Naval Facilities Engineering Systems Command Hawaii
JBPHH HI

Groundwater Protection Plan Update – Defueling Revision
Red Hill Bulk Fuel Storage Facility
JOINT BASE PEARL HARBOR-HICKAM, O‘AHU, HI

June 26, 2023

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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
AFFF	aqueous film-forming foam
AOC	Administrative Order on Consent
BWS	Board of Water Supply, City and County of Honolulu
COPC	chemical of potential concern
CAS	Chemical Abstracts Service
CCIR	Commander's Critical Information Requirement
CNRH	Commander, Navy Region Hawaii
COA	course of action
DoD	Department of Defense, United States
DOH	Department of Health, State of Hawai'i
DW LTM	drinking water long-term monitoring
EAL	Environmental Action Level
EPA	Environmental Protection Agency, United States
EOC	Emergency Operations Center
EV	Environment
Facility	Red Hill Bulk Fuel Storage Facility
GWPP	Groundwater Protection Plan
JBPHH	Joint Base Pearl Harbor-Hickam
JP	Jet Fuel Propellant
JTF	Joint Task Force
LNAPL	light nonaqueous-phase liquid
LOD	limit of detection
LTM	long-term monitoring
NAVSUP FLC PH	Naval Supply Systems Command Fleet Logistics Center Pearl Harbor
Navy	Department of the Navy, United States
NOI	Notice of Interest
NPDES	National Pollutant Discharge Elimination System
OIC	Officer in Charge
PAH	polynuclear aromatic hydrocarbon
PFAS	per- and polyfluoroalkyl substances
PID	photoionization detector
ppbv	parts per billion by volume
QC	quality control
SGC	silica gel cleanup
SGH	Simpson Gumpertz & Heger
SME	subject matter expert
TAT	turn-around time
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual oil range organics
U.S.	United States
VOC	volatile organic compound

1. Introduction/Objectives

This document updates the Red Hill Groundwater Protection Plan (GWPP) (DON 2008; 2014b) for the Red Hill Bulk Fuel Storage Facility (the “Facility”) located on O‘ahu, Hawai‘i with revisions that present an integrated strategy to manage risks associated with potential inadvertent fuel releases from the tanks or associated infrastructure (e.g., pipelines) by establishing detection and mitigation measures to protect groundwater resources. The Navy first developed the Red Hill GWPP in 2008 at the request of the Hawai‘i State Department of Health (DOH) after previous environmental investigations (DON 1999; 2002; 2007) showed that past inadvertent releases had impacted the fractured lava rock (basalt), basal groundwater, and soil vapor beneath portion of the Facility with petroleum hydrocarbons.

The Navy has prepared this 2023 GWPP Update – Defueling Revision in response to an April 2023 request from the United States Environmental Protection Agency (EPA) to “prepare an additional supplement for EPA and DOH review... [to] confirm or update trigger action levels and associated response procedures for detection of fuel constituents in environmental media.” This GWPP Revision specifically addresses monitoring for potential impacts to the environment if an inadvertent spill occurred during the Facility’s upcoming defueling process, including activities to be conducted to ensure steps are taken to protect groundwater until the defueling process is complete. With the cessation of fuel storage at the Facility after defueling, it is anticipated that another revision to the GWPP will be prepared to ensure long-term protection of groundwater and drinking water resources.

Groundwater protection measures that are currently implemented at the Facility include:

- Preventive inspection, maintenance, and repair in accordance with modified American Petroleum Institute 653 procedures.
- Leak detection via weekly soil vapor monitoring under the fuel storage tanks.
- Regular groundwater monitoring in accordance with the Consolidated Groundwater Sampling Program (DON 2023c), which consolidates several previously separate groundwater sampling programs (i.e., the Notice of Interest [(NOI]), Groundwater Long-Term Monitoring (LTM), Delineation and Sentinel Well, and Per- and Polyfluoroalkyl Substances [(PFAS] programs) into one comprehensive, optimized groundwater sampling program.
- Update Spill Response Plans (Facility Response Plan, Integrated Contingency Plan) and increased spill exercises specific to the facility
- Contingency planning for response actions, including actions that would be required to remediate the basal drinking water aquifer if a large release of fuel were to migrate to the water table.

1.1 Description of the Facility

The Facility is a large underground fuel storage complex that stored and provided fuel for operations in Hawai‘i and throughout the Pacific. Its twenty 12.5-million-gallon bulk fuel storage tanks were field-constructed of steel-lined concrete under a volcanic mountain ridge in the early 1940s. The tanks are connected to a fuel pumping station and fueling piers 2.5 miles away at Pearl Harbor via a tunnel system. The Facility is owned by Defense Logistics Agency (DLA) and prior to ceasing fueling operations in late 2021 was operated by Naval Supply Systems Command Fleet Logistics Center Pearl Harbor (NAVSUP FLC PH).

Each fuel tank is 100 feet in diameter and approximately 250 feet in height with a capacity of approximately 12.5 million gallons. Fourteen fuel storage tanks currently contain fuel and store either Jet Fuel Propellant (JP)-5, North Atlantic Treaty Organization-grade F-24 jet fuel, or F-76 Marine Diesel Fuel. The 104 million gallons of fuel that currently remain in Facility tanks are scheduled for defueling, as described in Section 1.2 (DoD 2022b).

The Facility's fuel storage tanks are located approximately 100 feet above the Oahu Sole Source Aquifer (also referred to as the Southern Oahu Basal Aquifer, designated a Sole Source Aquifer in 1987 under Section 1424(e) of the Safe Drinking Water Act [61 Fed. Reg. 47752]), which supplies a significant portion of the island's drinking water. The nearest active or inactive drinking water supply wells are:

- Navy Well 2254-01 (Red Hill Shaft), located topographically downgradient from the tank farm approximately 2,600 feet to the west of the Facility tanks (i.e., the tank farm), which previously provided drinking water to Joint Base Pearl Harbor-Hickam (JBPHH) customers until November 2021. Red Hill Shaft is currently physically disconnected from the drinking water system and will be unable to serve drinking water for as long as it remains physically disconnected from the drinking water system.
- Honolulu Board of Water Supply (BWS) Well 2354-01 (BWS Hālawa Shaft), located approximately 4,600 feet to the north-northwest, which provided municipal drinking water to the City and County of Honolulu until it ceased pumping in December 2021.
- BWS Moanalua Wells 2153-10, -11, and -12 (Moanalua 1, 2, and 3), located approximately 1.3 miles to the south, which continue to provide municipal drinking water to the City and County of Honolulu.
- Navy Well 2254-032 (Navy ʻAiea Hālawa Shaft), located approximately 1.9 miles to the west-northwest, which provided drinking water to JBPHH customers until December 2021.
- Navy Well 2558-010 (Waiawa Shaft), located approximately 5.5 miles northwest of the Facility.

1.2 DESCRIPTION OF THE PROBLEM

The Facility had a documented history of releases prior to the early 1980s that led to establishment of a soil vapor and groundwater monitoring network in the mid to late 2000s. During Tank 5 refilling operations following a routine 3-year tank inspection and refurbishment process, a release of approximately 27,000 gallons of JP-8 fuel was confirmed and reported to DOH on January 23, 2014. A fuel hydrocarbon seep was observed on a tunnel wall below Tank 5, soil vapor monitoring points (SVMPs) installed beneath Tank 5 exhibited a sharp increase in hydrocarbon vapor concentrations, and several near-tank monitoring wells exhibited increases in total petroleum hydrocarbon (TPH) concentrations. Subsequent analyses indicated that the causes of the release were defective workmanship in welding by the tank refurbishment contractor, poor inspection, and ineffective quality control (QC). The release resulted in the United States (U.S.) Environmental Protection Agency (EPA), DOH, the Navy, and DLA agreeing to the Red Hill Administrative Order on Consent (AOC) in September 2015 (EPA Region 9 and DOH 2015). Work described in Section 7 "Groundwater Protection and Evaluation" of the AOC's Attachment A Statement of Work was to be completed in part to inform subsequent changes to the GWPP, including response procedures and trigger points. Although an extensive amount of work required by the AOC has been completed, the groundwater protection and evaluation work remains ongoing, therefore no update to the GWPP prior to this revision was completed since its 2014 Interim Update (DON 2014b).

The May and November 2021 fuel releases from the Facility's tunnel system pipelines impacted the vadose zone and groundwater underneath the Facility (DON 2023b). Drinking water at Red Hill Shaft was contaminated with fuel from the Nov 2021 releases:

- **May 2021 Release.** On May 6, 2021, Navy personnel responded to a reported release of fuel from a distribution pipeline inside the Facility in the vicinity of Tank 20. The Navy notified DOH of the release within 24 hours. The fuel containment system at Red Hill was used to collect the fuel from the pipeline breach.

The Navy provided preliminary findings of the ongoing investigation to DOH on October 1, 2021, indicating that JP-5 fuel was released during a fuel transfer and collected by the fuel containment system; there were no leaks from any fuel tanks. The Navy captured JP-5 fuel from the tunnel drain system, which was followed by a complete wash down of the area with fresh water on May 7, 2021 (DON 2021b). Some soil vapor monitoring vaults on the tunnel floor near the May 2021 Release were impacted by fuel, and the below-tank SVMPs exhibited elevated concentrations of volatile organic compounds (VOCs) measured in the field with a photoionization detector (PID).

- **November 2021 Release.** On November 20, 2021, a release of JP-5 fuel occurred in the Adit 3 Tunnel of the Facility. Unbeknownst at the time, a portion of the JP-5 released on May 6, 2021 had made its way into an overhead 14-inch polyvinyl chloride fire suppression recovery drain line that ran from the tank farm to Adit 3. JP-5 fuel was released from this drain line at a location approximately 400 feet east of the Navy's water supply pumping station Red Hill Shaft and approximately 200 feet east of the junction with the Pearl Harbor Tunnel. The location of the release point was in close proximity to Red Hill Shaft's water development tunnel, which extends horizontally more than 1,200 feet east-southeast from the pumping station at an elevation of approximately 0–20 feet above mean sea level.

  Released fuel flowed along the Adit 3 Tunnel floor westward past the junction with the Pearl Harbor Tunnel and Red Hill Shaft. Fuel accumulated in a groundwater sump (Adit 3 Sump), approximately 750 feet west of the November 2021 Release point. JP-5 fuel was recovered from the Adit 3 Sump, connected piping, the fire suppression recovery drain line, and a nearby Holding Tank/Leach Tank area including subsurface soil.

  The November 2021 Release released fuel to the environment from the Adit 3 Sump, a Hume line located immediately below the tunnel floor, and the Adit 3 Sump drain leading to the Holding Tank and Leach Tank area. Fuel was observed in the water development tunnel of Navy water supply well Red Hill Shaft.

Upon confirmation that a fuel-like odor was present in drinking water in JBPHH homes served by Red Hill Shaft, Red Hill Shaft was shut off and physically disconnected from the JBPHH Drinking Water Distribution System on November 28, 2021. Navy Aiea Hālawa Shaft also ceased pumping, and remains turned off to this day. Red Hill Shaft was later connected to a newly installed temporary water treatment system to support the capture and treatment of groundwater potentially impacted by the November 2021 release. Treated water is permitted by DOH to be discharged to Hālawa Stream, and Red Hill Shaft and remains disconnected from the JBPHH Drinking Water Distribution System.

In March 2022, the U.S. Secretary of Defense directed the Department of Defense (DoD) to defuel and permanently shut down the Red Hill Bulk Fuel Storage Facility (DoD 2022a). The directive ordered standup of the Joint Task Force (JTF) Red Hill to accomplish the safe and expeditious defueling of the Facility's fuel storage tanks, recognizing the multi-stage nature of the process. DoD established the JTF Red Hill on September 30, 2022; as of December 2022, JTF Red Hill has established physical control of the Facility (DoD 2023).

The DoD published the Facility Defueling Plan in June 2022 (DoD 2022b). The Plan noted the iterative nature of the process and its need to be continually refined and supplemented as initial phases are completed and further insights into needed critical actions are gained through ongoing assessments. Supplements published to date (1.A, 1.B, and 2) further identify the studies, repairs, and training that are first required to ensure safe defueling of the 104 million gallons of jet fuel and marine diesel fuel remaining in the tanks

(DoD 2022c; 2022d; 2023); additional revisions after publication of this GWPP Revision are likely. Current information on the Defueling Plan is available on the JTF Red Hill website.[1] The projected completion date for defueling the tanks is currently June 2024 (DoD 2022d).

1.3 Conceptual Site Model

1.3.1 Subsurface Conditions

The Facility's bulk fuel storage tanks are surrounded by rock in the vadose (i.e., unsaturated) zone, which consists primarily of basalt flows in complex, alternating layers. These heterogeneous layers vary from extremely high to extremely low permeability, with a correspondingly variable ability to transmit and hold light nonaqueous-phase liquid (LNAPL, also referred to as free product), depending on the layer's rock type and micro-pore structure (i.e., high ability in high-permeability a'ā and thin pāhoehoe flows and in a'ā clinker zones; low ability in massive a'ā and massive pāhoehoe flows). Geologic and water saturation characteristics in the rock surrounding the tanks could cause LNAPL to spread as it moves through the rock. As LNAPL moves through the larger pore spaces, some of it could be trapped in poorly connected fractures and blocked by nearby low-permeability regions or by surface tension and capillary forces of moisture, especially water held in the smaller pores. The potential presence of intact lava tubes might serve as preferential pathways and conduits for LNAPL migration.

Hawaiian volcanic rocks vary in porosity and permeability depending on the emplacement process, lava type, genesis, flow thickness, flow rate, extent, cooling rate, and weathering. Permeability is typically highest in the relatively thick, unweathered, rubbly a'ā clinker zones and intensely fractured zones or lava tubes of pāhoehoe flows. Permeability is much lower in the interior portions of massive flows, weathered interflows, intrusive rocks (dikes and sills), ash beds, and weathered rocks (saprolite) and soil horizons, which can impede both vertical and horizontal flows across valleys. Generally, the bulk vertical permeability of the basalt is orders of magnitude lower than the bulk horizontal permeability. Horizontal permeability is generally higher in the direction that the lava flowed than in the transverse direction.

Groundwater flow and solute transport are controlled by both the hydraulic conditions (e.g., gradients) and the physical properties of the hydrogeologic units, including hydraulic conductivity, effective porosity, specific yield, specific storage, anisotropy, and dispersivity, all of which vary significantly under highly heterogeneous conditions.

Fresh groundwater inflow originates as deep infiltration of precipitation and seepage from surface water features. According to the U.S. Geological Survey, estimates of recharge for O'ahu for recent conditions (2010 land cover and 1978–2007 rainfall) differ from predevelopment recharge values by only a few percent (Izuka et al. 2018). Spatial distribution of recharge mimics the orographic rainfall pattern; recharge is highest on windward slopes and mountain peaks below the top of the tradewind inversion.

Groundwater outflow includes withdrawals from wells and natural groundwater discharge to springs, streams, wetlands, and submarine seeps. Data collected by the U.S. Geological Survey for groundwater levels, saltwater/freshwater interface, spring flow, and stream base-flow indicate an overall reduction in aquifer storage for most areas where groundwater has been extracted; this has caused groundwater levels to decline across O'ahu (Izuka et al. 2018).

[1] https://www.pacom.mil/JTF-Red-Hill/Joint-Task-Force-Red-Hill/

Regional groundwater levels decrease from areas of recharge (mauka) to areas of discharge (makai) (Hunt Jr. 1996). Locally, water level gradients are extremely low and are influenced by geologic conditions, as well as by variability in local pumping stresses from water development shafts and wells.

1.3.2 Exposure Model

Potentially contaminated media are tunnel air; unconsolidated materials, volcanic rock, and soil/rock vapor surrounding the tanks and tunnel; groundwater beneath the Facility, which has the potential to migrate off site; and offsite surface water where groundwater may discharge. Human receptors that may potentially contact onsite or offsite Facility-impacted media are Facility occupational workers, construction workers, visitors, and offsite residents. Among the potentially complete exposure pathways identified, the primary pathway of concern is exposure to impacted tap water via direct ingestion and dermal contact, and via inhalation while showering and bathing with tap water. Animals and vegetation may also be exposed to tap water as pets or from irrigation. Exposure by ecological receptors is considered incomplete or insignificant (DON 2019).

The November 2021 release followed a different pathway to groundwater from the previous historical releases. Whereas the historical releases affected the basalt beneath the Facility's tank farm, the 2021 release discharged in Adit 3 directly above the Red Hill Shaft water development tunnel, which provided a faster and more direct pathway to groundwater and the Red Hill Shaft water supply. The Red Hill Shaft water supply was previously identified as the primary complete exposure pathway identified at Red Hill for offsite human residents using tap water sourced from the Red Hill Shaft water supply well (DON 2019, Section 8).

Red Hill Shaft was isolated from the JBPHH Water Distribution System on November 28, 2021. BWS Hālawa Shaft also ceased pumping on December 2, 2021 and remains turned off to this day. Out of an abundance of caution, on December 3, 2021, the Navy also discontinued use of the Navy 'Aiea Hālawa Shaft. Red Hill Shaft was later connected to a newly installed temporary water treatment system to support the capture and treatment of the groundwater potentially impacted by the November 2021 release. The treatment system discharges treated groundwater to surface water rather than supplying drinking water. The discharged water is permitted under a National Pollutant Discharge Elimination System (NPDES) permit and is regularly tested and has met all discharge requirements. As such, untreated water from Red Hill Shaft no longer offers a complete pathway for human exposure.

1.4 SCOPE AND OBJECTIVES

The Defueling Plan and its supplements (DoD 2022b; 2022c; 2022d; 2023) identify the primary protective measures to be implemented by Facility personnel for defueling, such as unpacking of fuel lines, critical infrastructure repairs, safety planning and training, and defueling procedures, as summarized below. This GWPP Revision identifies monitoring measures that will be implemented during the defueling process for protection of the groundwater resources. The measures established in this GWPP Revision include visual observations of the pipelines within the tunnels, monitoring of soil vapor concentrations under the fuel storage tanks, and groundwater monitoring in wells located in and around the Facility. Response procedures and trigger points (i.e., action levels) are also provided. After defueling is accomplished and tank closure is completed (DON 2022a; 2023a), a complete update of this GWPP will be prepared for long-term protection of the groundwater resources after the potential for releases is removed.

1.4.1 Fuel Line Unpacking

The unpacking procedure summarized below was completed in November 2022.

To initiate pipeline repairs necessary to complete defueling, DoD unpacked (i.e., removed) approximately 200,000 gallons of fuel in the JP-5 pipeline, approximately 170,000 gallons of fuel in the F-24 jet fuel pipeline, and approximately 690,000 gallons of fuel from the F-76 Marine Diesel Fuel pipeline.

Unpacking was performed in accordance with the approved unpacking plan. The unpacking plan directed a Supervisor of the Watch, a control room operator, and an assistant control room operator to be present in the control room during the entire unpacking operation. A supervisor and work leader oversaw all phases of unpacking and verified valve positions. Roving watch-standers monitored the pipelines during the unpacking process. These manpower redundancies provided necessary controls to minimize the risk of release.

The unpacking plan included updated spill response plans and spill exercises to prepare for various scenarios. In advance of un-packing, several spill mitigation actions were taken to minimize any spills from impacting the aquifer; including barriers to divert fuel away from Adit 3, sealing of cracks in lower access tunnel, and placing spill mats over monitoring wells. In addition to barriers, DoD pre-positioned absorbents and booms in the lower access tunnel in Adit 3 and in the Red Hill Shaft pump room prior to unpacking. This pre-positioned equipment complemented the barriers by allowing operators and safety personnel to quickly address and remove any fuel that spilled.

1.4.2 Infrastructure Repairs and Enhancements

The Defueling Plan is focused on the 43 activities associated with the critical defueling recommendations that support defueling identified in a report by an independent third-party contractor (Simpson Gumpertz & Heger [SGH]) dated April 29, 2022. DoD continues to address the existing SGH recommendations.

1.4.3 Training

DoD’s training efforts for the defueling process includes programmatic changes, operational training that applies lessons learned from the Red Hill operations and incidents, as well as comments provided by EPA and DOH during EPA’s 2022 site inspection (EPA 2022).

The existing Spill Prevention, Control, and Countermeasures Plan and existing Facility Response Plan were updated to enhance procedures in place and training to promote safe defueling. As revised, these plans document actual or planned implementation of corrective actions and clarification of spill response procedures and responsibilities. The updated plans reflect operational improvements made in response to the Navy’s Command Investigation, EPA Mar 2022 Inspection and incorporate lessons learned from the May 6, 2021 and November 20, 2021 releases (DON 2022b; 2022c; 2022d; 2022e).

DoD updated the Spill Response Program prior to the unpacking operations to improve command and control and overall response capabilities. DoD added additional dedicated spill response positions, bringing the total number of spill response positions to five, and added approximately 50–150 additional trained individuals to respond to a spill.

2. Monitoring Program

This section describes visual inspections, soil vapor monitoring, and groundwater monitoring that will be performed during the defueling operations. Navy contractors will be responsible for implementing the monitoring program for the duration of the defueling program. Analytical laboratories accredited under the Department of Defense Environmental Laboratory Accreditation Program and data validators are currently under subcontract to Navy prime contractors to perform soil vapor and groundwater analytical services.

2.1 VISUAL INSPECTIONS

Similar to the unpacking process, JTF Red Hill will assign a supervisor and work leader to oversee all phases of the defueling operations, including daily visual verification of all valve positions. The supervisor and work leader will be supported by validators who will independently complete these inspections and confirm proper operation of valves to ensure correct system configuration.

Watchstander teams under the oversight of the JTF Red Hill supervisor and work leader will continuously monitor the full length of the pipeline and the tanks during the defueling process. The watchstanders will be assigned specific coverage areas each day to ensure full coverage of the operations and will be trained in spill response and communications procedures to ensure timely reporting of observed releases (if any).

2.2 SOIL VAPOR MONITORING

Soil vapor monitoring points were installed under the Facility's active fuel storage tanks in the mid-2000s (DON 2007) following environmental investigations at the Facility (DON 1999, 2002) and are currently sampled weekly with a PID. In addition, passivated (Summa) canister samples are collected monthly for analysis of VOCs at the SVMPs with the highest PID readings (i.e., SV15S, SV17S, SV18S, SV20M) and the associated deep (outermost) probes for those four tanks (i.e., SV15D, SV17D, SV18D, SV20D). As described in the following subsections, the frequency of soil vapor monitoring during defueling will generally be increased.

2.2.1 Soil Vapor Monitoring Network

The soil vapor monitoring network under the fuel storage tanks consists of two to three monitoring points installed in angle borings under the active storage tanks (Tanks 2 through 18 and Tank 20), as shown on Figure 1. The angles of the borings are relatively flat (generally within 10–15 degrees of horizontal), such that all monitoring probes are relatively close to the tank bottoms.

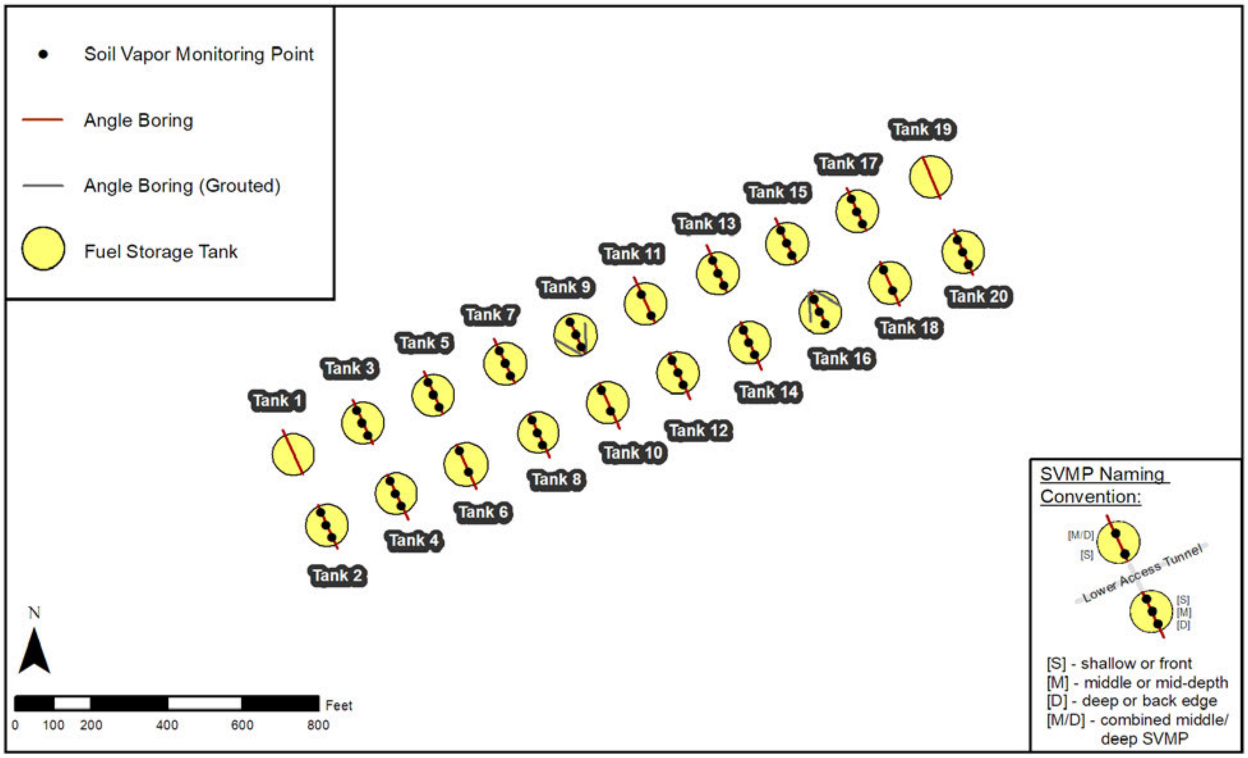

Figure 1: Soil Vapor Monitoring Network Below the Red Hill Fuel Storage Tanks

During defueling, the SVMPs underneath the Facility's fuel storage tanks will be sampled with a PID two times per week.

Historically, soil vapor monitoring beneath the Facility's fuel storage tanks has been conducted monthly at a minimum in accordance with the existing GWPP (DON 2008; 2014b), the Red Hill AOC (EPA Region 9 and DOH 2015), and DOH NOIs for the January 2014 JP-8 Release (DON 2014a). Since the 2021 releases, all SVMPs beneath the tanks have been sampled with a PID at least weekly.

2.2.2 Soil Vapor Action Levels

During defueling, the soil vapor actions level for tanks that currently contain or last contained JP-5 or JP-8 (Tanks 1 through 12 and 17 through 20) is 50,000 parts per billion by volume (ppbv); the action level for tanks that currently contain or last contained F-76 Marine Diesel fuel (Tanks 13 through 16) is 8,000 ppbv. These soil vapor action levels were developed following review of the extensive soil vapor data, including data collected after known releases, and account for routine fluctuations. They are consistent with the AOC Statement of Work Sections 3 and 4 deliverable Supplement to AOC Tank Upgrade Alternatives and Release Detection Decision Document (DON 2021a, Response to RFI 9).

A PID reading above 50,000 ppbv from the SVMPs beneath Tanks 1 through 12 and 17 through 20 or above 8,000 ppbv from the SVMPs beneath Tanks 13 through 16 will trigger the response actions detailed in Section 3.1, including but not limited to collection of a passivated (Summa) canister soil vapor sample for laboratory analysis and evaluation.

2.3 GROUNDWATER MONITORING

As noted in Section 1, the current groundwater sampling effort is conducted in accordance with the Consolidated Groundwater Sampling Program (DON 2023c), which consolidates several required or requested sampling programs that were previously conducted under separate programs (i.e., NOI, Groundwater LTM, Delineation and Sentinel Well, and PFAS programs). During defueling, the Consolidated Groundwater Sampling Program will continue.

2.3.1 Groundwater Monitoring Network

The Red Hill groundwater monitoring network is currently being expanded and will eventually consist of 41 monitoring locations once additional proposed groundwater monitoring wells are completed, including 39 monitoring wells installed by the Navy; the state-owned well HDMW2253-03 (Hālawa Deep Monitor Well) located on Halawa Correctional Facility property; and the sampling location at Navy supply well Red Hill Shaft (RHMW2254-01). The following prefixes are used in the wells' nomenclature:

- "RHMW": existing, in-progress, or proposed monitoring location installed by the Navy within the Facility boundaries and surrounding the tank farm.
- "RHP": existing or in-progress well installed by the Navy within the Facility boundary in the immediate vicinity of Red Hill Shaft for site characterization and evaluating (i.e., delineating) the nature and extent of the November 2021 JP-5 release.
- "NMW": existing or proposed well installed by the Navy outside the Facility boundary to monitor aquifer conditions in the direction of potential offsite receptors (water supply wells) and to gain a better understanding of site hydrogeologic conditions around Red Hill.

The groundwater monitoring network is shown on Figure 2.

[redacted]

Table 2-1 identifies the following three categories of groundwater monitoring locations:

- **Release Detection Wells** are positioned to identify tank releases or impacts from pipeline releases in the tank farm. During defueling, Release Detection Wells will be sampled weekly.
- **Compliance Wells** are positioned to monitor groundwater conditions entering or leaving the tank farm and tunnel areas, including locations near the Facility boundary. During defueling, Compliance Wells will be sampled monthly in accordance with the Consolidated Groundwater Sampling Program (DON 2023c).
- **Sentinel Wells** are used to monitor groundwater conditions between the Facility and offsite locations or receptors, and to provide advance warning prior to impacts should offsite migration occur in these directions. During defueling, Sentinel Wells will be sampled monthly in accordance with the Consolidated Groundwater Sampling Program (DON 2023c).

Table 2-1: Groundwater Monitoring Network Categories

Release Detection Wells	Compliance Wells		Sentinel Wells
RHMW01R	RHMW04	RHMW18 (JJ) [a]	RHMW12A
RHMW02	RHMW05	RHMW19	NMW22(MM) [b]
RHMW03	RHMW06	RHMW20(BB) [a]	NMW23 (XA) [b]
RHMW08	RHMW09	RHP01	NMW24 (ZZ) [b]
RHMW21 (II) [b]	RHMW10	RHP02	NMW25 (TT) [b]
RHMW2254-01	RHMW11	RHP03	NMW26 (KK)
RHP07	RHMW13	RHP04A, 04B, 04C	NMW27 (QQ) [b]
	RHMW14	RHP05	NMW28 (PP) [b]
	RHMW15	RHP06 [a]	NMW29 (MW1) [b]
	RHMW16	RHP08 [a]	NMW30 (MW3) [b]
	RHMW17		HDMW2253-03

[a] Drilling and well installation activities currently in progress
[b] Proposed for future installation

In addition, Figure 2 shows the location of the surrounding water supply wells identified in Section 1.1 that are the main potential exposure points for groundwater impacts to human health.

The following wells are or will be located between the Facility and the BWS Hālawa Shaft to the north and the Navy 'Aiea Hālawa Shaft to the west:

- Eleven Compliance Wells located near the Facility perimeter: RHP01, RHP02, RHP03, RHMW04, RHMW06, RHMW11, RHMW13, RHMW14, RHMW16, RHMW17, RHMW20(BB)
- Six offsite Sentinel Wells: RHMW12A, HDMW2253-03, NMW22 (MM), NMW23 (XA), NMW27 (QQ), NMW28 (PP)

The following wells are or will be located between the Facility and the BWS Moanalua water supply wells to the south:

- Ten Compliance Wells located near the Facility perimeter: RHP04A, RHP05, RHP06, RHP08, RHMW05, RHMW09, RHMW10, RHMW15, RHMW18, RHMW19
- Two offsite Sentinel Wells: NMW25 (TT), NMW30 (MW3)

2.3.2 Groundwater Action Levels

Groundwater action levels for this GWPP were referred to as "trigger levels" in the original 2008 GWPP and 2014 Interim Update (DON 2008; 2014b). At the time of the 2014 Interim Update, the groundwater monitoring network consisted of:

- Four monitoring wells located in the lower access tunnel to the tank farm (RHMW01, RHMW02, RHMW03, RHMW05)
- One groundwater sampling point at Red Hill Shaft (RHMW2254-01)
- One background monitoring well (RHMW04)

At that time, the focus was on monitoring tank releases within the tank farm that had the potential for impacting water quality at the nearest downgradient water supply well, Red Hill Shaft. Specific risk-driving compounds in middle distillate petroleum hydrocarbon mixtures (JP-5, JP-8, Navy Marine Diesel fuel) were developed as COPCs, based on the regulatory limits at the time of the document's publication.

The groundwater monitoring network has since expanded and continues to do so to include the following:

- Release Detection Wells in proximity to the tanks to monitor for evidence of a new significant release
- Compliance Wells along the Facility perimeter monitoring for COPC concentrations in groundwater that exceed regulatory limits and may be moving off site
- Sentinel Wells to monitor and be protective of surrounding water supply wells

2.3.2.1 RELEASE DETECTION WELLS

Release Detection Wells are in close proximity to the Facility's fuel storage tanks and underground piping systems. RHMW01 RHMW02, and RHMW03 were installed in 2005 in response to regulatory requirements to begin a groundwater LTM program at the Facility. Petroleum-related compounds have been observed in these wells, including well-specific COPCs, since their initial sampling. RHMW01R was installed in 2021 in the vicinity of RHMW01 and is currently sampled in lieu of RHMW01 in the Navy's sampling program.

Some Release Detection Wells, such as RHMW08, have only sporadically shown detectable amounts of petroleum-related compounds, generally limited to TPH fractions or mixtures, rather than specific compounds. In addition, the fractions observed in these wells are generally older components that can be identified as such in the laboratory with a silica gel cleanup (SGC) process. The SGC process removes older weathered organic compounds that have polar characteristics and leaves fresh fuel components that are non-polar and thus indicative of a new release.

Other Release Detection Wells include RHP07 and RHMW2254-01, which samples the Red Hill Shaft water development tunnel.

COPCs for action-level evaluation are the polynuclear aromatic hydrocarbon (PAH) compounds naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene; and TPH fractions (TPH-diesel and residual oil range organics [TPH-d and TPH-o]). In addition, a second aliquot of each sample will be processed through SGC and analyzed for TPH-d and TPH-o. The TPH-SGC results will be evaluated for fresh (non-polar) hydrocarbons that could be indicative of a new release. Action levels are listed in Table 2-2.

Table 2-2: Action Levels for Release Detection Wells

Release Detection Well	Action Level (µg/L)						
	TPH-d	TPH-d (SGC)	TPH-o	TPH-o (SGC)	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene
RHMW01R	670	320	720	330	0.5	0.5	0.5
RHMW02	4,000	1,400	860	340	56	30	26
RHMW03	470	200	660	350	0.5	0.5	0.5
RHMW08	300	300	450	300	0.5	0.5	0.5
RHMW2254-01	300	300	450	300	0.5	0.5	0.5
RHP07	300	300	450	300	0.5	0.5	0.5

µg/L micrograms per liter
SGC silica gel cleanup
TPH-d total petroleum hydrocarbons, diesel range
TPH-o total petroleum hydrocarbons, residual oil range

These action levels are based on the evaluation of 148 weekly groundwater sampling results from RHMW01R, RHMW02, RHMW03, and RHMW05 collected between May 12, 2021 and January 24, 2023. Appendix A presents the well-specific action levels compared to the analytical results for the COPC for each well. These results are described in detail in the Navy's ongoing series of Quarterly Release Response Reports (DON 2023b).

2.3.2.2 COMPLIANCE WELLS

Compliance Wells located near the Facility boundary will be sampled to identify whether COPCs are migrating beyond the Facility boundaries above regulatory action levels. If groundwater sampled from these Compliance Wells does not exceed regulatory action levels, it is assumed that water is not migrating off site above these regulatory limits and that the Facility is in compliance for this objective. Currently, 17 Compliance Wells are located near the Facility perimeter, and installation of four additional wells is in progress, as described in Section 2.3.

As presented in the May 2023 groundwater sampling program consolidation and optimization memorandum (DON 2023), these wells will be tested for the petroleum-related compounds listed in Table 2-3 and screened against the DOH Environmental Action Levels (EALs) sourced from the DOH-EAL-Surfer-Fall-2017 guidance document, Summary Table A (Soil and Groundwater, for groundwater greater than 150 meters of a surface water body) (DOH 2017). These Compliance Wells are screened in basal water that does not empty into any nearby surface water tributary located within 150 meters of the Facility (the tributaries are at least 50 feet vertically above the basal aquifer in these areas).

Table 2-3: Action Levels for Compliance Wells – DOH EALs, Groundwater IS Current or Potential Source of Drinking Water

Contaminant	Action Level (µg/L)
TPH (gasolines)	297
TPH (middle distillates)	401
TPH (residual fuels)	500
Benzene	5
Toluene	40
Ethylbenzene	30
Xylenes	20
1-Methylnaphthalene	10

Contaminant	Action Level (µg/L)
2-Methylnaphthalene	10
Naphthalene	17
1, 2-Dibromoethane	0.04
1,2-Dichloroethane	5
Phenol	300
2-(2-Methoxyethoxy)ethanol [a]	800
Acenaphthene	20
Acenaphthylene	236
Anthracene	0.18
Benzo(a)anthracene	0.03
Benzo(a)pyrene	0.20
Benzo(b)fluoranthene	0.22
Benzo(g,h,i)perylene	0.13
Benzo(k)fluoranthene	0.40
Chrysene	1
Dibenzo(a,h)anthtracene	0.022
Fluoranthene	13
Fluorene	236
Indeno(1,2,3-cd)pyrene	0.1
Phenanthrene	214
Pyrene	68

Source: Appendix 1, Table D-1a (<150m to Surface Water Body) and Table D-1b (>150m to Surface Water Body) (DOH 2017).
[a] 2-(2-Methoxyethoxy)ethanol (CAS No. 111-77-3) is a common de-icing additive that the Navy has added to jet fuel (JP-5 and JP-8). It has no established EAL; the action level (800 µg/L) is from EPA (2023) Regional Screening Levels (RSLs) for residential exposure, for noncarcinogenic health risks.

2.3.2.3 SENTINEL WELLS

Sentinel Wells are currently being planned and will be installed after the Navy obtains access and completes permitting requirements. Once installed, these wells will be used to assess groundwater conditions between potential releases within the Facility and the potential offsite receptors identified in Section 3.2: BWS Hālawa Shaft; Navy ‘Aiea Hālawa Shaft; TAMC-MW-2; and Moanalua-1, Moanalua-2, and Moanalua-3.

The Sentinel Wells have the potential to detect releases from other sources in their proximity; therefore, not all chemicals detected in these wells should be automatically attributed to the Red Hill Bulk Fuel Storage Facility:

- If chemicals detected at these Sentinel Wells are not attributable to the Red Hill Bulk Fuel Storage Facility, they will be attributed to another offsite source and not associated with the Facility.
- If concentrations of COPCs are detected that exceed those observed at Compliance Wells, they will not be completely attributed to the Facility unless other direct evidence is observed, such as evidence of Navy de-icing additives or other forensic data.

If COPCs are detected in Sentinel Wells, DOH will be notified and the data will be evaluated for verification purposes. Included in the verification will be an immediate resampling of the Sentinel Well where the COPCs were observed, as well as a review of chromatograms, data quality control (QC) samples, and laboratory QC results.

2.4 CONTINGENCY PFAS MONITORING

PFAS sampling is performed monthly in accordance with the Consolidated Sampling Program in response to the 2022 AFFF release. This GWPP Revision specifically addresses monitoring for potential impacts to the environment associated with the Facility's upcoming defueling process. PFAS are not associated with the fuels that are currently stored in the Facility's bulk fuel storage tanks (i.e., JP-5, F-24, and F-76). Accordingly, PFAS are not chemicals of concern for the defueling process, and currently no PFAS sampling requirements are included in this GWPP Revision.

However, if AFFF is inadvertently released or used in the Facility during the defueling process, the Navy will sample the Release Detection Wells weekly for the PFAS compounds listed in Table 2-4 by EPA Draft Method 1633 and screen them against the latest DOH EALs.

Table 2-4: Action Levels for Contingent PFAS Sampling

CAS #	Chemical [a]	DOH Groundwater EAL (Revised May 8, 2023) (µg/L) [b]
45187-15-3	Perfluorobutane sulfonate (PFBS-)	1.69
108427-53-8	Perfluorohexane sulfonate (PFHxS-)	0.08
146689-46-5	Perfluoroheptane sulfonate (PFHpS-)	0.04
45298-90-6	Perfluorooctane sulfonate (PFOS-)	0.01
126105-34-8	Perfluorodecane sulfonate (PFDS-)	0.04
45048-62-2	Perfluoro butanoate (PFBA-)	14.62
45167-47-3	Perfluoro pentanoate (PFPeA-)	1.54
92612-52-7	Perfluoro hexanoate (PFHxA-)	1.92
120885-29-2	Perfluoro heptanoate (PFHpA-)	0.08
45285-51-6	Perfluoro octanoate (PFOA-)	0.01
72007-68-2	Perfluoro nonanoate (PFNA-)	0.01
73829-36-4	Perfluoro decanoate (PFDA-)	0.01
196859-54-8	Perfluoro undecanoate (PFUnDA-)	0.02
171978-95-3	Perfluoro dodecanoate (PFDoDA-)	0.03
862374-87-6	Perfluoro tridecanoate (PFTrDA-)	0.03
365971-87-5	Perfluoro tetradecanoate (PFTeDA-)	0.26
754-91-6	Perfluroroctane sulfonamide (PFOSA)	0.05
122499-17-6	2,3,3,3-tetrafluoro-2-(heptafluoropropoxy) propanoate (HFPO DA-)	0.01
425670-75-3	6:2 Fluorotelomer sulfonate (6:2 FTS-)	1.50
958445-44-8	Ammonium 4,8-Dioxa-3H-perfluoro nonanoate (ADONA-)	1.15

Source: (DOH 2023) (PFASs Surfer [Excel electronic lookup tables] April 2023 Rev 05-08-23) [2]
CAS Chemical Abstracts Service
[a] Abbreviations refer to anion form of compound, assumed to be dominant in environmental samples (noted by "-" sign after abbreviation; refer to Table 1a in November 2020 Technical Memorandum).
[b] Assumes potential impacts to drinking water source and discharge of groundwater into a freshwater, marine or estuary surface water system. Compare to dissolved-phase concentration.

[2] https://health.hawaii.gov/heer/guidance/ehe-and-eals/#ehe6

2.5 Drinking Water Long-Term Monitoring

Drinking water long-term monitoring (DW LTM) will continue to be conducted during defueling in accordance with the DW LTM Plan (DOH, DON, and DA 2022). The DW LTM Plan was developed jointly by representatives of DOH, the Navy, the U.S. Army, and a team of technical and subject matter experts as a "surveillance tool intended to continuously ensure that the water is safe to drink, meets all State and Federal drinking water standards and is free of petroleum and response by-product contamination."

The DW LTM Plan includes a trigger to sample groundwater from Well 2558-010 Waiawa Shaft if any releases occur prior to or during the defueling process.

3. Groundwater Protection Responses for Releases and Action Level Exceedances

This section describes the groundwater protection actions that will be taken if soil vapor or groundwater concentrations indicate that a fuel release may have occurred during defueling operations, a fuel release is visually observed during defueling operations, or free product is observed in a groundwater sample during defueling operations. Additional and up-to-date details on spill response planning and activities are available in the defueling plan and associated supplements on the Navy's website.[3]

To demonstrate confidence that drinking water is safe, the Navy will sample Waiawa Shaft in response to any release event that may occur during defueling operations.

Surfactants will not be used in any cleanup activities.

3.1 Visual Observation Response Actions

If an active release is visually observed, the individual observing the active release will immediately report it to the Control Room Operator at 808-471-8081 / 808-473-1075 . The Control Room Operator will initiate the spill response by activating the Red Hill Spill Notification Call Tree (DoD 2022c, Enclosure B Spill Exercise Plan, pg. 41). Additional and up-to-date details on spill response planning and activities are available in the defueling plan and associated supplements.[4]

3.2 Soil Vapor Response Actions

Response actions for exceedances of action levels for soil vapor under the fuel storage tanks identified in Section 2.2.2 are described on Figure 3A and Figure 3B.

3.3 Groundwater Response Actions

Response actions for exceedances of groundwater action are described on Figure 3A and Figure 3C.

[3] https://cnrh.cnic.navy.mil/Operations-and-Management/Red-Hill/DoD-RHBFSF-Defuel-Plan/

[4] https://cnrh.cnic.navy.mil/Operations-and-Management/Red-Hill/DoD-RHBFSF-Defuel-Plan/

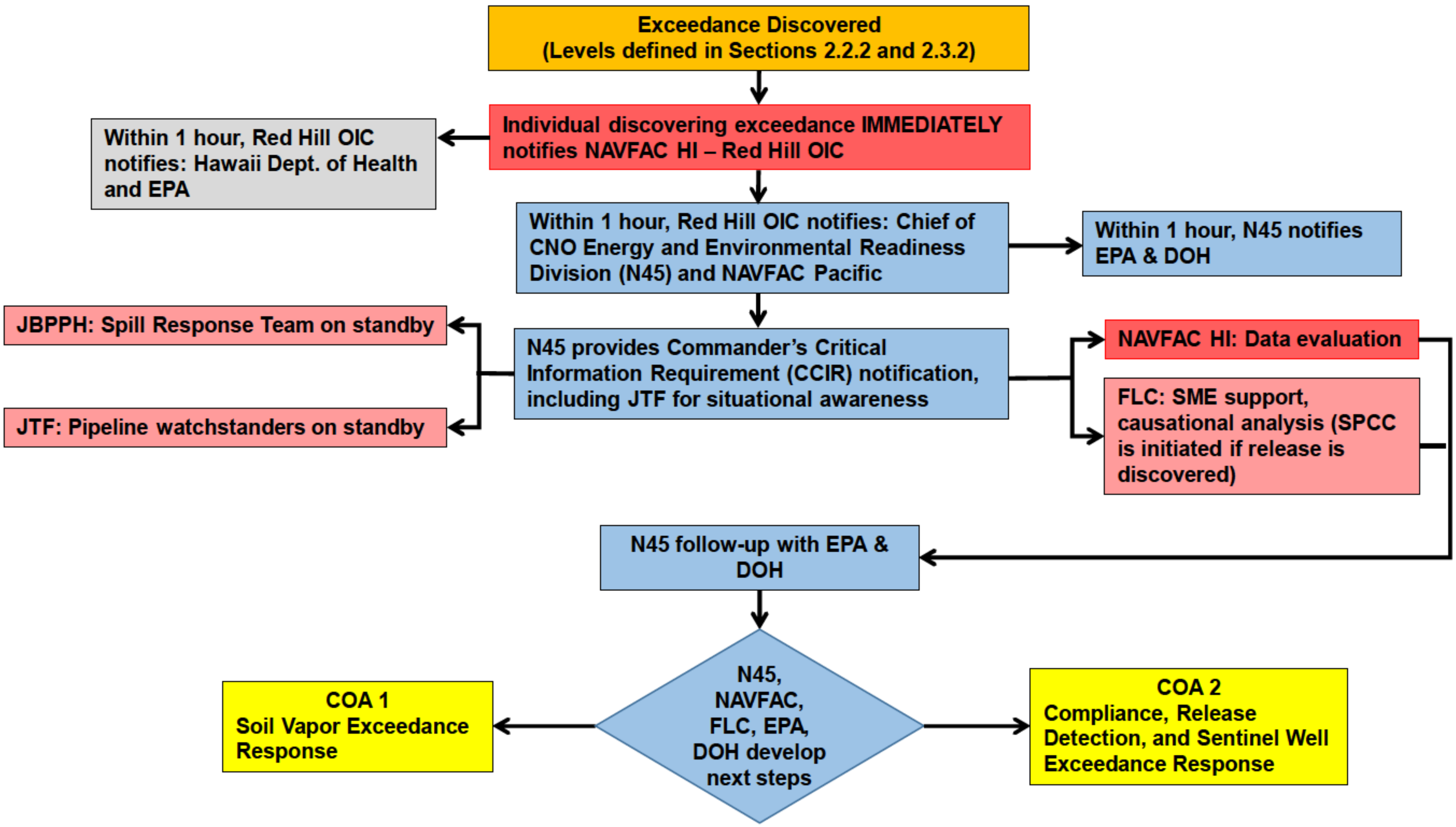

Figure 3A: Response Actions for Exceedance During Defueling

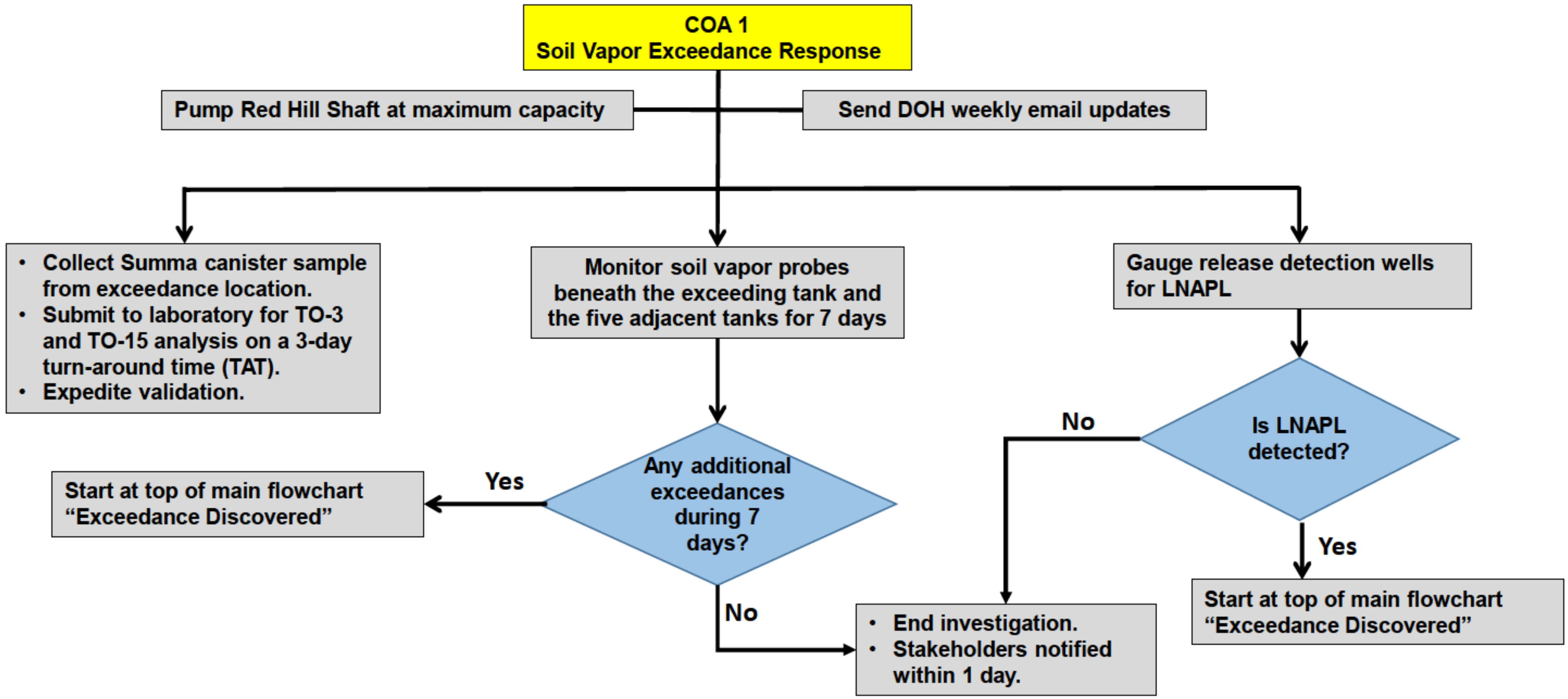

Figure 3B: Response Actions for Exceedance During Defueling

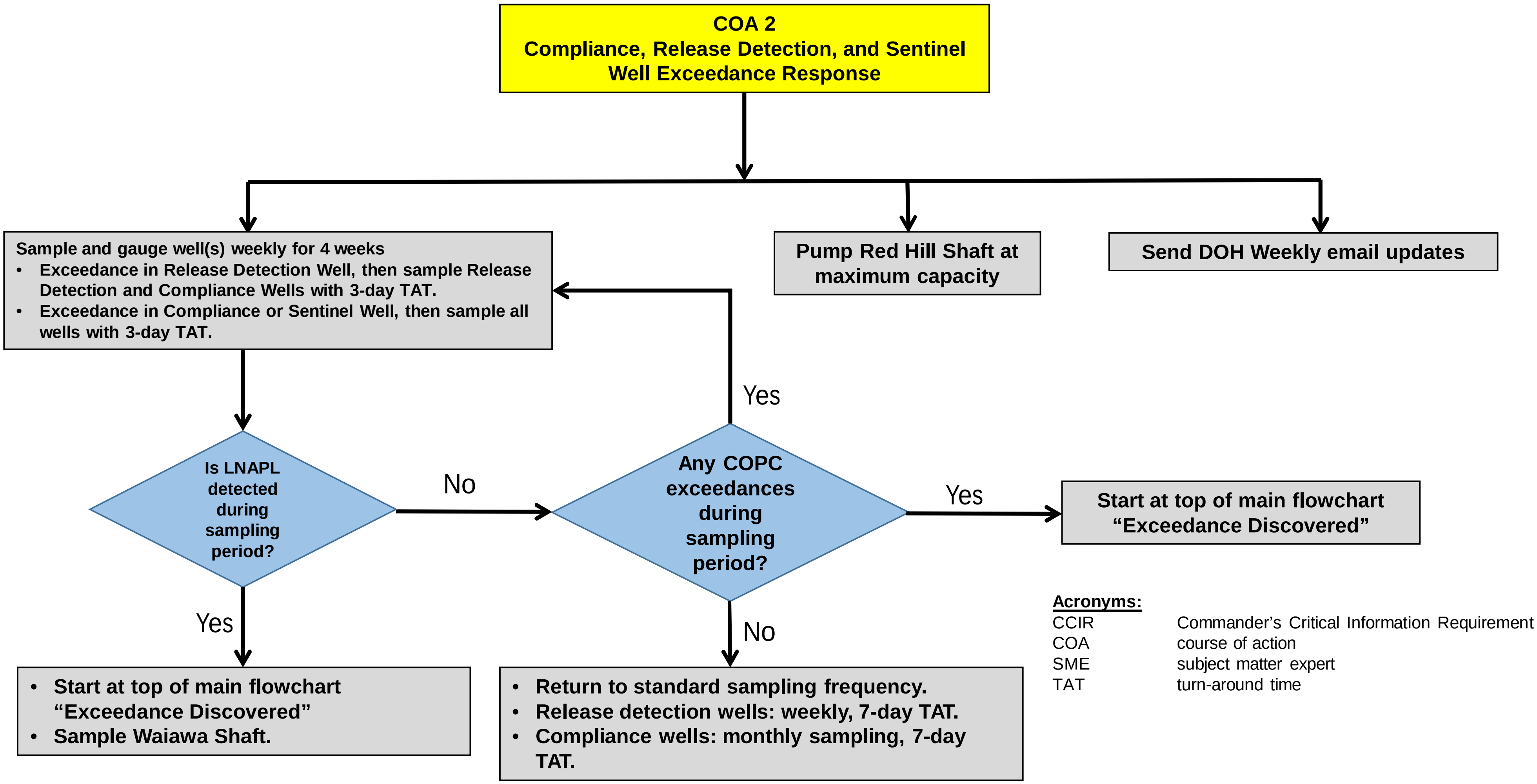

Figure 3C: Response Actions for Exceedance During Defueling

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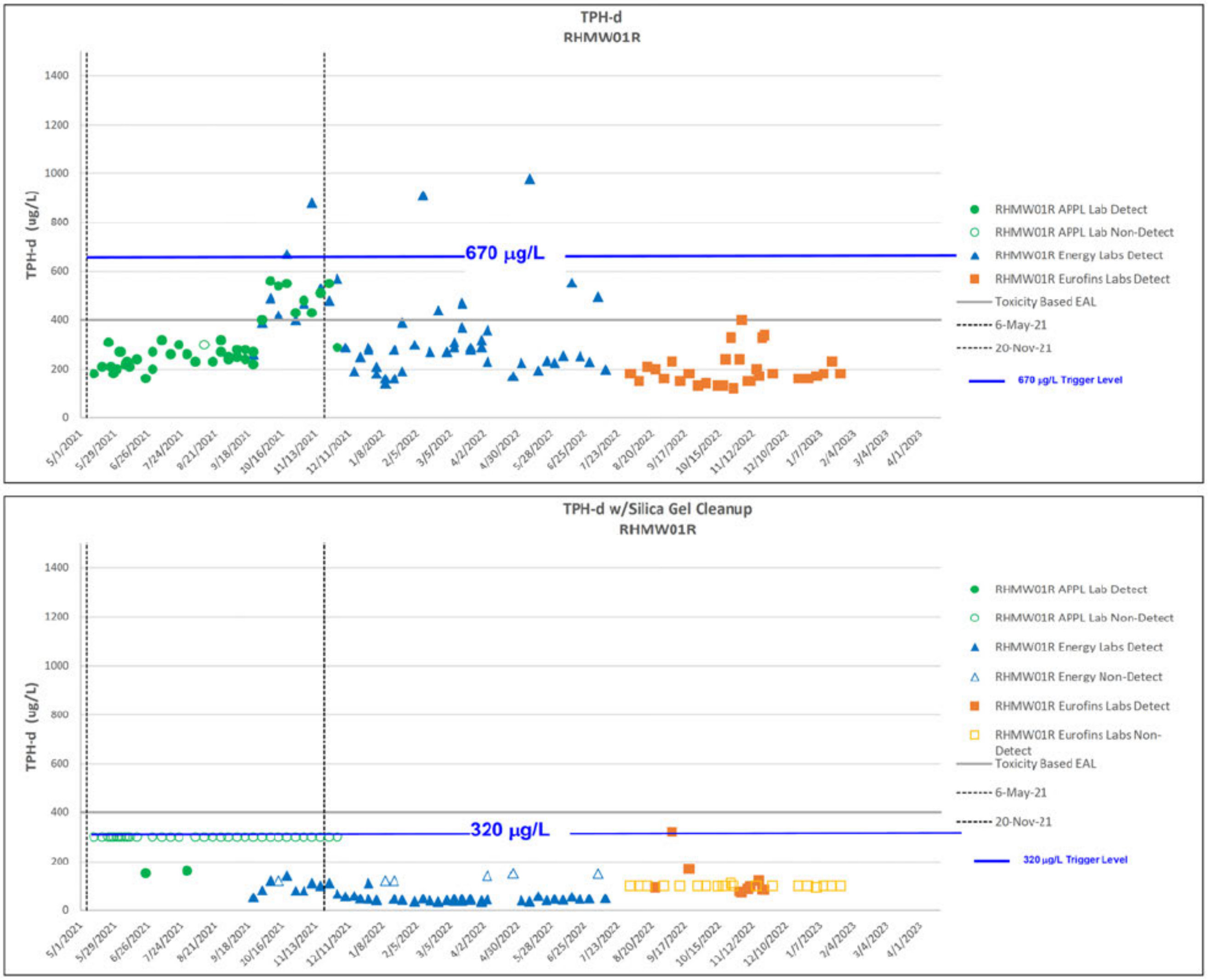
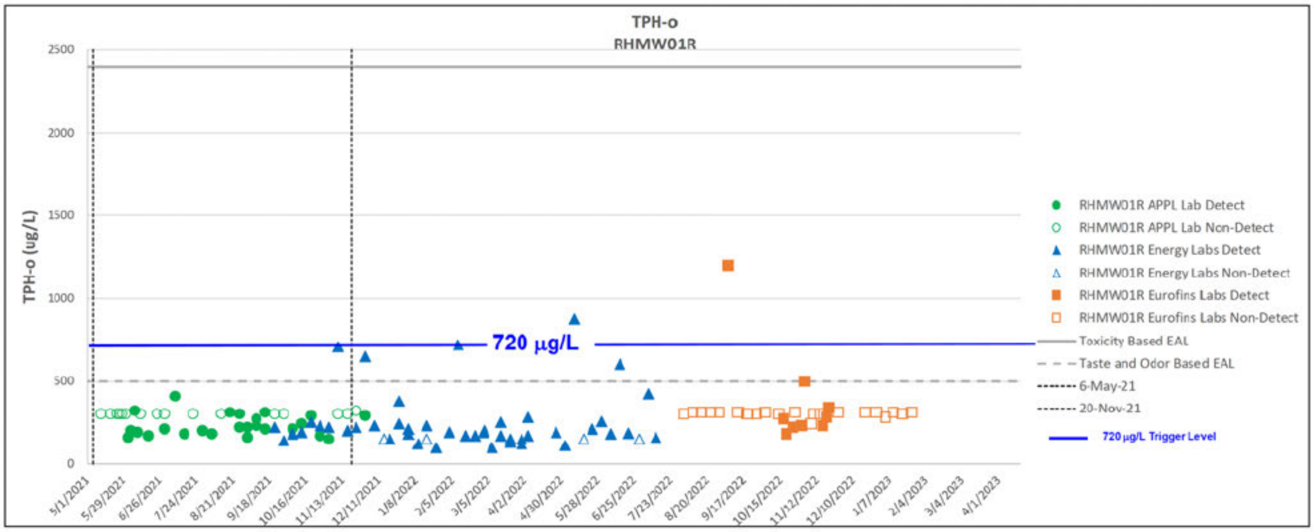


Figure APPA-1. Release Detection Trigger Levels for TPH-d in RHMW01R



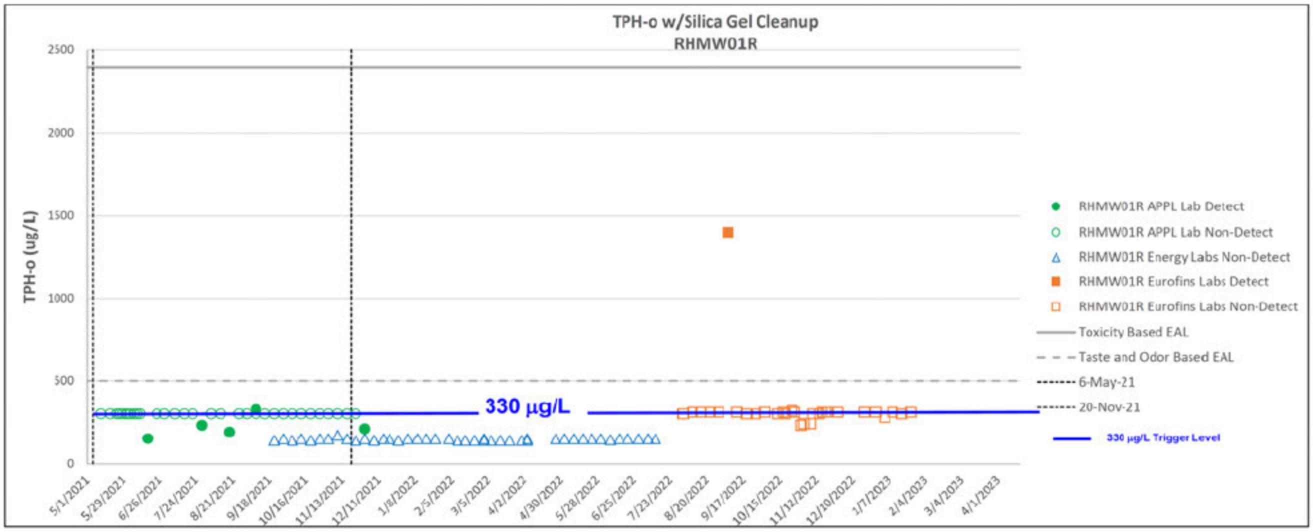


Figure APPA-2. Release Detection Trigger Levels for TPH-o in RHMW01R

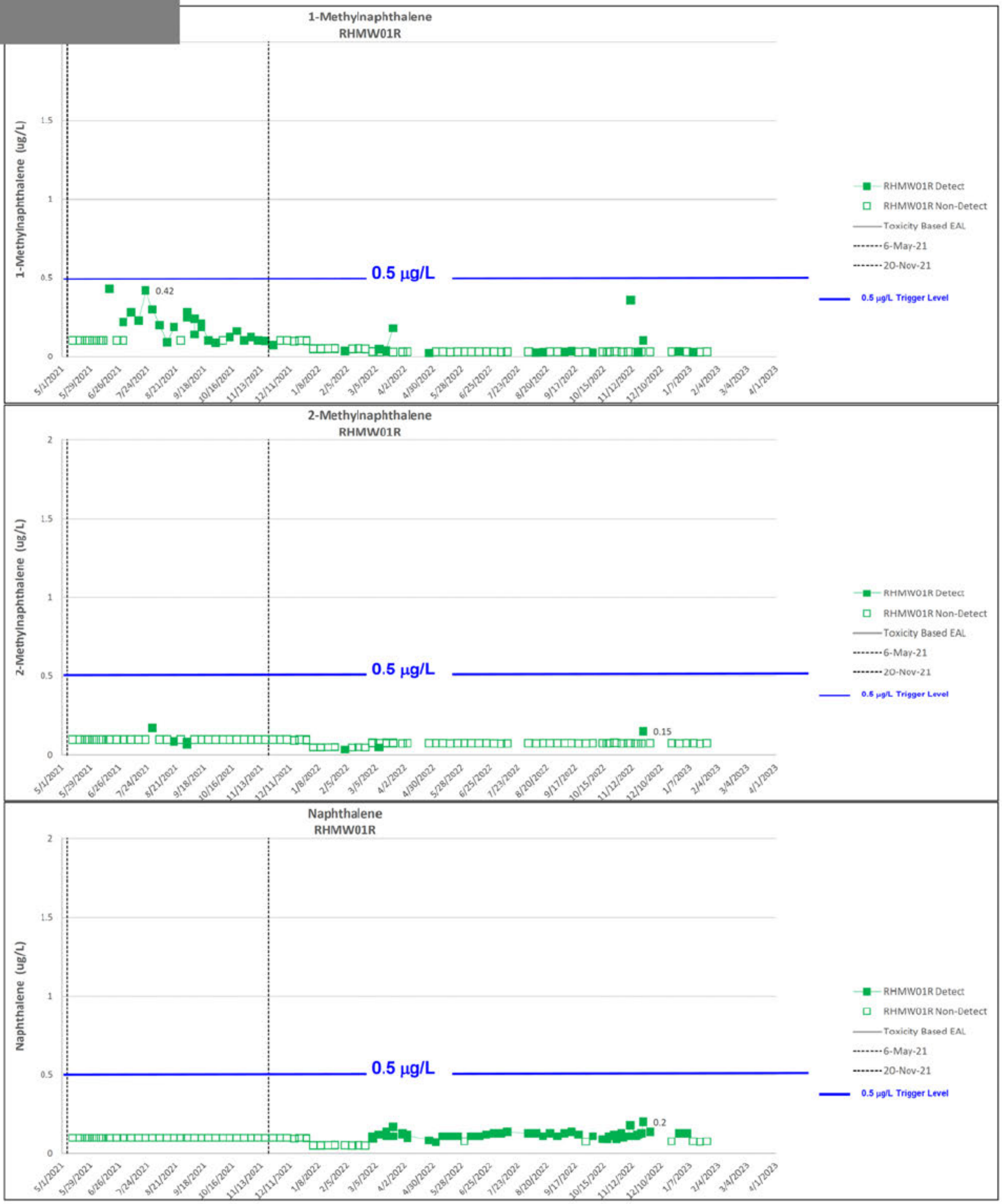
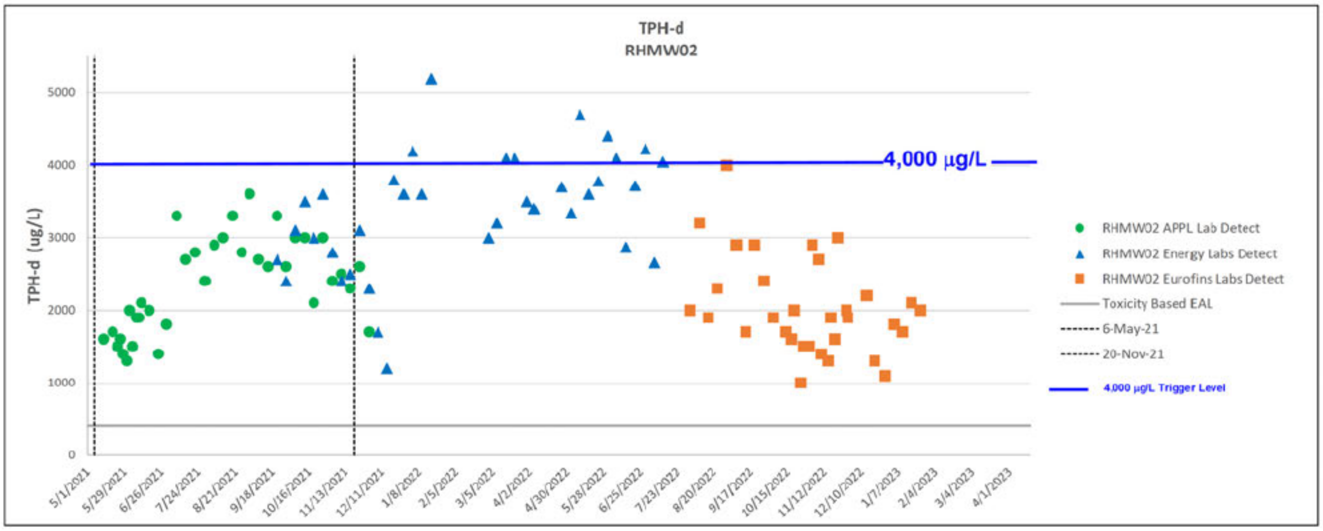


Figure APPA-3. Release Detection Trigger Levels for PAHs in RHMW01R



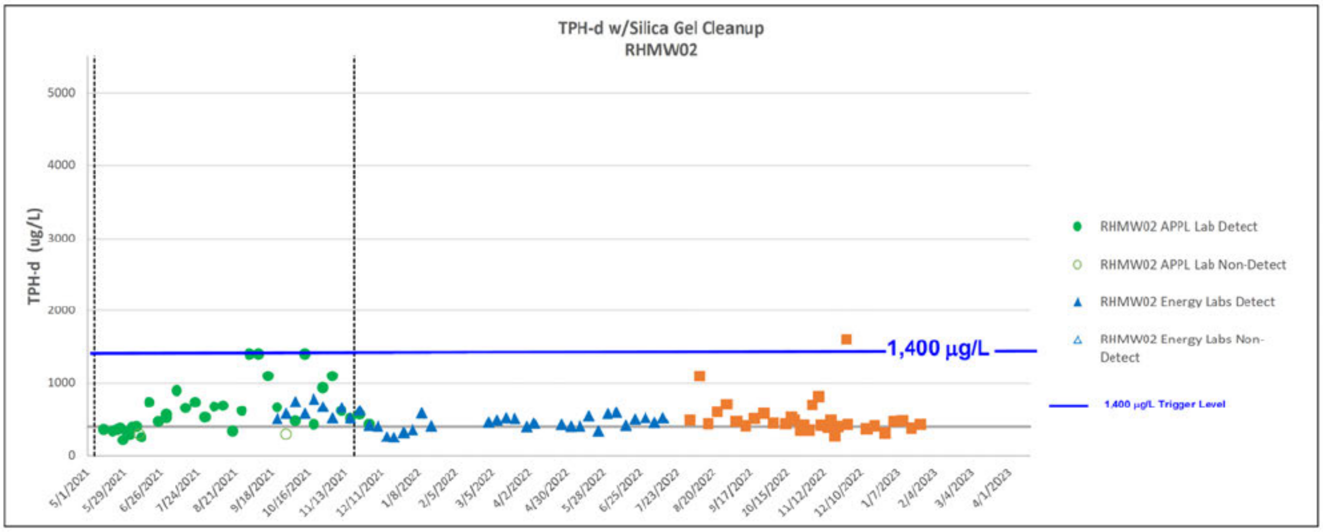


Figure APPA-4. Release Detection Trigger Levels for TPH-o in RHMW02

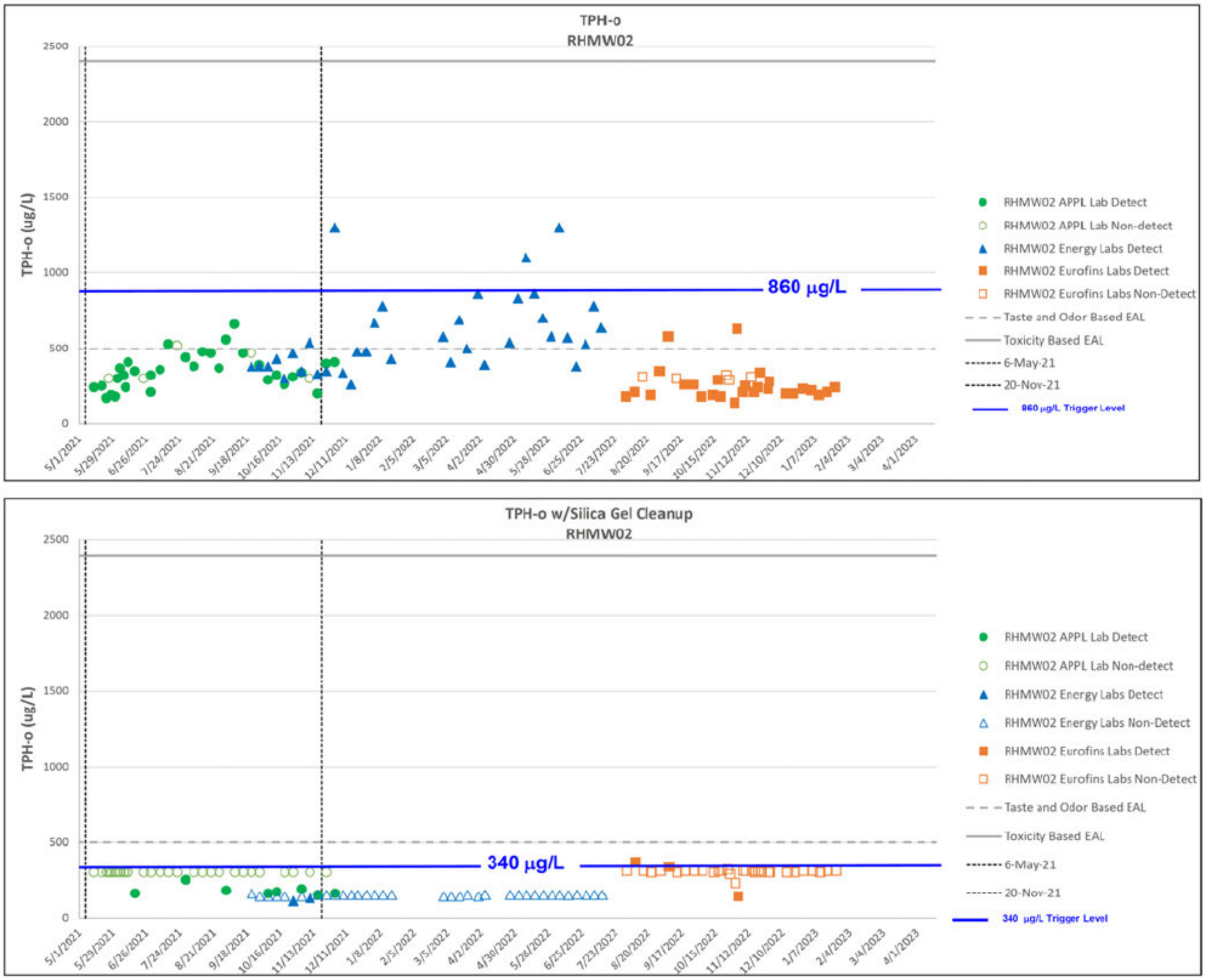


Figure APPA-5. Release Detection Trigger Levels for TPH-o in RHMW02

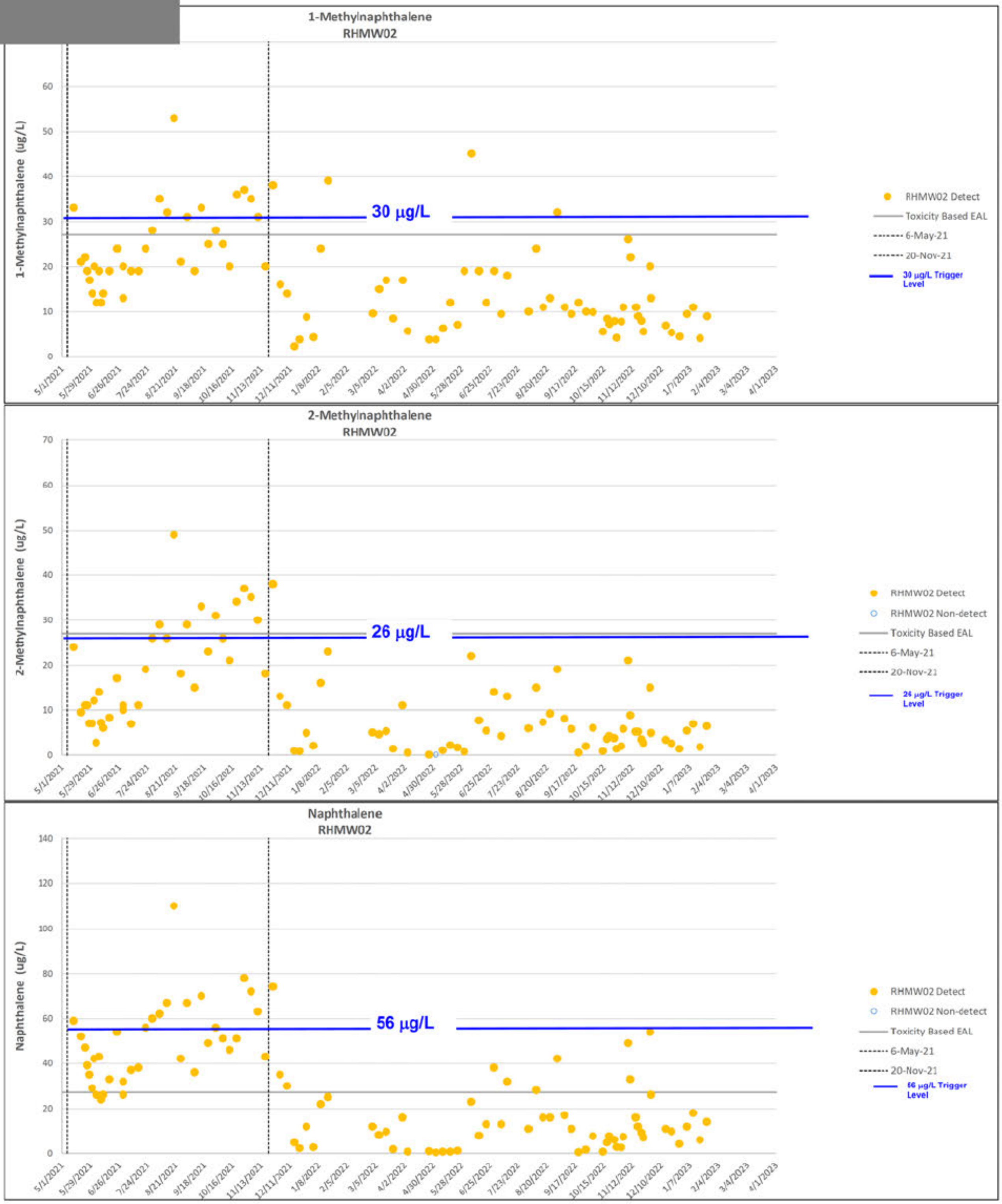


Figure APPA-6. Release Detection Trigger Levels for PAHs in RHMW02

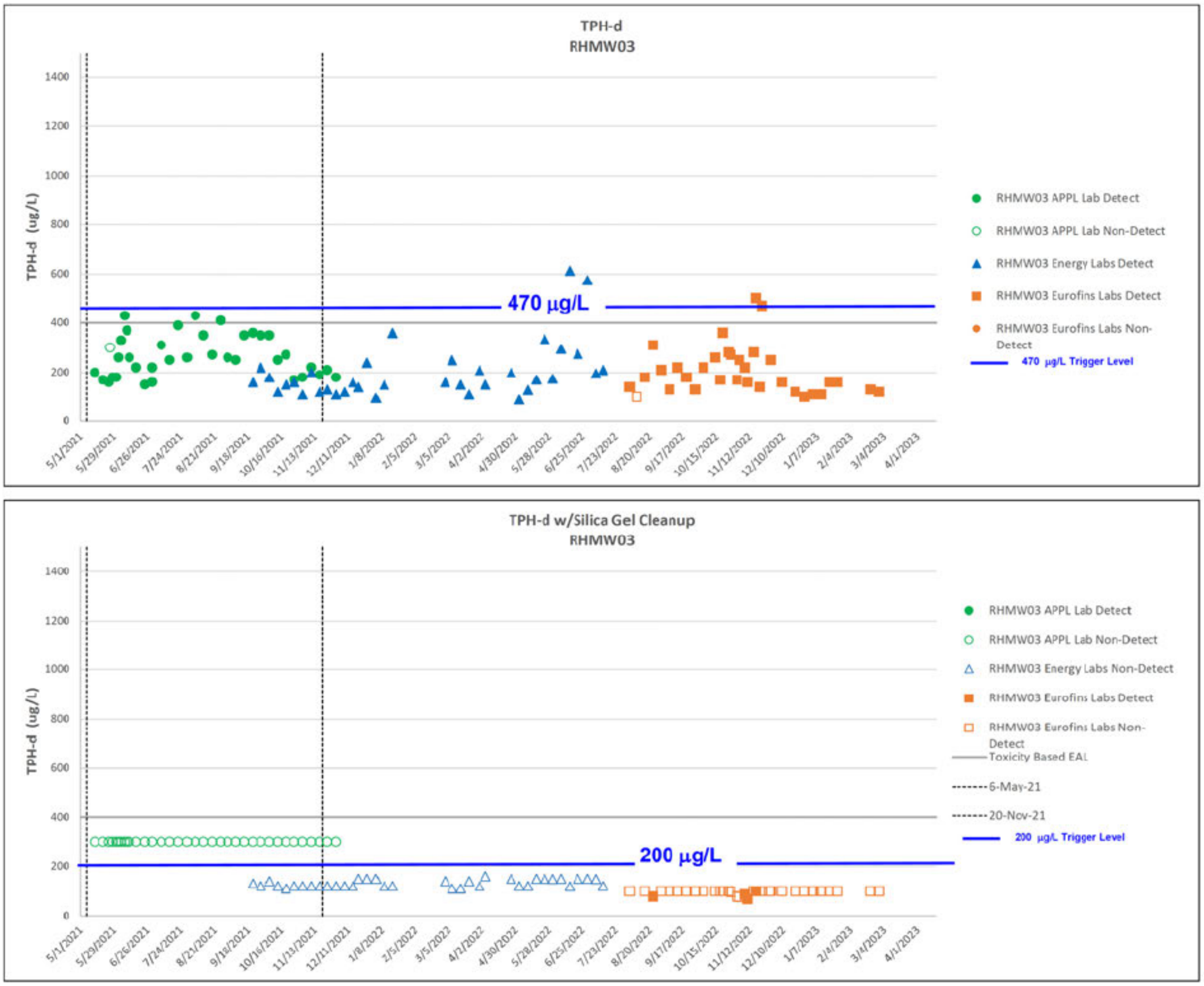
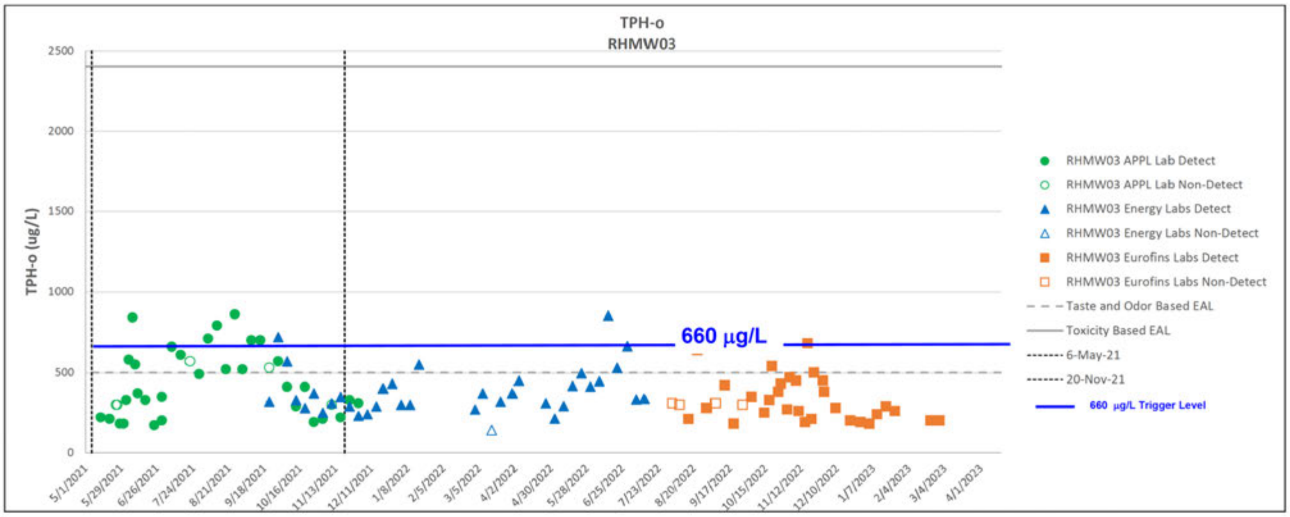


Figure APPA-7. Release Detection Trigger Levels for TPH-d in RHMW03



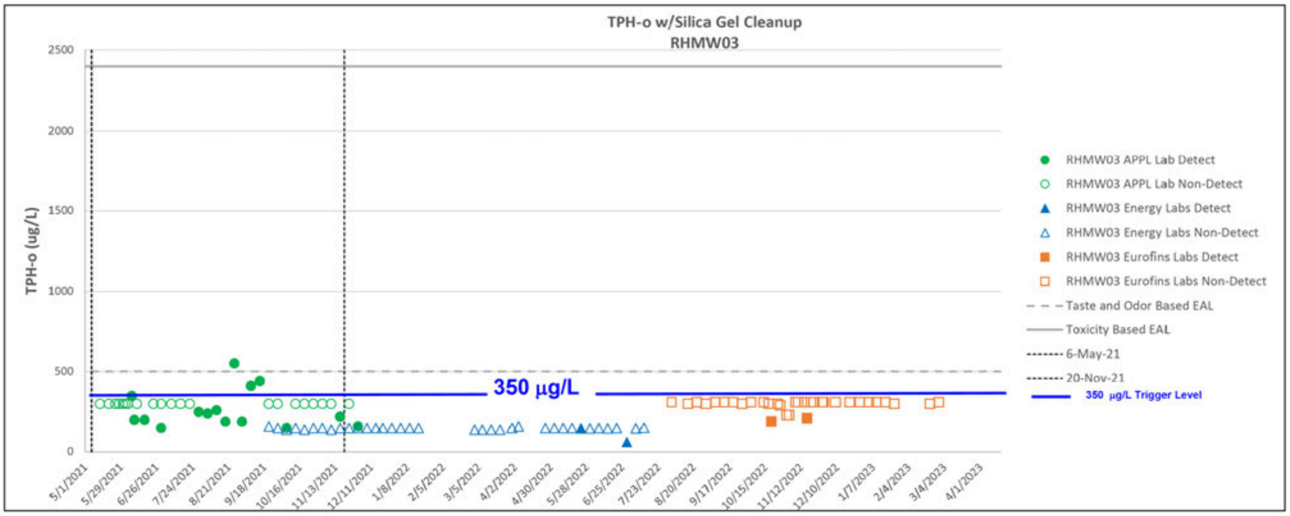


Figure APPA-8. Release Detection Trigger Levels for TPH-o in RHMW03

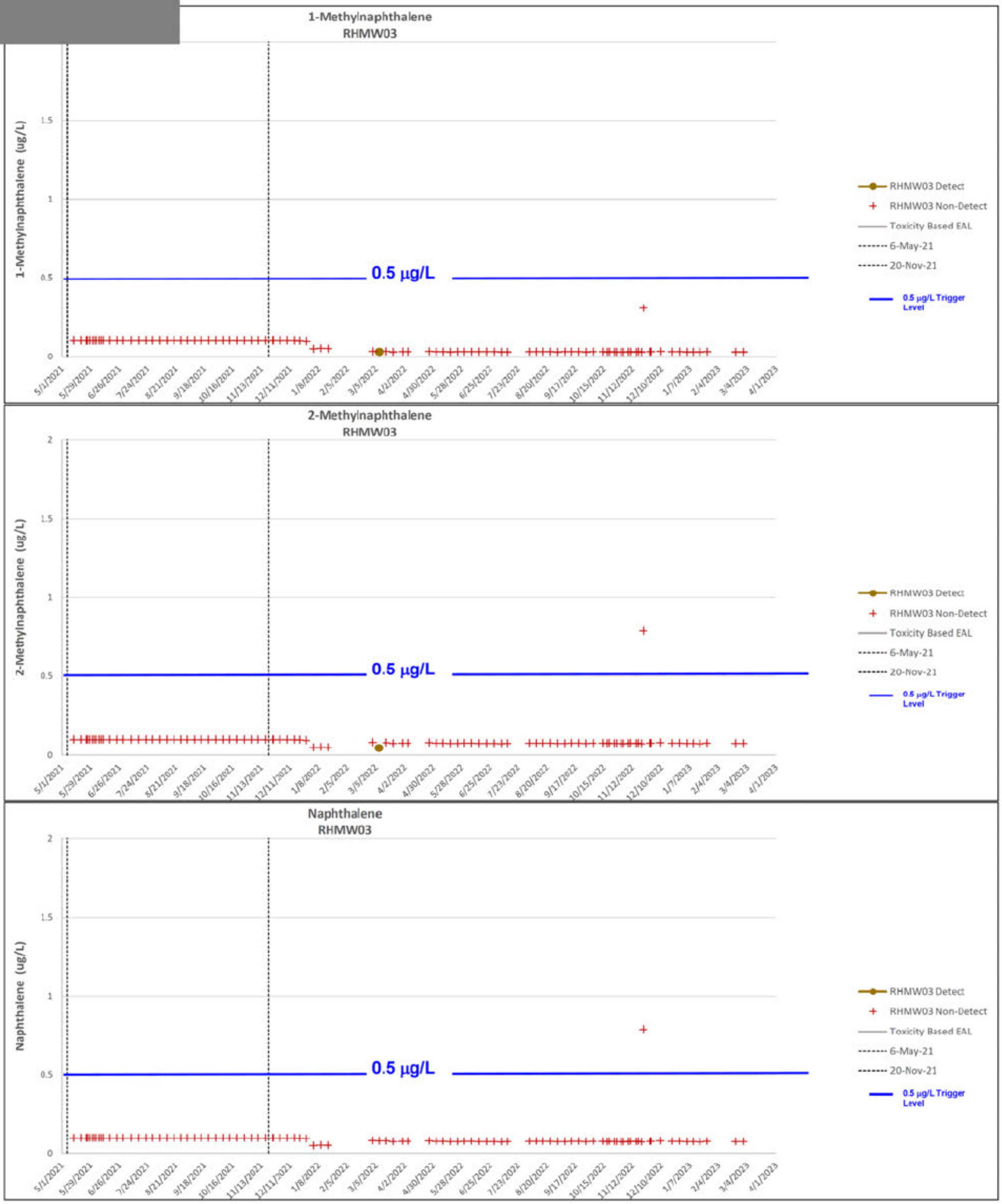
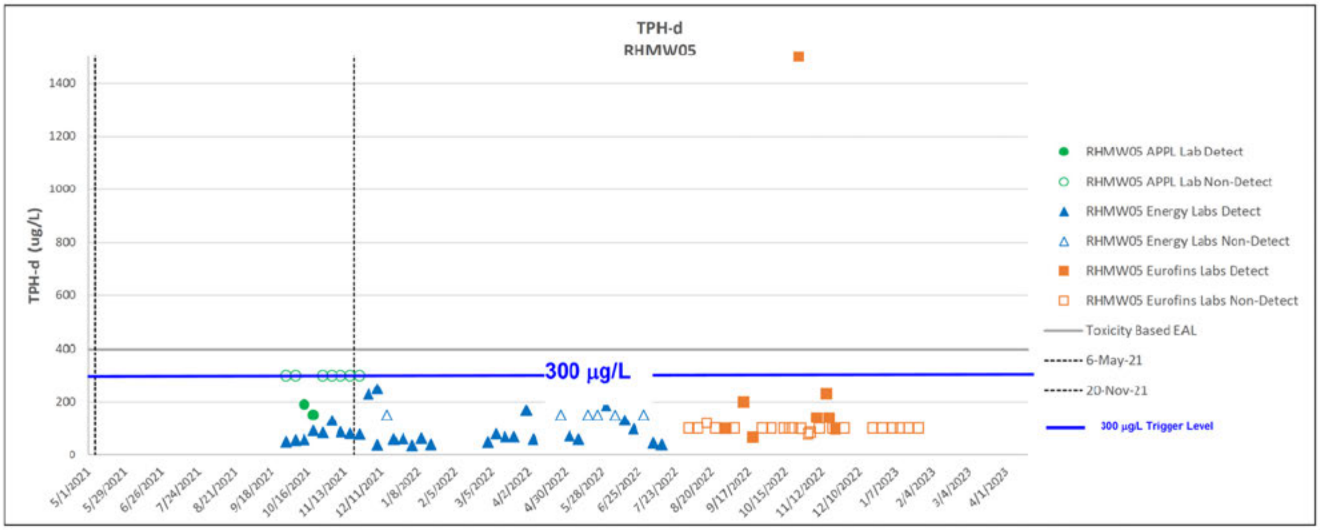


Figure APPA-9. Release Detection Trigger Levels for PAHs in RHMW03



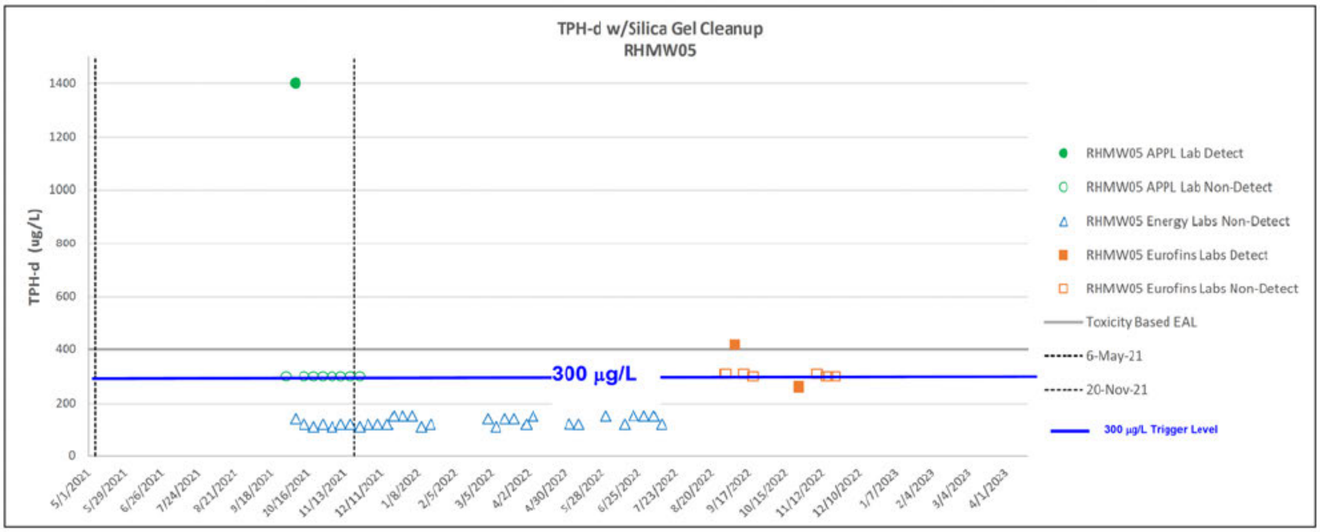
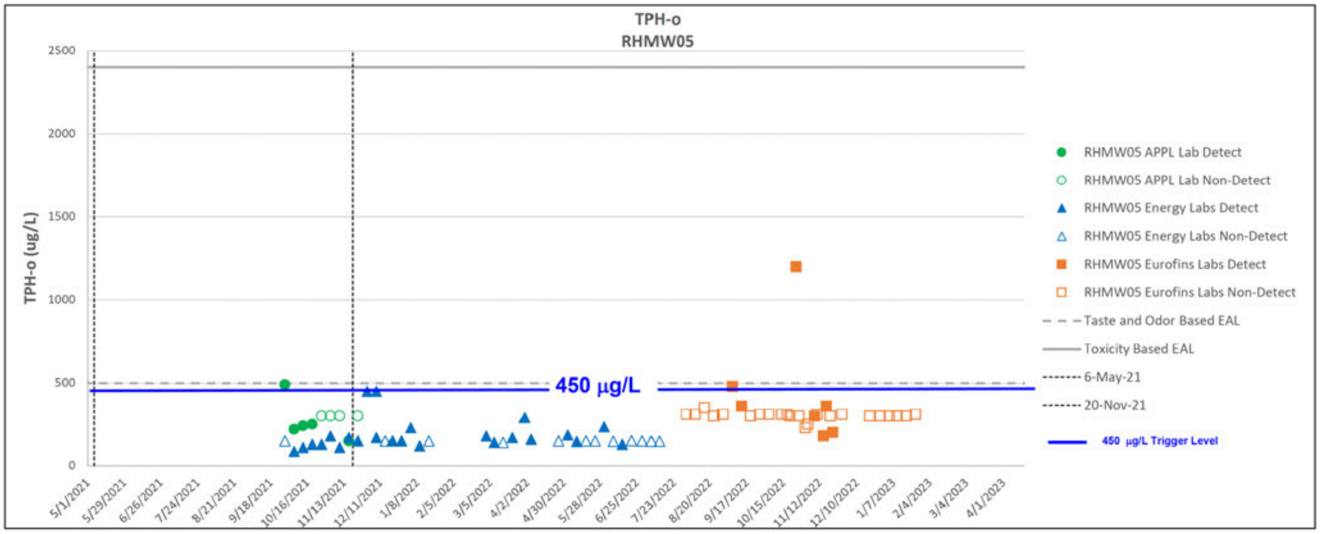


Figure APPA-10. Release Detection Trigger Levels for TPH-d in RHMW05



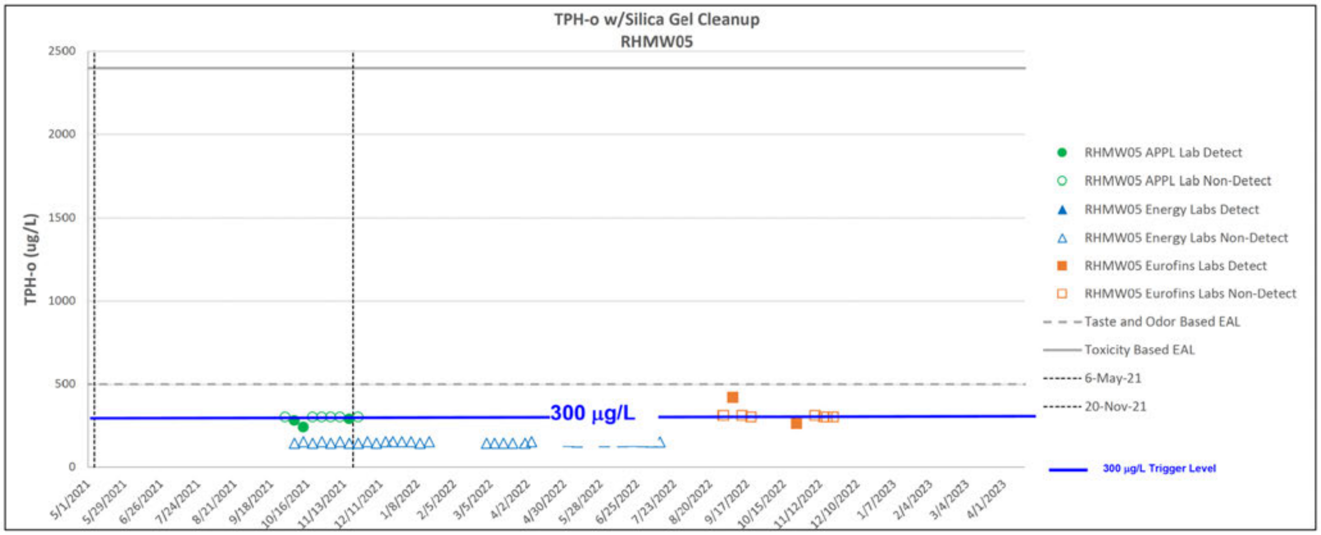


Figure APPA-11. Release Detection Trigger Levels for TPH-o in RHMW05

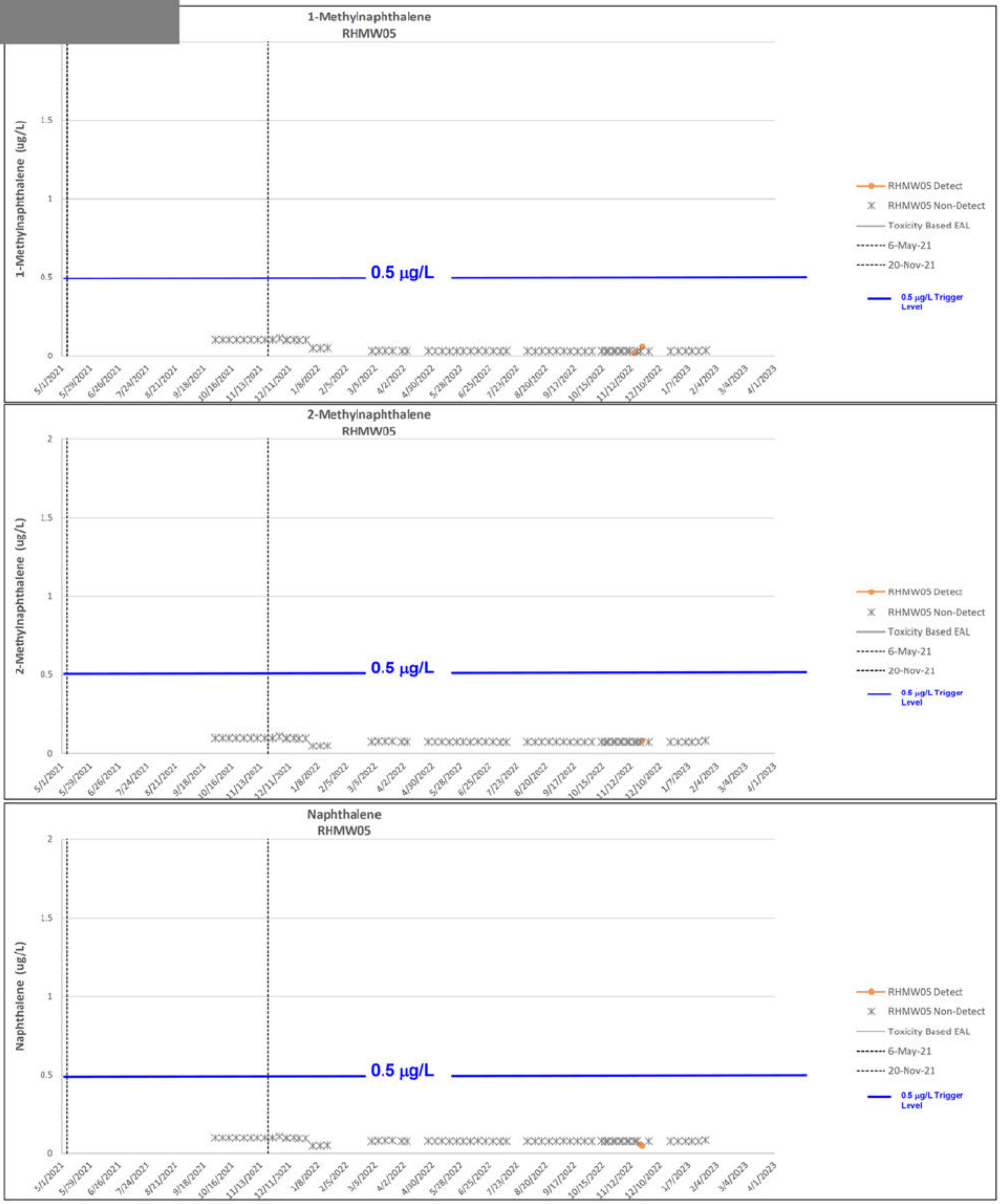


Figure APPA-12. Release Detection Trigger Levels for PAHs in RHMW05