen Top (ft msl)	Screen Bottom (ft msl)	2017 Q (mgd)
2052-08	Kalihi Shaft	52	-5	7.70
2053-11	Fort Shafter	-154	-309	[redacted]
2057-04	Hickam Air Force Base	-18	-170	0
2153-02	Moanalua	-59	-269	0.02
2153-05	Moanalua Deep	-30	-1218	0
2153-07	TAMC1	-22	-272	[redacted]
2153-10	Moanalua 1	-114	-264	1.28
2153-11	Moanalua 2	-115	-265	0
2153-12	Moanalua 3	-150	-300	0
2154-01	Honolulu International Country Club	-89	-280	0.40
2255-32	‘Aiea Hālawa Shaft	107	16	[redacted]
2255-37	Hālawa 2	-29	-78	0.88
2255-38	Hālawa 3	-37	-82	0
2255-39	Hālawa 1	-31	-135	0
2355-03	‘Aiea Gulch 1	16	-38	0.77
2355-05	‘Aiea Gulch 2	18	-40	0
2355-06	‘Aiea 1	-32	-102	0.97
2355-07	‘Aiea 2	-30	-100	0
2355-09	Kalauao P1	-61	-253	5.21
2355-10	Kalauao P4	-63	-254	0
2355-11	Kalauao P2	-60	-254	0
2355-12	Kalauao P3	-61	-254	0
2355-13	Kalauao P5	-68	-254	0
2355-14	Kalauao P6	-70	-253	0
2355-16	WG Minami 2007	-102	-202	0
2356-49	Waimalu I-1	-27	-225	0
2356-50	Waimalu I-2	-25	-225	0
2356-54	Pearl CC Golf	-21	-178	0.23

■ FOIA §(b)(3), Critical Infrastructure

Well ID	Well Name	Screen Top (ft msl)	Screen Bottom (ft msl)	2017 Q (mgd)
2356-55	Kaonohi I-2	-37	-291	0.78
2356-56	Kaonohi I-1	-44	-294	0
2356-58	Ka'amilo 1	-43	-192	0
2356-59	Ka'amilo 2	-42	-192	0
2356-60	Waimalu II-1	-77	-217	0
2356-61	Kaonohi II-1	-78	-218	0
2356-62	Kaonohi II-2	-83	-223	0
2356-63	Waimalu II-2	-179	-204	0
2356-64	Waimalu II-3	-143	-220	0
2356-65	Kaonohi II-3	-83	-223	0
2356-70	Lau Farm	40	-250	0.05
2455-02	Waimalu	-12	-78	0
2455-03	Waimalu	-80	-120	0
Red Hill Shaft SP1	Red Hill Shaft	9	3	[redacted]
Hālawa Shaft SP1 & 2	Hālawa Shaft	10	0	6.57
Red Hill Shaft SP2, 3 & 4	Red Hill Shaft	9	3	0
Hālawa Shaft SP3	Hālawa Shaft	10	0	6.33
Hālawa Shaft SP4	Hālawa Shaft	10	0	0

ID identification
Q pumping rate
SP stress period

3.3 DRAWDOWN AND PUMPING IN HĀLAWA SHAFT AND RED HILL SHAFT

Pumping and water level data were available for the 2017–2018 synoptic study. Synoptic impacts were also examined with then-available data for the interim model. Water level impacts within the pumping shaft provide a good estimate of the hydraulic conductivity surrounding the pumping location, and therefore the impacts were evaluated at Hālawa Shaft and Red Hill Shaft for their respective pumping rates.

A linear relationship between drawdown and pumping at Hālawa Shaft was estimated during the interim model to be 4.4 ft of drawdown for 10 mgd of pumping. The 2017–2018 synoptic study data indicated 3.8 ft of drawdown for every 10 mgd of pumping.

The relationship between drawdown and pumping at Red Hill Shaft was estimated during the interim model to be 1.5–3.5 ft of drawdown for [redacted] mgd of pumping. The 2017–2018 synoptic study data indicated 2.5 ft of drawdown for every [redacted] mgd of pumping. Variability was larger than at Hālawa Shaft, and therefore the water level data at Red Hill Shaft for specific pumping rates may not be as reliable.

Higher hydraulic conductivity values result in a smaller drawdown with a larger radius of influence than lower hydraulic conductivity materials. In that regard, pumping at Hālawa Shaft induces a greater drawdown than pumping at Red Hill Shaft; therefore, the hydraulic conductivity surrounding Red Hill Shaft is generally larger than that surrounding Hālawa Shaft. This is significant in calibrating and evaluating models with respect to each of these potential receptors, and therefore helps to assess the quality of a calibration in terms of the hydraulic connection of the Facility to Hālawa Shaft and Red Hill Shaft.

Table 5-2: Model Material Parameters

					51a	51b	51c	51d	51e	52	53	54	55	56	57	58	59
			Minimum	Maximum	Homogenous Basalt: Limit Horizontal Anisotropy	Homogenous Basalt: 10:1 Anisotropy	Homogeneous Basalt: Zoned Along Ridges	Homogeneous Basalt: Calibrate on Anisotropy	Homogeneous Basalt: Zoned Along Ridges and Within Valleys	Alternate Saprolite	Heterogeneous Basalt	Heterogeneous Basalt	Conceptual Clinker Zone	Structural Alterations to Tuff Cones	Recharge Uncertainty	Coastal Marine Discharge Variability	Lateral Inflow from SE
Geologic Material	Unit	Layer(s)	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
Caprock Kh (marine)	ft/day	1	2.00	33,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	2,500	5,000	5,000	5,000
Caprock Kv (marine)	ft/day	1	2.00	33,000	9.45	11.87	10.00	11.87	10.00	9.45	10.00	10.00	9.45	0.18	9.45	9.45	9.45
Caprock Kh (alluvial)	ft/day	1	0.10	1.00	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.10	[redacted]	[redacted]
Caprock Kv (alluvial)	ft/day	1	0.60	0.60	[redacted]	0.10	[redacted]	0.10	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	0.09	0.10	[redacted]	[redacted]
Valley fills, Kh	ft/day	1	0.019	0.37	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Valley fills, Kv	ft/day	1	0.058	0.066	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	[redacted]	0.001	0.001	0.001
Saprolite under valley fill, Kh	ft/day	2 and 3	0.0028	283.00	5.00	10.00	5.00	4.81	5.00	5.00	5.00	5.00	5.00	9.20	5.00	5.00	5.00
Saprolite under valley fill, Kv	ft/day	2 and 3	0.0028	283.00	0.015	0.011	0.010	0.009	0.010	0.015	0.010	0.010	0.035	0.008	0.002	0.003	0.80
Saprolite under caprock, Kh	ft/day	2 and 3	0.0028	283.00	5.00	10.00	5.00	4.81	1.00	5.00	0.80	0.80	5.00	9.20	5.00	5.00	5.00
Saprolite under caprock, Kv	ft/day	2 and 3	0.0028	283.00	0.015	0.011	0.050	0.009	0.025	0.015	0.087	0.038	0.035	0.008	0.002	0.003	0.80
Tuff overlying marine, Kh	ft/day	1	1.00	1,000	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	200.00	500.00	500.00	500.00
Tuff overlying marine, Kv	ft/day	1	1.00	100.00	0.010	0.10	0.010	0.10	0.010	0.010	0.010	0.010	0.010	0.48	0.010	3.17	0.010
Tuff overlying alluvial, Kh	ft/day	1	1.00	1,000	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	10.00	10.00	10.00
Tuff overlying alluvial, Kv	ft/day	1	1.00	100.00	0.001	0.10	0.001	0.10	0.001	0.001	0.001	0.001	0.001	0.18	0.001	0.014	0.001
Tuff cone, Kh	ft/day	2 to 9	1.00	1,000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.089	0.001	0.001	0.001
Tuff cone, Kv	ft/day	2 to 9	1.00	100	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.008	0.001	0.001	0.001
Basalt, Kh	ft/day	4 to 9	26.00	85,000	2,828	5,316	Zoned	8,280	Zoned	2,828	Zoned	Zoned	Zoned	3,747	1,814	1,995	2,444
Basalt, Kv	ft/day	4 to 9	7.40	7.50	[redacted]	[redacted]	Zoned	[redacted]	Zoned	[redacted]	Zoned	Zoned	Zoned	[redacted]	[redacted]	[redacted]	[redacted]
GHB South conductance	ft²/d	1			40.00	1,000,000	150.00	999,976	305.05	40.00	402.74	280.81	388.06	188.78	135.69	1.00E-05	1.87
GHB PH conductance	ft²/d	1			40.00	1,000,000	150.00	999,804	0.32	40.00	0.47	38.06	0.10	62,588	0.39	1,066	207.57
Kalauo Sp Farm conductance	ft²/d	1 to 4			7,000	10,924	17,000	11,279	13,724	7,000	61,960	11,363	8,026	10,448	7,665	9,461	9,632
Kalauao Sp conductance	ft²/d	1 to 4			3,000	4,841	7,000	5,883	9.05	3,000	8,523	4,948	3,000	5,399	218.14	4,671	4,198
Recharge multiplier SP1&2	(--)	1			0.83	1.00	1.00	1.00	1.00	0.83	1.00	1.00	0.83	1.00	0.70	0.83	0.83
Recharge multiplier SP3&4	(--)	1			0.56	0.73	0.73	0.70	0.72	0.56	0.72	0.72	0.55	0.73	0.42	0.55	0.56
Basalt anisotropy	(--)	4 to 9			0.33	0.10	Zoned	0.057	Zoned	0.33	Zoned	Zoned	Zoned	0.33	0.33	0.33	0.33
Red Hill Shaft skin 1	(--)	6			3,319	3,319	3,319	3,319	3,319	3,319	3,319	3,319	3,319	3,319	3,319	3,319	3,319
Red Hill Shaft skin 2					12.80	12.80	12.80	12.80	12.80	12.80	3,319	3,319	12.80	12.80	12.80	12.80	12.80
Hālawa Shaft skin	(--)	6			20,721	20,721	20,721	20,721	20,721	20,721	20,721	20,721	20,721	20,721	20,721	20,721	20,721
Caprock Ss (marine)	(--)	1			1.17E-06	9.69E-07	1.17E-06	9.69E-07	1.17E-06	1.17E-06	1.17E-06	1.17E-06	1.17E-06	4.48E-05	1.17E-06	1.17E-06	1.17E-06
Caprock Sy (marine)	1/ft	1	0.10	0.20	0.073	0.095	0.073	0.095	0.07	0.073	0.073	0.073	0.073	0.049	0.073	0.073	0.073
Caprock Ss (alluvial)	(--)	1			1.78E-06	1.72E-06	1.78E-06	1.72E-06	1.78E-06	1.78E-06	1.78E-06	1.78E-06	1.78E-06	1.65E-05	1.78E-06	1.78E-06	1.78E-06
Caprock Sy (alluvial)	1/ft	1	0.10	0.20	0.030	0.022	0.030	0.022	0.030	0.030	0.030	0.030	0.030	0.15	0.030	0.030	0.030
Valley Fills, Ss	(--)	1			6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06	6.91E-06
Valley Fills, Sy	1/ft	1	0.10	0.15	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Saprolite, Ss	(--)	2 and 3			5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06	5.31E-06
Saprolite, Sy	1/ft	2 and 3	0.10	0.10	0.026	0.070	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
Tuff overlying marine, Ss	(--)	1			1.27E-06	1.36E-06	1.27E-06	1.36E-06	1.27E-06	1.27E-06	1.27E-06	1.27E-06	1.27E-06	1.52E-05	1.27E-06	1.27E-06	1.27E-06
Tuff overlying marine, Sy	1/ft	1			0.056	0.070	0.056	0.070	0.056	0.056	0.056	0.056	0.056	0.15	0.056	0.056	0.056
Tuff overlying alluvial, Ss	(--)	1			2.41E-06	1.15E-06	2.41E-06	1.15E-06	2.41E-06	2.41E-06	2.41E-06	2.41E-06	2.41E-06	1.52E-06	2.41E-06	2.41E-06	2.41E-06
Tuff overlying alluvial, Sy	1/ft	1			0.061	0.062	0.061	0.062	0.061	0.061	0.061	0.061	0.061	0.015	0.061	0.061	0.061
Tuff cone, Ss	(--)	2 to 9			4.70E-06	7.12E-06	4.70E-06	7.12E-06	4.70E-06	4.70E-06	4.70E-06	4.70E-06	4.70E-06	7.70E-06	4.70E-06	4.70E-06	4.70E-06
Tuff cone, Sy	1/ft	2 to 9			0.058	0.070	0.058	0.070	0.058	0.058	0.058	0.058	0.058	0.026	0.058	0.058	0.058
Basalt, Ss	(--)	4 to 9	0.010	0.030	6.00E-05	9.88E-05	7.00E-05	9.09E-05	Zoned	6.00E-05	Zoned	Zoned	1.01E-04	1.06E-04	1.43E-04	1.19E-04	8.14E-05
Basalt, Sy	1/ft	4 to 9	0.040	0.080	0.01	0.002	0.010	0.010	Zoned	0.010	Zoned	Zoned	0.010	0.010	0.010	0.010	0.010

ft² square feet
GHB general head boundary
Kh horizontal hydraulic conductivity
Ky vertical hydraulic conductivity
Ss specific storage
SP stress period
Sy specific yield

Minimum and maximum values from Table 4-1.
Values at or below the minimum value are shaded light gray.
Values at or above the maximum value are shaded [redacted].

Table 5-3: Model Calibration Statistics

Run ID	Description	Comparison of Observed and Simulated Water Levels for Basalt Wells			Scatterplot of Water Level Differences Between Synoptic Study Wells: Difference with RHMW01			Difference with RHMW04			Drawdown Hydrographs: SP2			SP4		
		Mean Residual (ft)	RMS Error (ft)	R-square (-)	Mean Residual (ft)	RMS Error (ft)	R-square (-)	Mean Residual (ft)	RMS Error (ft)	R-square (-)	Mean Residual (ft)	RMS Error (ft)	R-square (-)	Mean Residual (ft)	RMS Error (ft)	R-square (-)
51	Homogeneous basalt															
51a	Limit horizontal anisotropy (3:1)	0.54	0.95	0.60	0.05	0.51	0.74	0.44	0.67	0.79	0.06	0.41	0.82	0.07	0.13	0.96
51b	10:1 anisotropy	0.39	0.82	0.68	0.03	0.38	0.77	0.49	0.60	0.80	0.09	0.54	0.81	0.06	0.10	0.98
51c	Zoned along ridges	0.96	1.22	0.65	0.08	0.43	0.74	0.53	0.66	0.78	0.08	0.53	0.82	0.10	0.18	0.99
51d	Calibrate on anisotropy	0.55	0.88	0.71	0.04	0.38	0.77	0.47	0.59	0.80	0.07	0.50	0.82	0.05	0.09	0.98
51e	Zoned along ridges and within valleys	0.16	0.62	0.75	-0.02	0.38	0.79	0.48	0.60	0.83	0.04	0.25	0.86	-0.01	0.04	0.99
52	Alternate saprolite	0.54	0.95	0.60	0.05	0.51	0.74	0.44	0.66	0.79	0.06	0.41	0.82	0.07	0.13	0.96
53	Heterogeneous basalt	0.13	0.54	0.82	-0.02	0.31	0.88	0.35	0.46	0.90	-0.002	0.08	0.96	-0.01	0.04	0.99
54	Heterogeneous basalt	0.19	0.63	0.76	0.02	0.37	0.84	0.43	0.56	0.88	-0.01	0.09	0.95	-0.0004	0.04	0.99
55	Conceptual clinker zone	0.19	0.69	0.71	0.03	0.45	0.74	0.50	0.65	0.80	0.02	0.14	0.86	0.05	0.08	0.98
56	Structural alterations to tuff cones	-0.06	1.06	0.54	0.002	0.40	0.75	0.48	0.61	0.79	0.09	0.56	0.83	0.02	0.08	0.97
57	Recharge uncertainty	0.21	0.78	0.64	0.001	0.42	0.75	0.53	0.66	0.80	0.07	0.61	0.81	0.03	0.08	0.98
58	Coastal marine discharge variability	0.27	0.78	0.64	0.01	0.41	0.76	0.53	0.65	0.80	0.07	0.56	0.81	0.04	0.07	0.98
59	Lateral inflow from SE	0.26	0.70	0.74	-0.01	0.38	0.77	0.53	0.63	0.80	0.03	0.29	0.81	0.06	0.09	0.98

RMS root mean square
\- no unit of measure

Table 5-6: Model Travel Times (days) from Tanks to Receptors for Hālawa Shaft Pumping at 12 MGD and Red Hill Shaft Off

Run ID	Description	Hālawa Shaft		Kalauao Spring Farm		Well 2255-32		Well 2255-37		Well 2255-39		Well 2355-06		Well 2355-07		Pearl Harbor	
		Low End	High End	**Low End**	High End	**Low End**	High End	**Low End**	High End	**Low End**	High End	**Low End**	High End	**Low End**	High End	**Low End**	High End
51	Homogeneous basalt																
51a	Limit horizontal anisotropy (3:1)	374	518	—	—	754	850	724	800	724	800	—	—	—	—	—	—
51b	10:1 anisotropy	259	375	—	—	—	—	—	—	—	—	—	—	—	—	—	—
51c	Zoned along ridges	—	—	—	—	588	652	559	577	559	577	—	—	—	—	688	793
51d	Calibrate on anisotropy	254	382	—	—	—	—	—	—	—	—	—	—	—	—	—	—
51e	Zoned along ridges and within valleys	—	—	883	1,031	—	—	—	—	—	—	—	—	—	—	—	—
52	Alternate saprolite	351	527	—	—	755	852	738	797	738	797	—	—	—	—	—	—
53	Heterogeneous basalt	384	953	1,761	1,831	1,052	1,180	1,020	1,223	1,020	1,223	1,304	1,458	1,304	1,458	—	—
54	Heterogeneous basalt	229	414	—	—	—	—	—	—	—	—	—	—	—	—	—	—
55	Conceptual clinker zone	295	580	1,236	1,252	708	864	685	757	685	757	—	—	—	—	1,938	1,938
56	Structural alterations to tuff cones	137	170	—	—	—	—	—	—	—	—	—	—	—	—	—	—
57	Recharge uncertainty	361	649	—	—	798	932	744	789	744	789	—	—	—	—	—	—
58	Coastal marine discharge variability	366	550	—	—	717	861	691	750	691	750	—	—	—	—	1,494	1,494
59	Lateral inflow from SE	251	463	—	—	539	595	523	590	523	590	—	—	—	—	635	671
60	Low-conductivity material extended partially up valleys	224	466	—	—	—	—	—	—	—	—	—	—	—	—	—	—

1 **Table 5-7: Summary of Multimodel Applicability for Risk-Based Decision Making**

Model #	Description	Significant Features	Weighting	Weighting Considerations
51	Homogeneous basalt with CSM saprolite	Evaluation of regional flow behavior		
51a	Limit horizontal anisotropy (3:1)	Assumed conservative assumption of previous modeling efforts	0.8	Good calibration metrics; fair calibration to water level differences; reasonable conceptual model and water budgets
51b	10:1 anisotropy	Evaluate impact of possible higher horizontal anisotropic conditions	0.9	Good calibration to all metrics; reasonable conceptual model and water budgets
51c	Zoned along ridges	Evaluate impact of possible higher horizontal anisotropic conditions	0.8	Good calibration metrics; fair calibration to water level differences; reasonable conceptual model and water budgets
51d	Calibrate on anisotropy	Evaluate what value of anisotropy best captures regional water level conditions (generally between 17 and 18)	0.9	Same as 51b
51e	Zoned along ridges and within valleys	Evaluate impact of additional zonation since zoned conditions of Model #51c did not adequately distinguish itself from the average conditions of homogeneous Model #51a	0.9	Good calibration to all metrics; reasonable conceptual model and water budgets
52	Alternate saprolite	Test impact of alternate (smaller) saprolite extent and depth below water table	0.8	Same as 51a
53	Heterogeneous basalt	Evaluate impacts of regional- and local-scale heterogeneities using pilot points using random initial parameter distributions	1	Excellent calibration to all metrics; reasonable conceptual model and water budgets
54	Heterogeneous basal	Evaluate alternate impacts of regional- and local-scale heterogeneities using pilot points using initial parameter distributions that block downhill flow from the Facility (tuff cone dam effect)	1	Excellent calibration to all metrics; reasonable conceptual model and water budgets
55	Conceptual clinker zone	Evaluate impact of fast-flow pathway in groundwater beneath the Facility	0.9	Good calibration to all metrics; reasonable conceptual model and water budgets; addresses impact of fast flow pathways
56	Structural alterations to tuff cones	Evaluate impact of a damming effect of tuff cones on flow down Red Hill	0.7	Good calibration to all metrics; reasonable water budgets; unlikely to have barrier as conceptualized
57	Recharge uncertainty	Evaluate impact of applying drought condition recharge inflow	0.8	Good calibration to all metrics; reasonable conceptual model low-end of water budgets
58	Coastal marine discharge variability	Evaluate impact of variability in discharge to ocean and Pearl Harbor	0.8	Good calibration to all metrics; reasonable conceptual model and water budgets
59	Lateral inflow from SE	Evaluate conceptual model of flow across valleys from Kalihi Valley to Pearl Harbor	0.8	Good calibration to all metrics; reasonable conceptual model; plausible water budgets

Addresses Regulatory Agencies' Top 10 issue

Addresses other regulatory issue

DEPARTMENT OF HEALTH
STATE OF HAWAII

IN THE MATTER OF Contested Case Hearing Re Permit Application	)	**CERTIFICATE OF SERVICE**

CERTIFICATE OF SERVICE

I hereby certify that, on this date, a true and correct copy of the foregoing documents were emailed to the following:

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Respectfully Submitted,

Dated: January 29, 2021

/S/ Marnie E. Riddle__________
Marnie E. Riddle
Agency Representative