UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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STATE OF HAWAII
DEPARTMENT OF HEALTH
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September 15, 2016

James A. K. Miyamoto, P.E.
Deputy Operations Officer
Naval Facilities Engineering Command, Hawaii
400 Marshall Road
Joint Base Pearl Harbor Hickam, HI 96860

Re: Disapproval of Red Hill Administrative Order on Consent ("AOC")- Attachment A Statement of Work ("SOW") Deliverable for Sections 6 and 7 – Work Plan/ Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility ("Facility"), May 4, 2016

Dear Mr. Miyamoto:

The U.S. Environmental Protection Agency ("EPA") and Hawaii Department of Health ("DOH"), collectively the "Regulatory Agencies", have reviewed the *Work Plan/ Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility* submitted by the U.S. Navy ("Navy") and Defense Logistics Agency ("DLA") on May 4, 2016 (hereafter referred to as "the Work Plan").The Regulatory Agencies are disapproving the Work Plan, pursuant to AOC Section 7(b)(d). **The Navy and DLA are required to resubmit the Work Plan with revisions <u>within 30 days</u> of receipt of this letter as pursuant to 7(b) of the AOC.**

The work to be conducted under Sections 6 and 7 of the SOW is critical for bounding the risk to drinking water resources from past and potential future releases at the Facility. To meet this objective, the Navy and DLA will need to gather sufficient data and conduct an analysis of the data to establish likely groundwater flow directions beneath and around the Facility in order to reasonably predict the movement of potential contamination. Achieving this objective in a manner that secures approval from the Regulatory Agencies and builds stakeholder acceptance will enable this analysis to be used to defensibly predict the probability of impact to drinking water resources from potential future releases.

The Work Plan does not adequately describe the work to be performed in order to meet the objectives of sections 6 and 7 of the AOC SOW. The Regulatory Agencies require Navy and DLA to revise the Work Plan pursuant to the comments below. In addition, the Navy and DLA must address the detailed comments included in attachment A (Regulatory Agencies Detailed Technical Comments and Observations) and attachment B (External Subject Matter Expert Comments).

Comments

1) **The work described in the Work Plan is not structured in a manner that supports an iterative and scientifically robust approach for achieving the AOC objective of adequately understanding subsurface conditions to characterize the consequences of releases from the Facility.** The Work Plan must be revised to adequately describe the process for implementing the AOC requirements in a manner that allows for sufficient review, by the Regulatory Agencies and external subject matter experts, of methods, decisions and assumptions to be used to develop the required products outlined in sections 6 and 7 of the AOC SOW. For example, the workplan should include the following:
    a. description of the process for constructing initial conceptual site model;
    b. description of the process for compiling all relevant historic data and creating data summary report;
    c. description of the approach proposed to assess the quality of historic information;
    d. description of the proposed content and format of deliverables;
    e. description of the limitations and sensitivity of existing groundwater model;
    f. description of the approach proposed to make improvements to the numerical flow model;
    g. description of the approach proposed to assess degradation rates of fuel in the subsurface under the range of potential release scenarios;
    h. description of the approach that will be used to gather Regulatory Agency and external subject matter input at important decision points in the process of implementing the work;
    i. description of the approach proposed for assessing adequacy of sentinel network; and
    j. description of the process to be used to update the groundwater protection plan.

2) **The conceptual site model presented in the Work Plan is an incomplete representation of existing data and does not adequately acknowledge uncertainty related to the conditions around the Facility.** Instead of presenting an inadequate conceptual site model in the workplan, the workplan should be revised to describe the process and approach that will be used to create a defensible initial conceptual site model, and subsequent updates to the conceptual site model, that acknowledges uncertainty and is based on all data available for the site. The Regulatory Agencies suggest the Navy and DLA submit for Regulatory Agency approval, a stand-alone plan for developing and updating the conceptual site model rather than combining it in the overall Work Plan.

3) **The conceptual site model needs to evaluate NAPL movement in the saturated and unsaturated zones for the purposes of risk characterization.** The plan for the conceptual site model needs to describe an approach for evaluating the potential migration rates and directions for NAPL movement from all areas of the Facility. Estimation of NAPL migration from potential releases identified as part of the Section 8 work is needed to characterize the consequences of potential future releases. In order to do this, the plan will need to describe how the lithology data will be used to estimate the probable NAPL migration direction, the fraction of NAPL that is expected to be immobilized in the vadose zone, and the fraction of released NAPL expected to reach the water table either as LNAPL or dissolved phase contamination. The Work Plan should further provide a plan for assessing the potential migration of LNAPL on the water table.
4) **The Work Plan needs to include a deliverable that adequately describes the existing data available to be used for the modeling effort and assesses the adequacy of the data to achieve the objectives of the AOC.** The Navy and DLA should compile all existing data, including but not limited to groundwater chemistry data, water table elevation data, precipitation data, groundwater production data, aquifer test data, boring logs, tank barrel logs, and other relevant data into a standalone deliverable for the Regulatory Agencies' review and approval. This document should not only present the existing data, but assess the quality and limitations of the data for the purposes of satisfying the objectives of the AOC.
5) **The Work Plan does not describe how groundwater flow paths will be determined since groundwater gradients and groundwater flow direction are not always coincident.** Anisotropy, formation heterogeneity, and subsurface structures can result in groundwater flow paths not adequately characterized by groundwater gradient. The Work Plan needs to specify how these factors will be evaluated and their impact on groundwater flow patterns assessed.
6) **The Work Plan does not adequately describe how the groundwater flow model will be updated, recalibrated, assessed for sensitivity, and ultimately utilized as a tool to inform future work to be performed.** The Work Plan should be revised so that the model refinement effort is transparent and provides appropriate opportunity for Regulatory Agency and external subject matter expert involvement. During this effort, the Regulatory Agencies expect that numerous professional judgements will be exercised. The Work Plan should describe how these professional judgements and other assumptions will be incorporated and documented as the model is refined. Given the model's importance in future work to be performed under the AOC, the modeling effort should strive to achieve a team approach that involves individuals with demonstrated expertise and experience. The desired expertise is describe further in the attached Regulatory Agency Detailed Technical Comments - Attachment A.
7) **The Work Plan does not adequately describe how the assessment of attenuation rate of fuel in the vadose zone and saturated zone will be evaluated as part of this effort.** Navy and DLA should present a plan for collecting and analyzing data to evaluate and bound the likely rate of fuel attenuation in the subsurface from the range of releases that could occur at the Facility. Understanding the likely range of attenuation rates is important for both the development of the conceptual site model and for the fate and transport modeling effort. Adequate understanding of attenuation of hydrocarbon relative

to releases at the Facility is important for accurate characterization of the consequences of releases.

8) **The Work Plan does not sufficiently describe how an adequate sentinel monitoring well network will be established for early detection of contaminants from the Facility that may threaten drinking water production facilities.** The Navy and DLA shall present a plan for evaluating and establishing a sentinel network for the existing groundwater production points that will provide sufficient certainty that any contaminants approaching these production points can be detected adequately and in a timely manner to allow for execution of contingency measures in a manner that will prevent contaminated groundwater from entering the drinking water distribution networks.
9) **The Work Plan does not describe how the results of the groundwater investigation and resulting modeling will be used to establish risk based decision criteria.** The Navy and DLA shall present a plan to integrate the risk assessment of section 8 of the AOC SOW with the data collected and models generated by section 7 to establish risk based criteria for the Groundwater Protection Plan and any emergency response plans that are developed to mitigate or prevent impact of groundwater resources by a fuel release.
10) **The Work Plan does not present an adequate process to assess the quality, sensitivities, and potential uncertainties of the current groundwater model that Navy and DLA are proposing to update in order to satisfy the objectives of the AOC.** Navy and DLA shall submit a groundwater model evaluation plan that describes a process for review of the existing groundwater model in a manner that identifies uncertainties and describes options for reducing uncertainty. This plan should include an evaluation of the benefits of additional aquifer tests to further reduce uncertainty. The Work Plan should also analyze how the most recently collected data fits the previously calibrated groundwater model.
11) **The Work Plan does not adequately describe the content and organization of deliverables, project schedules, and opportunities for Regulatory Agencies and external subject matter expert review of assumptions and information used to develop deliverables.** The Navy and DLA shall provide an outline of deliverables to be produced including an outline of groundwater monitoring reports, investigation reports, modeling reports, and other relevant reports. This outline of deliverables shall identify the tables, graphs, charts, and figures proposed for these deliverables. The Navy and DLA shall also provide a project schedule describing the work to be performed under sections 6 and 7 of the AOC SOW, including a schedule for activities including, but not limited to data collection events, interim deliverables, final deliverables, comment periods, and decision meetings. In developing this schedule, the Navy and DLA shall make a good faith effort to reduce as much as possible the duration of time between sample collection and data reporting to the Regulatory Agencies.

In order to expedite the work to be performed, we strongly suggest that this Work Plan be simplified. It should focus on the work to be performed and reserve the presentation of historical background data and other information to the individual deliverables outlined in the revised Work Plan. An acceptable work plan will need to describe the approach to creating the deliverables, describe the process for making decisions related to data quality and data accuracy, describe the expected content and format for the deliverables, and describe the schedule for creating the deliverables.

We are available to discuss our comments in more detail. Please contact us with any questions. Bob Pallarino can be reached at (415) 947-4128 or at pallarino.bob@epa.gov and Steven Chang can be reached at (808) 586-4226 or at steven.chang@doh.hawaii.gov.

Sincerely,

for BP

Bob Pallarino
EPA Red Hill Project Coordinator

Steven Chang, P.E.
DOH Red Hill Project Coordinator

Enclosures

cc: Captain R. D. Hayes
Mr. Stephen Turnbull, U.S. Navy

ATTACHMENT A – Regulatory Agencies Detailed Technical Comments

Comment 1

Section 2.1.1, Site Description, Page 2-1

Lines 4-11

- The Scope of work should clearly define the boundaries of the site, study areas and modeling domain. The yellow line on Figure 1, page 2-3 indicates the site boundaries. The Regulatory Agencies assume the study area is the entire area as presented in Fig. 1. The Navy should clarify the study area boundaries and use these definitions throughout the document.

Comment 2

Lines 25-29

- Similar to the comment the Regulatory Agencies made on the Monitoring Well Installation Work Plan ("MWIWP"), we believe it is incorrect to characterize the Red Hill Navy Supply Well as downgradient from the tanks. The terms "down gradient" and "cross gradient" are used throughout this SOW/WP, however the regulatory agencies believe this SOW/WP needs to reflect the uncertainty about the actual groundwater flow paths in the study area.

  Since the actual downgradient direction in the vicinity of Red Hill has not been adequately defined, this sentence should acknowledge that uncertainty by stating the importance of this and other investigations to characterize groundwater flow patterns beneath the footprint of the facility. It would be more accurate to state, "the assumed down gradient direction" or similar due to lack of certainty of local groundwater gradients beneath the facility.

  A consistent distance between the well 2254-01 and the USTs needs to be used. This issue was also discussed during the MWIWP review and changes similar to those agreed upon in finalizing the MWIWP are required in this SOW/WP. It seems most appropriate to use the distance from the east end of the infiltration gallery to UST 1 (approximately 1,500 ft).

Comment 3

Section 2.1.2, Site History, Page 2-2

Lines 18-22

- The construction sequence of tanks is not described accurately. Upper domes were constructed first, cavity for tank barrel and bottom blasted and excavated and then barrel and bottom of tank were constructed.

Comment 4

Lines 36-38

- The statement, "Test results from Navy Supply Well 2254-01 and the BWS wells' samples indicated that no petroleum constituents had reached the groundwater in the months following the release," incorrectly paraphrases the Red Hill Storage Facility Task Force Report from 2014. That report indicated that no petroleum compounds were detected in drinking water wells. It did not state that petroleum constituents were not detected in the groundwater. Elevated TPH concentrations detected at RHMW02 after the January 2014 tank 5 release were almost certainly related to that release, indicating that petroleum constituents did reach the groundwater.

Comment 6

Page 2-9

Lines 15-17

- This paragraph states that "major hydrogeologic barriers" are present near the Oily Waste Disposal Facility that, in combination with other factors, resulted in insignificant contaminant transport from the OWDF to the basal aquifer. The Navy should either describe these barriers in more detail or provide a reference. The presence of hydrogeologic barriers are important in the investigation of contaminant transport in this SOW. If information on their presence was considered in the OWDF investigation, then it may be applicable to the Red Hill investigation.

Comment 7

Section 2.3.1.3, RHSF Technical Report, Page 2-11

Lines 14-17

- This section states that the Fate and Transport (F&T) Modeling conducted in 2007 led the Navy to conclude that valley fills in the North Halawa Valley are effective barriers to particle migration of water beneath the facility. More precisely the F&T Modeling concluded it was the valley fill in North Halawa Valley that may pose a barrier to groundwater flow. Yet, while discussing monitoring locations as part of our review of the MWIWP (July 2016), the Navy seems focused on demonstrating that the South Halawa Valley fill is the more relevant barrier to groundwater flow and resisted suggestions from the Regulatory Agencies to investigate the extent and nature of the North Halawa Valley fill. This paragraph seems to support the Regulatory Agencies view that the North Halawa Valley should be further investigated as part of this work plan.

Comment 8

Section 2.3.1.5, Type 1 Letter Report, Page 2-12

Lines 34-40

- This paragraphs states that a groundwater gradient of 0.00022 ft/ft was reported toward well 2254-01, while a gradient of 0.00028 ft/ft was reported to the northwest. This is not consistent with numerous statements throughout the SOW/WP that well 2254-01 is downgradient from the USTs while the Halawa Shaft is cross gradient from the USTs as it appears the greatest gradient is to the northwest. The groundwater flow direction (i.e. effective gradient) is currently unresolved and one of the purposes of the proposed work is to remove the uncertainty.

Comment 9

Section 2.3.2.2, Groundwater Monitoring Program, Page 2-14

Overall comment on section 2.3.2.2

Rather than simply providing the data in a narrative form, which makes it more difficult to visualize data trends, this section should include figures for each monitoring well location that plot the data over time for the major contaminants of concern.

Comment 10

Lines 36-39

- This description of the TPH-d trends at RHMW01 fails to note the generally increasing trend in concentrations since January 2015. This paragraph should be amended to note the increasing trend of TPH-d concentrations since that date. As currently written, the paragraph implies that TPH-d concentrations continue to decrease since 2005 and that statement is not supported by the data.

Comment 11

Page 2-15,

Lines 20-21

- The contention that the very low COPC (primarily TPH-d) concentrations detected at RHMW05 suggest that contamination is not migrating downgradient is really an overstatement of the facts as we currently understand them. Since the groundwater flow patterns are not resolved, the direction of contaminant migration is likewise unresolved.

Comment 12

Section 2.3.2.2, Groundwater Monitoring Program, Page 2-16

Lines 11-16

- This description of the COPC detections at RHMW04 fails to note the generally increasing trend in TPH-d since January 2015. The Regulatory Agencies wish to note that the location of RHMW04 and the fact that TPH-d has been detected implies that there is some component of groundwater flow that moves in the general direction of the Halawa municipal pumping centers.

Comment 13

Section 3.5.2, Site Geology, Page 3-7

Line 1

- This sentence describes the lava beds as "nearly horizontal". However, there is a dip to the lava flows and the direction of dip is important to understand how fuel product may move in the vadose zone. The Regulatory Agencies believe an acknowledgement of the potential for these beds to dip is important. This paragraph should include a sentence stating that characterizing the strike and dip of the lava flows is important for understanding any product migration in the vadose zone outside of the concrete cocoon of the tanks and will be conducted as part of the overall hydrologic investigation.

Comment 14

Section 3.6.1, Regional Hydrogeology, Page 3-7

Lines 20-31

- These two paragraph state that there are two principle aquifer types in Hawaii. It fails to mention high level dike confined water that is an important aquifer type and supplies municipal drinking water in many locations on Oahu.

Comment 15

Section 3.6.2, Site Hydrogeology, Page 3-8

Lines 4-7

- This paragraph incorrectly ranks the hierarchy of the State of Hawaii Aquifer designation in the eastern portion of the Red Hill Facility. The eastern portion of the Red Hill Facility is in the Moanalua System of the Honolulu Aquifer Sector (i.e. the Moanalua Aquifer is subordinate to the Honolulu Aquifer). It would be more accurate to state the facility overlies the Waimalu Aquifer System of the Pearl Harbor Aquifer Sector and the

Moanalua Aquifer System of the Honolulu Aquifer Sector. The two aquifers almost equally bisect the Red Hill Facility.

Comment 16

Lines 17-20

- As mentioned in comment 5 above, the Regulatory Agencies believe it is important for this work plan to include further investigation of the extent and nature of the North Halawa Valley fill. This paragraph states that the North Halawa Valley fill is likely acting as a barrier to flow between the Moanalua and Waimalu aquifers.

Comment 17

Lines 26-31

- See Comment 1 above

Comment 18

Page 3-13, Figure 6, Geological Cross Section (Transverse)

- As we stated in our comments to the MWIWP, the Navy provides no basis for the extent of the Valley Fill and Saprolite areas as depicted in Figure 6. The Navy needs to provide supporting documentation or references to support the characterization of the valley fill or clearly indicate that the extent of the valley fill depicted on the figure is speculative and not supported by geologic evidence.

Comment 19

- Figure 6 should be updated to show the new location of proposed well RHMW11 as well as an indicator to show the additional depth of RHMW11 in the event that bedrock is not encountered at the target depth.

Comment 20

- As stated in our comments on the MWIWP, Figure 6 incorrectly shows the Halawa Shaft terminating within the valley fill. The Halawa Shaft is actually a horizontal infiltration gallery in the basalt northwest of the valley fill. The Halawa Shaft is bored into the wall of North Halawa Valley so the depiction of a vertical well located in the center of the valley is inaccurate.

Comment 21

- Remove the word “sporadic” from Note 1 of Figure 3. Note 1 should be revised to, “Existing well logs show a complex subsurface comprised of alternating pahoehoe and a’a lava flow with clinker zones, fractures, and voids.”

Comment 22

Page 3-15, Figure 7, Longitudinal Cross Section

- Delete the word “Geological” from the title of this figure since no geologic features are depicted in this figure. Also the year associated with symbol for RHMW2254-01 should be 2005 not 2009.

Comment 23

Section 3.6.2.2, Groundwater Levels and Hydraulic Gradients, Page 3-17

- This section should include an introductory discussion of groundwater flow gradients and the potential impacts of measurement or survey error, pumping effects, and seasonal and tidal effects on gradient.

Comment 24

Lines 2-24

- The description of the hydraulic flow characteristics of the various rock types would be more appropriate in Section 3.6.1, Regional Hydrogeology.

Comment 26

Lines 36-43

- It should be noted, and as described by D. Oki of the USGS, that USGS/HBWS pumping test done in May 2015 did see a response on the Red Hill side of the North and South Halawa Valleys to changes in pumping stress at the Halawa Shaft. A careful evaluation of the 2006 aquifer test responses also indicate a possible response across the Halawa Valley Fills.

Section 3.7, Geological Conceptual Site Model

Comment 27

- The Navy should follow the DOH Technical Guidance Manual, Section 3.3 guidelines for the Conceptual Site Model (CSM) development. The Navy should include the representative site environmental conditions with respect to environmental hazards, such as site conditions, extent of contamination, contaminant pathways and potential receptors, then present the CSM specific to Red Hill. For the CSM the Navy shall use tank construction information, available boring logs, barrel logs, pump tests and historical analytical data. The CSM should include a discussion of potential contaminant pathways including, but not limited to, a release from Tank 5 that flows laterally out of the concrete surrounding the tanks, and a release from tank that flows down within the concrete cocoon.

Comment 28

Section 3.7.4, Red Hill Vadose Zone, Page 3-28

- This section repeats general geology information that was presented earlier in Section 3. Much of the information presented is not site-specific to Red Hill. Perhaps a review of Wentworth (1942), MacDonald (1941), and Stearns (1941) may provide valuable Red Hill specific insight. Section 3 does not meet the requirement for developing a thorough Conceptual Site Model (CSM) as required by the AOC.

Comment 29

Lines 14-22

- The contention that RHMW07 is not in hydraulic communication with the other Red Hill wells is not borne out by the USGS/HBWS pumping test. The water level in RHMW07 did vary in response to pumping stresses as did other wells located at the Facility. It is true that the connection must be through some hydraulic barrier to account for the abrupt change in water between RHMW07 and nearby wells. The Navy postulates that the barrier could be a dike and this is certainly within the realm of possibility. These dikes, if they exist, will also greatly influence the groundwater flow direction in a way that is not predictable from water level observations alone. Also, the discussion in these lines do not seem to fit in a description of the vadose zone.

Comment 30

- The SOW/WP proposes that the Red Hill area may be a dike complex. This contention comes with serious implications. First is that the assumption the geology can be modeled as an Equivalent Porous Medium becomes invalid since the scale of dikes are 100s to 1,000s of meters. These heterogeneities will not be averaged out over the scale of concern that is also 100s to 1000s of meters. These statements also fail to show how the density of dikes if present could meet the definition of a dike complex that is more than 100 dikes per mile (Takasaki and Mink, 1984). There are no identified dikes in the Red Hill area, yet there are deeply incised valleys that should reveal a dike complex if one was located there. However, the Regulatory Agencies do acknowledge that the anomalous water levels in RHMW07 and Moanalua DH43 well as well as the late stage eruptions makai of the facility indicate some dikes and other intrusives could be present.

Comment 31

Section 3.7.4, Red Hill Vadose Zone, Page 3-29

Lines 8-12

- It is true that numerical modeling of NAPL transport in the vadose zone would be fraught with such uncertainty as to make this effort meaningless. However, a vadose zone assessment is critical and ample data exists to significantly increase our understanding of the fate and transport of fugitive fuel as it moves through the vadose zone. Knowledge of likely migration paths and amount of NAPL residual held in the vadose zone are important parameters for evaluating risk to the groundwater and to drinking water.

  Much characterization of the vadose zone can be done without intrusive drilling. A vadose zone assessment could include many important evaluations such as:

  - Defining the strike and dip of the lava flows using tank excavation and well geologic log;
  - Vertical fluid transport velocities using correlations between precipitation, and water level and soil vapor data; and
  - A statistical interpretation of the stratigraphy to evaluate relative abundances and thickness of the major fluid transport formations including; massive basalt, clinker zones, and vesicular basalt.

Section 4 – Scope of Work

Specific Comments

Page 4-2

Comment 32

Lines 12-13

- As part of the data and literature search, the SOW shall include the use of the tank barrel logs.

Comment 33

Lines 27-28

- The effort should not only focus on vertical components of flow but should consider all components of flow direction within the vadose zone and characterize the mechanisms influencing this flow.

Section 4.2 Task 2: Investigate Light Non-Aqueous-Phase Liquid (LNAPL), Page 4-2

Comment 34

Lines 31-41

- The only approach proposed for investigating any NAPL and the risk posed to groundwater and drinking water is an electrical resistivity survey in the lower tunnel. The likely interference from reinforcement metals in the floor of the tunnel and of the similar resistivity characteristics of air and NAPL could significantly reduce the likelihood of gaining useable data. However, given that there is an eight year history of soil vapor readings, and a longer history of groundwater level and contamination data, the Navy should correlate these data sets with other environmental data sets such as precipitation. This may yield much valuable data about NAPL and other contamination in the vadose zone.

Comment 35

Section 4.3 – Task 3: Identify Chemicals of Potential Concern, Page 4-5

Lines 5-10

- This work plan seems to categorically exclude the possibility that the TPH detected in OWDFMW1 originated from Red Hill UST releases. It must be noted that:
    - OWDFMW1 is part of the NAVFAC agreed upon GWPP monitoring network for evaluating groundwater contamination from the USTs. The source of TPH at this well is not known and the flow paths beneath the facility are poorly understood. No definitive conclusions can be made as to the source of the elevated TPH at OWDFMW1, so releases from the USTs remain a possibility.
    - Figure 3-7 of the EarthTech (2000) report shows groundwater from beneath the Oily Waste Disposal Basin (OWDB) flowing in a direction roughly toward well 2254-01. The groundwater flow direction in this figure is also consistent with recently acquired groundwater chemistry (i.e. chloride data from RHMW06 and RHMW07). Whatever the source of the recurring TPH spikes at OWDFMW1, chemistry at this well should be viewed as indicating what may be captured by drinking water well 2254-01.
    - If it is the desire of the Navy to remove OWDFMW1 from consideration in the Red Hill risk assessment, then an approach is required to answer critical questions on the source and nature of the TPH at this well and groundwater flow patterns beneath the OWDB relative to well 2254-01.

Comment 36

Section 4.4, Page 4-5, lines 32-33

- The SOW should define the process for identifying data gaps, and should establish data qualify objectives for the monitoring network.

Comment 37

Section 4.5, Task 5: Update the Existing Groundwater Model, Page 4-9

Lines 14-36

- See comments for Appendix H
- SOW needs to identify all potential data sources for model, compare to what was used on previous model, assure the model utilizes all available data, resurvey well elevations, evaluate past modeling efforts based on data, and then come up with an approach using new data to refine model and evaluate model sensitivity. The SOW appears to indicate that only minor updates to the model will be made rather than a thorough revisit of past modeling efforts.

Comment 38a

Page 5-1, line 9

- The term "government" should not be used. All parties to the AOC along with the external subject matter experts are part of government.

Comment 38b

Page 5-2

- Revise this section of SOW to include detailed description of report content and schedule. Outline of reports with minimum content, tables, graphs and figures should be included. Additionally, data management should be discussed. The regulatory agencies would like to get all environmental data in either spreadsheet or database format along with hardcopy and PDF reports.

Page 5-8

- The SOW needs to better describe the process for optimizing the design of data collection. Much the other discussion in section 5.4 is too generic. The SOW should be more specific on how these concepts will be applied at Red Hill.

- The conceptual model should address the flow variation between wet and dry season.

Comment 38c

Section 5.5 Conceptual Site Model

Page 5-9, Figure 12, Preliminary Conceptual Site Model

- The preliminary CSM should highlight the site and study area boundaries. It should also depict, to the extent that information is available, the two main potential contaminant pathways (a release that flows vertically from the tank down to the saturated zone and a release from the sides of the tank that flows laterally from the tanks into the formation. The preliminary CSM should also depict the bedding geology in the study area.
- The conceptual site model should address attenuation. The SOW should describe the approach proposed for assessing attenuation rates.

Comment 39

Section 5.5.2 – Tier III Human Health Risk Assessment, Page 5-11

- Section 8 of the AOC requires a Risk and Vulnerability Assessment. The Navy and DLA should consider eliminating the form 6 and 7 and focusing the Risk assessment effort in Section 8.
- This SOW should include revision of the Groundwater Protection Plan based on the work in the AOC. A revised Groundwater Protection Plan should be a section 6 deliverable.

Lines 15-30

- Although the regulatory documents for a Tier III Health Risk Assessment are referenced, no approach is given as how this evaluation will be done. It is well established that conservative HDOH EALs are exceeded routinely at the site, necessitating the need for a more detailed Tier III risk assessment.
- To be protective of groundwater, an important specific limit that should be evaluated are the soil vapor action limits. A confirmed release occurred at Tank 5 resulting in significantly elevated soil vapor readings beneath the UST. However, the current soil vapor SSRBLs (site-specific risk based levels) were not exceeded until months after the release. An analysis of the historical soil vapor data should be done to establish the normal range, then a more protective action level established. Specific actions to be followed for exceedances should be included in the updated GWPP.

Comment 40

Section 6.1 Sampling Process Design, Page 6-1

- While the Regulatory Agencies acknowledge that the majority of samples collected as part of this scope of work will be groundwater samples, information on the sample process design for fine grain sediments should be included. This information was included in and can be copied from the recently approved Monitoring Well Installation Work Plan.

Comment 41

Section 6.2.1 – Groundwater Sampling, Page 6-3

Lines 20-22

- OWDFMW1 currently lacks a downhole pump. This should be noted and information provided on how this critical well will be sampled.

Comment 42

Section 6.2.2 – Topographic Surveying, Page 6-4

Lines 4-12

- The surveying procedures in these sections are suitable for the majority of the environmental investigation sites managed by the Navy. However, in the case of Red Hill the Navy has chosen to characterize the groundwater gradient over an area extending from the Moanalua Ridge to west of the North Halawa Valley as the approach to evaluate possible migration paths of contamination. This is a regional groundwater problem that spans two aquifer systems. This requires that the water level elevations relative to those at the Facility be measured accurately over distances of miles.

  This is a difficult undertaking. Lack of precise Top of Casing Elevations (TOC) of the wells has been a problem with Red Hill investigations from the beginning. Two efforts have been made to resolve this issue, TEC in 2009 and USGS in 2015. Both of these efforts relied on GPS that has vertical accuracies in the tenths of feet. Again, we recognize doing accurate TOC elevations over an area this large is a challenging effort.

  We recommend a two-step process:

  1) A sensitivity analysis to determine an acceptable level of accuracy that will be required to adequately characterize the groundwater flow gradient.

  2) Consult with the NOAA National Geodetic Survey to develop a survey plan that can attain the needed level of accuracy. The contact information is given below.

  Edward E. Carlson
  National Geodetic Survey
  808-532-3205
  ed.carlson@noaa.gov

Comment 43

Section 6.2.3 – Synoptic Water Level Reading, Page 6-3

Lines 14-31

- A week long monitoring of groundwater elevations at multiple locations will give a good time-averaged snap shot of relative water level elevations. However, the Navy is proposing to answer critical but currently unanswered questions using water level measurements and groundwater modeling. Key to current investigation is to characterize the response of monitoring locations to pumping stresses. The two previous aquifer response tests lasted for about a month. A review of both tests show that the aquifer water levels may not have recovered completely to pre-test conditions. Currently the response of Red Hill area wells to pumping stresses at the Halawa Shaft may not have been adequately answered during the 2015 USGS/BWS aquifer tests due to interfering pumping at well 2254-01. We recommend that data loggers be retained in critical wells after the week long status-quo water level monitoring period and a series of coordinated (between HBWS and Navy PWS) aquifer tests be done to definitively measure the hydraulic connection between the Red Hill area and the Halawa municipal well source area.

Comment 44

Section 6.2.4 – Proposed Electrical Resistivity Survey, Page 6-4 & 6-5

Lines 32-41 and Lines 1-10

- The Navy needs to further evaluate the practical limitations of the site (e.g. locations of pipelines, presence of rebar in the concrete of the tunnel) to define the study design to ensure that interpretable and usable data are recovered. Assuming the presence of steel rebar embedded in the lower tunnel floor, it is likely the steel will interfere with the readings obtained, leading to inconclusive results.

- The Navy should consider a resistivity transect at the lower to the northwest edge of the Facility in the vicinity of OWDF-MW1, RHMW07, and RHMW06 to see if they can image the high chloride shallow groundwater present in these wells. This could be helpful in evaluating groundwater flow paths within the facility.

Comment 45

Section 6.3, Field and Analytical Sampling Program, Page 6-6

Table 9

- Alkalinity should be added to the list since it also is a chemical indicator of natural attenuation. Also, the Navy has indicated verbally that a suite of major ion samples will be collected. There is no indication of this in the Sampling Program. The regulatory agencies would strongly encourage a round of major ion and dissolved silica analysis to characterize the groundwater chemistry of the study area. Analysis of geochemical data collected by this study, other Red Hill investigations and by University of Hawaii research can be very helpful to understanding the hydrogeology of study area.

Comment 46

Section 7.1.2.2, Matrix Interference, Page 7-1

Lines 30-40

- We would like the Navy to better define the term "biogenic hydrocarbons" since it seems that this term is also used to propose that elevated hydrocarbon detections are not related to fuels stored at the Red Hill USTs.

Appendix H – Work Plan / Scope of Work, Groundwater Flow and Contaminant Fate and Transport Modeling

Comment 47a – Recommended Characteristics of a Red Hill Groundwater Modeling Team

Utilizing a team approach involving highly skilled and experienced members will be critical to the success of the Red Hill modeling effort. The work and products related to this modeling effort will likely be scrutinized in detail by AOC stakeholders, technical experts and the public. In order to achieve the AOC goals, the model related deliverables will need to be able to stand up to this scrutiny and be able to adequately communicate the groundwater flow and fate and transport conditions to the expected diverse audience.

The groundwater and flow and transport models are the data and visualization product upon which risk based decisions will be made. The Moanalua/Red Hill/Halawa area provides approximately 25 percent of the drinking water for urban Honolulu. This area is also the site of a massive fuel storage facility separated from the groundwater by a little more than 100 feet of fractured rock. It is critical that water resource planners, environmental regulators and managers, and water utility owners and operators have an adequate groundwater characterization to develop proper response measures should a catastrophic release occur. The team doing the groundwater study and associated modeling needs to understand Hawaii hydrogeology, the fate transport processes of fuel transport in all of the phases (i.e. free product, vapor, LNAPL and dissolved), and more importantly the limitations of modeling. Since it is likely that the Red Hill AOC process will be litigated the need for a very defensible groundwater risk study needs to be done by a team that has credibility with the stakeholders and public. Below are listed the desired qualifications for a groundwater risk assessment/modeling team (The Team).

1. The Team must have credibility with the primary stakeholders and the public. The primary stakeholders include:

a. The Navy,

b. The Hawaii Dept. of Health,

c. The U.S. Environmental Protection Agency,

d. The Dept. of Land and Natural Resources,

e. The Army, and

f. The Honolulu Board of Water Supply.

2. The Team must have a superior understanding of Hawaii groundwater flow dynamics and hydrogeology supported by a history of previously successful investigations. The scale of the groundwater risk assessment/modeling problem is regional rather than confined to a specific site. The primary regional problem deals with the degree of water exchange between adjacent aquifers. More specifically, does groundwater that is potentially impacted by a release from the Red Hill USTs remain in the Moanalua Aquifer only impacting the Red Hill Shaft; or is there a flow component toward the Waimalu Aquifer where major municipal pumping centers are located?

3. The Team should have a track record of developing Hawaii groundwater resource assessment models on a regional scale. The groundwater flow, and fate and transport model should not be the primary means of investigation but is rather one of the end products. A model is only as good as the data and skill that goes into the development. However, the model is the product that allows visualization of the results of the groundwater investigation and is the tool for risk mitigation planning. Thus the model becomes the most important product of the investigation. For the model to have credibility The Team must have a proven track record in groundwater resource and risk assessment modeling.

4. The Team should be able call upon assets with demonstrated expertise in other disciplines such as geophysics, geochemistry, and structural geology. If there is a significant groundwater flow component from the Moanalua Aquifer to the Waimalu Aquifer it is due to unidentified subsurface structures. The Team needs to be able to evaluate whether or not it is likely that these structures exist. If the investigation concludes a high likelihood that these structures exist, The Team should be capable of developing a plan to investigate the distribution and geometry of these structures.

5. The Team should have demonstrated expertise in multiphase fate and transport assessments. The drinking water risk assessment must include an assessment of fugitive fuel in its various phases that include free petroleum product in the vadose zone, vapor phase, light non-aqueous phase liquid (LNAPL) phase on the water table, and dissolved phase in the groundwater. The Team needs to have capability or be able to call upon assets to characterize a fuel release from the time it leaves the concrete cocoon surrounding the steel tanks until the dissolved and LNAPL plumes reach steady state, effectively becoming immobile.

Comment 47

Section 1 – Background, Page H-1

Line 38

- The Tripler Army Medical Center drinking water supply wells are located in close proximity to the HBWS Moanalua Wells and should be included in the description of potentially affected wells.

Comment 48

Section 2. Objectives of the Planned Groundwater Modeling, Page H-2

Lines 35-36

- The modeling objectives (and the groundwater study in general) fail to address the primary risk driver. This is the migration of LNAPL due to a large release. As estimated by the 2007 F&T modeling, contaminant concentrations could degrade to less than environmental action levels about 1,200 ft downgradient from an LNAPL source. However, during a large release, the LNAPL would form a relatively thin layer on the water table that could extend significant distances. The important risk driver is not the dissolved plume alone, but rather the combined fate and transport of the LNAPL and dissolved plume. Characterizing the direction and the distance an LNAPL plume will migrate from a large release needs to be critically evaluated.

Comment 49

Section 3.1 – Conceptual Site Model, Page: H-7

- The SOW should describe the process for analyzing the adequacy of previous groundwater studies.

Lines 12-17

- As in previous sections, the SOW/WP refers to a probability of dikes being present. If it is believed dikes are present, this will greatly complicate the groundwater modeling and some approach should be articulated to deal with this difficulty.

Comment 50

Lines 31-34

- The Underground Injection Control (UIC) line is a State of Hawaii boundary between what is considered a drinking water aquifer and a non-drinking water aquifer. The EPA does not recognize this line and considers water makai of the UIC line also a potential source of drinking water.

Comment 51

Lines 36-41

- The description Navy Supply Well 2254-01 also pre-supposes a mauka to makai groundwater gradient. Determining the groundwater gradient is one of the tasks of the groundwater investigation, thus it is inappropriate to make statements such as this: "The infiltration gallery is located hydraulically downgradient from the USTs and intercepts most of the water that would be affected by releases from RHSF."
- Statement: "This well operates at variable flow rates, extracting between 4 and 18 mgd of groundwater from the basal aquifer." Please state the average mgd or range of mgd that pump station 2254 has produced from January 2014 to present if different than 4 to 18 mgd.

Comment 52

Section 3.2 Groundwater Monitoring, Water Levels, and Hydraulic Gradients, Page H-8

Lines 21-22

- The contention that transport of LNAPL to the valley streams could not occur is incorrect. Much of the tank profiles extend above the elevation of the streams (See SOW/WP Figure 7). Due to fractures and in the concrete cocoon, angle iron brackets around the tanks, etc. it is not inconceivable that the fuel could enter the rock formation at an elevation above the bottoms of the tanks and above the stream bed.

Comment 53

Lines 27-34

- Statement: "No dissolved petroleum constituent concentrations, however, have been detected at concentrations approaching the solubility limit of JP-5 suggesting that LNAPL is not present on the groundwater surface." This statement is misleading.

  TPH-d has been detected at concentrations greater than 5 mg/L on numerous occasions at RHMW02. The EPA considers dissolved concentrations equal to or greater than 1% of the solubility limit of a DNAPL as an indication that NAPL is present near the monitoring point (EPA, 2009). Although petroleum free product has not been detected at the groundwater interface, the principle stated in EPA (2009) is applicable and indicates that free phase petroleum may be present near the groundwater interface. The 1% limit (45 μg/L) has been exceeded at RHMW02 for the history of monitoring at this well and routinely at other wells. Also, the contention that low TPH concentrations at RHMW01 suggest that dissolved petroleum compounds are not migrating off site at levels of concern is equally unsupportable since there is no measureable hydraulic gradient between RHMW02 and RHMW01 based on the monthly water level measurements.

Comment 54

Section 3.2 Groundwater Monitoring, Water Levels, and Hydraulic Gradients, Page H-11

Lines 6-7

- See previous comments on this issue. But basically, these numbers indicate a stronger gradient to the NW than to the SW.

Comment 55

Section 3.3.1 Basal Aquifer, Page H-12

Lines 1-15

- Under the heading of "Basal aquifers", the SOW/WP discusses volcanic dikes and dike complexes. Basal aquifers, particularly in the study area, are generally considered to be dike free so the discussion of dikes is not appropriate in this section. A section titled "High Level Groundwater" should be added to discuss dikes and their hydrogeology.

Comment 56

Lines 39-43

- The hydraulic conductivity value the SOW/WP cites as being used by Oki is the transverse not longitudinal value. Oki used 4,500 ft/d for the longitudinal hydraulic conductivity. Also, the referenced to ratio of vertical to horizontal hydraulic conductivity is out dated. Currently the USGS uses 1:100 or 1:200 or more in their models. See Oki (2005), or Gingerich (2012) for examples.

Comment 57

Section 3.4 Previous Numerical Groundwater Flow Modeling, Page H-13

Lines 15-17

- The contention that the longitudinal hydraulic conductivity used in the Rotzoll and El-Kadi (2007) calibrated flow model was substantially higher than other relevant groundwater studies in incorrect. The Kh values are nearly identical to those used by Oki (2005) for a model that included the same area.

Comment 58

Lines 21-27

- Groundwater flow patterns and well zones of contribution modeled by Rotzoll and El-Kadi (2007) cannot be used to assess contamination risk to well 2254-01 or to the Halawa Shaft as this model was not adequately calibrated due to TOC elevation survey issues.

Also, there was only a single calibration point used in the Red Hill Ridge so local groundwater flow paths were not properly tested. This is not an indictment of the modelers but indicates that new data has come to light that brings the results of the past model into question. It is also important to note that groundwater flow patterns modeled by Rotzoll and El-Kadi were generally accepted as being correct at the time and accepted by the HBWS. See Hunt (1996) and Todd Engineers and ETIC Engineering (2005).

Comment 59

- The reference to Figure H-3 is not valid to assess the impact of valley fills on contaminant migration since the cross-section shown is well downslope from the USTs and the Halawa Shaft. This figure is also conceptually incorrect in that it shows a depressed water table in the valley fill. A mounded water table would actually be expected due to the low permeability of the alluvium and the increased infiltration from the stream bed.

Comment 60

Lines 36-38

- As with the flow model, the Fate and Transport Model was essentially uncalibrated since there was no field data to compare modeled degradation rates with. Drawing conclusions about degradation rates must be done with caution. As stated in Section 4.5.2, page 4-11, third paragraph F&T model report, the much lower RT3D BTEX package default degradation rates produced a much closer agreement with degradation rates compiled from 39 Air Force remediation sites. An important implication of a slower degradation rate is that the contamination will travel further prior to degrading below action levels. Developing a robust method to estimate a representative degradation rate is an important component of the groundwater risk assessment.

Comment 61

Section 3.5 Evaluation of Fuel Sources, Page H-14

Lines 24-25

- The SOW/WP cites Potter and Simmons (1998) as providing the water solubility limit of Benzene in JP-5 fuel. The maximum solubility of 0.75 mg/L was actually calculated as part of the 2007 F&T modeling effort. No JP-5 chemical analysis could be found that gave a weight percentage for Benzene. A worst case was assumed based on the ASTDR Toxicological Profile for JP-A, JP-5, and JP-8. JP-A has a maximum Benzene concentration of 0.02 weight percent.

Comment 62

Section 3.6, Previous Reactive Transport Simulations, Page H-14

Lines 31-39

- This particular paragraph cites the transport model conclusion that well 2254-01 is the only drinking water source that would be impacted by contamination from the Facility. However, since the underlying flow model was not properly calibrated and the F&T degradation rates were not validated, the modeling conclusions must be used with caution.

Comment 63

Section 3-6, Previous Reactive Transport Simulations, Page H-18

Lines 21-24

- This comment is for clarification. The SOW/WP correctly cites that early detections of a thin free product layer were followed by a long history of no detections. The absence of any product detection at the monitoring wells after January 2008 is an artifact of redefining what constituted a product detection. Prior to January 2008, any product tone from the oil/water interface detector constituted a detection. However, since many of the detections seemed spurious as indicated by the detection only on the initial meeting of the probe with water surface and were not repeatable, the definition of a detection was changed to that of requiring a confirmation detection by re-lowering the probe to the water table surface.

Comment 64

Lines 25-32

- This paragraph states that JP-5 was released in January 2014. Actually it was JP-8. However, chemical properties are similar.

Comment 65

Lines 36-40

- The statement "..the few groundwater samples in which BTEX compounds have been detected…" is misleading since detections of ethylbenzene and xylenes occur frequently at RHMW02. Although the concentrations, as stated in the SOW/WP, are below DOH HEER EALs, these compounds were detected.

Comment 66

Section 4.1, Model Selection, Page H-19

Line 12

- The SOW should describe the process for reviewing and revising model parameters.

Line 25

- The stated model assumption that all simulated wells fully penetrate the aquifer is incorrect and needs to be changed.

Comment 67

Lines 33-39

- It is important to note that while the model did replicate the relative drawdowns due to changes in pumping stress, there were significant absolute errors. It is also incorrect to state that the agreement between modeled and simulated drawdowns confirms that the Porous Equivalent Medium assumption is valid. Voss (2011) states that the accuracy of a model calibration should be view with some caution and other aspects of the modeling effort given more weight. Numerical model solutions are non-unique in that the same result can be obtained from different input parameter values and distributions. Meaning that a model that calibrates well does not guarantee that correct parameter values and distributions were used.

Comment 68

Section 4.2, Model Domain, Layers, Grid, and Boundary Conditions, Page H-21

Lines 4-19

- A better discussion/justification of boundaries is needed. This discussion should include the type of boundary condition (e.g. no flow, specified head, specified flux, etc.) and justification of the selected boundary condition. Since the Rotzoll and El-Kadi model results were released new groundwater data has come to light showing the potential for inter-aquifer flow, which necessitates closer evaluations of the model boundaries. This is also a recommendation from the USGS.

Comment 69

Section 4.4, Calibration, Page H-21, 22

General Comment

- The USGS aquifer test conducted in 2015 has shown that there are anomalously high water levels within the Red Hill Ridge area. The test further showed the wells with the high water levels responded to pumping stresses, likely those generated at the Halawa Shaft. It is desirable for the modeling work plan to describe how these data will be used in the modeling and calibration process since these anomalies could indicate important heterogeneities in the subsurface.

Comment 70

Section 4.4, Calibration, Page H-22

Lines 12-14

- Estimating recharge is a very involved process. Suggest using recharge values already calculated by the USGS (Engott, et al, 2015 and Izuka et al., 2016).

Comment 71

Lines 15-22

- Porosity is an important parameter for contaminant transport. Porosity should be included in the list of parameters to be varied when calibrating the transient model. Also, there is a reference in these lines to acquiring pumping test data from the USGS. The USGS data are available on-line so there should be no difficulty in obtaining this information. However, the USGS data should be supplemented with pumpage and water level data from the HBWS.

Comment 72

Lines 31-32

- The 15 percent RMSE calibration criteria needs more justification. Cite modeling standards etc. that list acceptable model accuracy standards.

Comment 73

Section 4.5, Predictive Flow Modeling, Page H-31

Lines 37-39

- The SOW needs to define the process for determining the appropriate range of alternative simulations needed and the respective approach to sensitivity analysis for each alternative simulation.
- All but the base case scenario seem to be very vague. At this point in the planning process this may not be unreasonable. However, the input on the future scenarios needs to extended beyond the AOC parties to the HBWS and CWRM since they are stakeholders in this process. The distribution of pumping and the location of a hypothetical new well in the future scenarios will greatly influence the model results. Thus it is important to get input from the stakeholders that will likely initiate any changes in groundwater withdrawals. One scenario that should be run is a drought scenario using the USGS drought period recharge coverage for Oahu (Engott et al., 2015).
- Also, as suggested by the USGS, modifying the model from the base scenario will require that the boundary conditions be carefully evaluated and appropriate modifications may be necessary.

Comment 74

Section 5, Technical Approach for Refining the Contaminant Fate and Transport Model, Page H-33

Line 2

- It is important to note that production of CO_2 due to natural attenuation of hydrocarbons increases the alkalinity of the water. Alkalinity should be included in the NAPs analysis list.

- General Note: Both the groundwater flow, and fate and transport model technical approaches uses the word "Refine". This implies minor revisions. It should be considered that major changes may be necessary to adequately assess the risk to groundwater and drinking water posed by the Facility.

Comment 75

Section 5.1, Objections, Page H-33

Lines 18-29

- The AOC – SOW **Section 7.2, Contaminant Fate and Transport Model Report**, states that "The purpose of the Contaminant Fate and Transport Model Report is to utilize the Groundwater Flow Model to improve the understanding of the potential fate and transport, degradation, and transformation of contaminants that have been and <u>could be released</u> from the Facility".

  It should be explicitly stated as a modeling goal that the fate and transport of a major release be rigorously characterized. To accomplish this, a large release needs to be characterized from the time it leaves the concrete cocoon, until the plume becomes immobile (i.e. LNAPL transport) and the dissolved plume reaches steady state (i.e. through degradation, transformation, and dilution).

Comment 76

Section 5.2, Model Selection, Page H-34

Lines 1-3

- This is inaccurate to state that there was an attempt to match modeled NAP reaction rates to measured data. There was insufficient data to attempt to develop site specific reaction rates. Reaction rates were tested during sensitivity analysis and it was determined that reaction rates borrowed from the Hill AFB site may have been too optimistic. We concur with the uncertainties regarding the modeled RT3D degradation rates. However, these uncertainties exist even if MT3D is used.

Comment 77

Section 5.2, Model Selection, Page H-35

Lines 1-16

- It is unclear in the SOW/WP how a first-order degradation rate will be selected, and more importantly, validated. Typically, this requires having concentrations at two or more locations along a groundwater flow path and knowing the velocity along that flow path. The SOW/WP needs to document how these two parameters (i.e. flow path and transport velocity) will be quantified with confidence and how the results will be used to develop defensible first order degradation rates.

- This comment is provided for informational purposes to assist with the work plan development. There are serious plumbness issues with TAMC MW2. Being a two inch well with long depth to groundwater, its casing snakes around severely biasing water levels measured at this well. Also, it unlikely that a True Vertical Depth survey can be done on this well due to the kinks in the casing.

Comment 78

Section 5.2, Model Selection, Page H-35

Lines 20-21

It is difficult to see how decay rates can be estimated using time series data. The first order decay equation that is likely to be used does not account for advective transport of contamination away from the source area or sorption within the source area. There are too many undefined variables to do the decay constant calculation with confidence. Some method needs to be articulated to replace some of the unknown variables with measured parameters. The most straightforward way to do this is with a well-designed and executed tracer test where the critical transport parameters can be measured.

Comment 79

Section 5.3, Model Setup, Page H-35

Lines 22-39

- Although the header says "Model Setup" the text only justifies using MT3D versus RT3D. There is nothing else in this section that deals with model setup other than stating it will use the same grid as the MODFLOW model. Since MT3D requires the MODFLOW solution to simulate transport there is no flexibility in using any other grid.

Comment 80

Section 5.5 Model Parameters, Page H-36

Lines 10-13

- The SOW/WP incorrectly states that the longitudinal dispersivity used in the 2007 F&T model was 20 meters. The actual value was 112 feet (34 m). It is likely that the 20 m value stated came from the Lahaina tracer test report. This needs to be clarified and corrected. Also, the porosity value of 0.05 for the 2007 F&T model was chosen to be consistent with SWAP modeling. Inverse modeling during the flow simulations estimated a porosity of 0.031. If the inverse modeling porosity were used in the transport model, the contaminant migration velocity would increase by a factor of 1.6. This does need to be considered when developing the model and interpreting the results.
- The SOW should define a process for evaluating the sensitivity of the transport parameters.

Comment 81

Section 5.5.4, Dispersivity, Page H-38

Lines 3-5

- The dispersivity value stated in this section differs from that in Table 2. Of greater consequence (as this section points out) is the broad range of literature dispersivity values. The parameter can be directly estimated from a well-designed and executed tracer test.

Lines 17-18

- The rate of degradation for future releases cannot rely solely on site-specific concentration data. Varying degrees of mass release would likely influence degradation rate. The SOW should define a robust process for evaluating the range of potential degradation rates likely to occur for various release scenarios at Red Hill.

Comment 82

Section 5.5.5, Degradation, Page H-38

Lines 7-21

- Multiple processes are working on these concentrations. Each has to be accounted for in some way to estimate a first order decay coefficient. Particularly problematic is the spatial distribution of contaminant concentration. Unless the groundwater flow direction is aligned with the positional track of the monitoring wells and the groundwater flow velocity is known with certainty, then calculating the first order decay coefficient becomes very problematic. Wiedimeier et al., 1996 documents a method to estimate degradation rates by comparing the contaminant concentration trends with that of a tracer. In the case of this investigation, it would likely be necessary to introduce a conservative tracer. So again, a well-designed and executed tracer test can provide valuable data for F&T modeling.

Comment 83

Section 5.6, Calibration, Page H-38

Lines 26-37

- The degree of calibration described does not seem reasonable to obtain. The uncertainties are too great and include; the mixing of recent and legacy contamination, the footprint of the contaminant source area, unknown sorption and degradation coefficients, and the geometry of subsurface structures that are implied by the groundwater level anomalies. An alternative analytical approach may be to produce a set of probability realizations showing likely transport paths and velocities.

Comment 84

Section 5.7 Predictive Transport Simulations, Page H-39

Lines 1-13

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- The SOW/WP only proposes to simulate the dissolved phase transport from an arbitrarily defined stationary LNAPL source. This is a repeat of what was done in 2007. Since it is a repeat it is uncertain why it needs to be done again in a numerical F&T model. There are many other critical F&T processes that need to be evaluated but are not included in the SOW/WP (e.g. vadose zone transport, LNAPL transport on the water table, etc).
- The purpose of the modeling is to define the risk to groundwater and to the area's drinking water resources threatened by the current and any future potential releases.

When considering a future release, the F&T of a large LNAPL release must be considered. The proposed modeling only evaluates the groundwater flow paths and the F&T of the dissolved plume after the LNAPL becomes immobile. Also, there is insufficient detail in the SOW/WP for the regulatory agencies to evaluate whether or not the dissolve phase F&T portion of the risk assessment will be adequately validated.

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Attachment B -

BOARD OF WATER SUPPLY

CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU, HI 96843

June 3, 2016

Mr. Bob Pallarino
United States Environmental Protection Agency
Region 9
Underground Storage Tank Program Office
75 Hawthorne Street (LND-4-3)
San Francisco, California 94105

And

Mr. Steven Y.K. Chang
State of Hawaii
Department of Health
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Honolulu, Hawaii 96801-3378

Dear Messrs. Pallarino and Mr. Chang:

Subject: Board of Water Supply (BWS) Comments to the Work Plan / Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility

The BWS and its consultants have reviewed the document titled "Work Plan / Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility" (WP), dated 4 May 2016, under the Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7. Our review of the WP also includes information and statements from the Tuesday 10 May 2016 meeting concerning the AOC scopes of work for AOC SOW Sections 6 and 7. The BWS provides the following comments and recommendations to the WP with the goal of ensuring that all work conducted under the final document will produce defensible scientific and engineering results needed to continue to protect our drinking water supplies from past and future fuel releases from the Red Hill Bulk Fuel Storage Facility (RHBFSF).

The following section provides a summary of the most important comments and recommendations, followed by the individual detailed comments. The last section lists the references cited.

Summary Comments and Recommendations

1. Continued Reliance on Assumptions That Have Yet to be Tested

The WP relies on three untested assumptions 1) the valley fill units (valley fill and underlying saprolite) in Moanalua and Halawa valleys act as barriers to groundwater flow between the RHBFSF and the nearest BWS water supplies; 2) regional groundwater flow is from northeast to southwest near the RHBFSF; and 3) drilling and installing monitoring points in the vadose zone will likely remobilize fuel. Our previous letters to you have repeatedly stated that: 1) there are no direct data to show that the valley fill units are barriers to groundwater flow and contaminant migration; 2) at present there are too few wells to understand the groundwater flow directions and rates in the Halawa and Moanalua valleys; and, 3) monitoring wells and soil borings can be safely drilled and constructed through contaminated zones without either carrying contaminants downward as the borehole advances or, when completed, acting as a vertical pathway for the downward movement of petroleum contaminants.

Basing the groundwater flow and transport modeling (Appendix H) on assumed valley fill barriers in the absence of direct evidence is neither conservative (in an engineering sense) nor defensible. At present, there are no borings that delineate the lithology and dimensions of valley fill materials in these valleys and recent USGS pump test data revealed responses to BWS Halawa shaft pumping changes at several RHBFSF monitoring wells. The WP's failure to address the data gaps for the valley fill units should be rectified immediately and the groundwater flow and transport models should not include valley fill barriers in Moanalua and Halawa valleys until and unless there is direct evidence that the valley fill units in these valleys will prevent migration of groundwater and contaminants from the RHBFSF to BWS water supplies or the surrounding clean aquifer. We ask that the regulatory agencies, the US Environmental Protection Agency (EPA) and the Hawaii Department of Health (DOH), acknowledge this untested assumption and accompanying critical data gaps and take responsibility for ensuring that the Navy provide the necessary information. Otherwise, the regulatory agencies may be perceived as ignoring their public trust responsibility to protect our drinking water resource.

The conceptual site model and numerical model for groundwater flow near the RHBFSF and its vicinity should be based on site-specific data, not an assumed groundwater flow pattern. Available data are sufficient to define the mauka to makai flow (mountain to sea) direction for the aquifers to the east, but questions about groundwater flow direction and rate between the Moanalua and Halawa valleys have remained since 1942 (see Wentworth, 1942; Wentworth, 1951; and Mink, 1980). Despite these questions, the Rotzoll and El-Kadi (2007) groundwater flow model assumed regional groundwater flow was from the northeast to the southwest, and instead of adopting the more defensible approach used in Oki (2005) or addressing this critical data gap, they forced the groundwater model boundary conditions to match this assumption. The TEC (2010) letter report revealed that correcting for the errors in the head measurements known at that time yielded a groundwater flow direction to the northwest and indicated the need for one or more monitoring wells be installed along that northwesterly direction. The WP should be revised to include a sufficient number of monitoring wells that will help directly estimate groundwater flow directions and rates from the RHFSF toward Halawa shaft change during pumping at the Red Hill and Halawa shafts. The model updates in Appendix H should be revised to use the data from these new monitoring wells to determine a defensibly conservative set of boundary conditions. Any model revisions made prior to filling this critical data gap should conservatively assume groundwater flow is from the RHBFSF toward Halawa shaft or instead create boundary conditions that are sufficiently distant that they allow groundwater flow directions between the RHBFSF and the nearby water supplies to be determined by local stresses such as pumping at those water supplies and hydrogeologic features.

The WP and statements from the Navy and EPA dismiss installation of more vadose zone monitoring points because, in part, such actions will remobilize fuel. This is only an unsupported assumption because monitoring wells and vadose zone monitoring points have been successfully constructed in other basalt environments through proper planning, drilling, and oversight. The EPA's stated refusal to require more vadose zone monitoring points near Tank 5 is both disappointing and surprising. It is disappointing because work products for the proposed activities under Tasks 5 through 7 in the WP depend on a defensible understanding of the vadose zone sources and their migration toward the aquifer. It is surprising because an examination of the soil vapor and groundwater data in Appendix D demonstrate that 1) there is more than one LNAPL source near Tank 5, 2) fuel vapors can migrate laterally over many tens or hundreds of feet in the vadose zone toward the monitoring points beneath the 20-foot-thick concrete plug under Tank 5, and 3) the recent extended rise in groundwater contamination corresponds to similar increases in soil vapor concentrations under Tank 5. Adding more vadose zone monitoring points at various elevations alongside Tank 5, carried out with proper planning, drilling, and oversight, will provide the Parties and all stakeholders with a more quantitative understanding of future contaminant migration from the vadose zone into our drinking water aquifer. The argument that access is limited at the ground surface of Red Hill should not be considered a limiting factor – drill pads can be constructed as evidenced by the fact that the Red Hill tanks were initially installed by drilling at the ground surface of Red Hill. Also, if the vadose zone monitoring points help identify LNAPL in the vadose zone, then remediation can be designed and installed to remove the contamination from the vadose zone before it reaches the groundwater. LNAPL in contact with the groundwater is much more difficult to remediate than LNAPL present in the vadose zone.

2. Does Not Use Available Data on Soil Vapor and Groundwater

The WP makes little use of the available data pertaining to soil vapor and groundwater levels and chemistry in the conceptual model and task sections. Tasks should be defined as much as possible using these data so that the investigation activities can be adequately planned. The most recent data from the first quarter of 2016 are not used in either text or figures but are instead restricted to tables in Appendix D. Presenting and interpreting these most recent data should play a central role in discussing the location and migration of the fuel leaked from Tank 5 and other tanks as light non-aqueous phase liquid (LNAPL) and vapor in the vadose zone and as dissolved contaminants in groundwater. We request that the WP Tasks 2 through 7 be revised to 1) present the full data set, 2) examine relationships between soil vapor concentrations and groundwater heads and chemistry, and 3) revise the work plan activities to correspond to the findings and remaining data gaps. Specifically, the tasks should be revised to address the observed concentration changes in soil vapor and groundwater that demonstrate a continued increase since mid-2015 and mid-2014, respectively.

3. *Lacks Characterization of Vadose Zone Sources and Migration*

The WP has no provision for directly characterizing the fuel sources in the vadose zone in and around the tanks beyond an electrical resistivity survey intended to locate LNAPL. The available data demonstrate that contamination continues to migrate through the vadose zone, exceeding the action level, and appears to be driving an increase in groundwater contamination, exceeding the site specific risk-based level (SSRBL) and State of Hawaii Environmental Action Levels (EALs) for groundwater. As currently written, the WP has no way of determining whether fuel contamination migrates through the vadose zone as vapor, as LNAPL, as dissolved contaminants in infiltrating water, or some combination of these. Vapor migration is very likely an important process because vapors have migrated laterally beneath Tank 5's underlying concrete plug many tens or hundreds of feet to reach the soil vapor monitoring points located there. Screening of the remedial alternatives as described in Task 7 will have little to no value in the absence of information about the spatial distribution of fuel contamination or the observed rates of migration. The WP currently has no way of determining whether there is any evidence of fuel degradation in the vadose zone, e.g., levels of oxygen, carbon dioxide, and other degradation-associated compounds.

Tasks 1 and 2 under the WP should be revised to include coring, core analysis, and installation of vapor monitoring points at various elevations around Tank 5. The goal is to install vapor monitoring points that will show how fuel vapors vary with depth over time. This additional work will provide important information about the nature of the fuel contamination (LNAPL, dissolved, or vapor), where it may be located in the vertical dimension (especially given that the holes in Tank 5 spanned a range of elevations and locations), and the rates of contaminant migration as revealed by changes in vapor concentrations such as those observed beneath Tank 5 since mid-2014. The additional work will also provide the site-specific information necessary for a defensible understanding of future contamination rates and a defensible evaluation of remedial alternatives.

4. *Lacks a Decision Process for Extending the Subsurface Monitoring Network*

During the May 10th meeting, the Navy contractor stated that placing a single well near South Halawa Stream will determine how the valley fill unit beneath the stream affects groundwater flow from the RHBFSF toward Halawa shaft. Neither the contractor nor the WP's Task 4 description explain how the data from only one monitoring well will be used to make that determination. Task 4 should be revised to include a priority ranking of the proposed well locations and a process (decision tree) about how decisions will be made to change well location and well installation order based on new data acquired during the drilling program. For example, the decision tree should describe the changes to well locations and order given the following possible findings at proposed RHMW11 and the ability to add monitoring well locations as needed:

- What if RHMW11 groundwater head is found to be lower than heads at upgradient wells (e.g., RHMW02, RHMW06) but higher than head at Halawa shaft?
- What if RHMW11 groundwater head is found to be significantly higher than the nearest upgradient and downgradient heads (such as would be expected for a compartmentalized zone in the aquifer)?
- What if RHMW11 does not intersect valley fill units below the water table?

Such a decision process may not be needed for all the proposed monitoring wells, but it should be added to address the long-standing questions about groundwater flow direction and rate between RHFSF and Halawa shaft. This task should also include a discussion of how groundwater gradients will be calculated under the dynamic pumping stresses and of how a decision will be made as to whether valley fill units in Halawa or Moanalua valleys will or will not prevent contaminant migration toward the water supplies.

5. *Ambiguous Risk Assessment*

The risk assessment does not include any details on who will define what level of risk can be tolerated. "Acceptable risk" target levels should be jointly defined by all Stakeholders before commencing the risk assessment. The Navy will determine if the existing site-specific risk-based levels (SSRBLs) will be evaluated to confirm that they remain protective of the groundwater resource. If they are found to no longer be protective, new SSRBLs will be proposed. There is no discussion on how new SSRBLs will be evaluated by the parties and the process by which they will be reviewed and/or approved. Further, discussion of subject matter expert involvement should be outlined and part of the overall risk assessment process. We recommend that the risk assessment include a critical evaluation of the basis of the DOH's Environmental Action Levels (EALs) for TPH-d and the current drinking water toxicity EALs by either the Navy or EPA and/or DOH.

Detailed Comments and Recommendations

1. Section 2.3.1.1: The first sentence incorrectly states that the Oily Waste Disposal Facility (OWDF) monitoring well (OWDFMW01) is "downgradient" of the Red Hill shaft. Data from the USGS 2015 pump test show water levels were higher than 17 feet above sea level (ft asl) whereas data from the DOH show water levels at the Red Hill shaft were between 16 and 17 ft asl during this time. Thus, the Red Hill

shaft was downgradient of the OWDFMW01 well during that time. The word "downgradient" should be removed from this sentence and Section 3.6.2.2 of the WP should be revised to present and discuss available head data from all the wells and shafts to provide a clearer understanding of groundwater heads in and around the site area with time.

The sentence: "However, the removal of the primary contamination source, reduction of infiltration, and the presence of major hydrogeologic barriers confirmed that the potential for contaminant transport to the basal aquifer was insignificant" is based on erroneous information and should be revised to state: "However, the removal of the primary contamination source, reduction of infiltration, and the presence of major hydrogeologic barriers suggest that the potential for contaminant transport to the basal aquifer may be insignificant." The evaluation of the site-specific geology given in Earth Tech (2000) and ATSDR (2005) incorrectly stated that the basal aquifer is an artesian confined system at the OWDF protected in part by an upward vertical gradient. Heads at the OWDFMW01 are very similar to those at other Red Hill monitoring wells, which are all in the unconfined basal aquifer, and show no indication of confined behavior. Moreover, total petroleum hydrocarbons – diesel range (TPH-d) have been detected at monitoring well OWDFMW01 consistently since at least late 2009. The Oki (2005) USGS groundwater flow model shows confining units are about 1,000 feet away and that the area surrounding the Oily Waste Disposal Facility is part of the unconfined basal aquifer. The presence of contaminants in the basal aquifer at OWDFMW01 indicates that either or both the Oily Waste Disposal Facility and the RHFSF are the sources, indicating that the supposed "major hydrogeologic barriers" may not impede contaminant migration through the vadose zone to the basal aquifer.

2. Section 2.3.1.1: Line 16 states "the presence of major hydrogeologic barriers" was one criterion used by the Navy and DOH to discontinue cleanup actions at the OWDF in 2000. The facility received a No Further Action determination from DOH in April 2005. Based on the recent work conducted documenting the uncertainty regarding the presence and effectiveness of the "major hydrogeologic barriers", including the continued detection of fuel contaminants at the OWDFMW01, the AOC process should include a discussion about whether additional work should be conducted at the OWDF. The Navy and DOH should consider whether the No Further Action determination remains valid given the data collected and evaluated at the OWDFMW01 since 2005.

3. Section 2.3.1.2: Line 36 states "Light non-aqueous phase liquid (LNAPL) was also detected within several slant borings located beneath the tanks but not on the groundwater table." Has any consideration been given to determine the nature and extent of LNAPL from the historic releases that occurred prior to the release at Tank 5 in January 2014? Why is there no mechanism or discussion in the AOC SOW to address such historic LNAPL issues? Should it be discussed and investigated for under the 2014 Groundwater Protection Plan?

4. Section 2.3.1.3: Lines 18 and 19 state that in the core samples, "no constituents were detected above reporting limits or associated action levels." The work plan should be revised to provide more quantitative evaluation of what was observed, even if below the reporting limits or action levels, and discuss why cores collected from under the 20-foot-thick concrete plugs had any fuel.

5. Section 2.3.1.5: Lines 34 through 40 should be revised because the dominant groundwater flow direction as stated in line 37 is to the northwest, not toward the Red Hill shaft to the southeast. Given the stated dominant gradient to the northwest, the 2007 Tier 3 risk assessment is no longer complete and this section should be revised to state that its results are only partially valid.

6. Section 2.3.2.1: Lines 35 and 36 state that the Red Hill shaft has not been "impacted by the January 2014 release". This statement is misleading and should be revised to state that fuel contaminants have been found in the Red Hill shaft but not above levels that require regulatory action.

7. Section 2.3.2.2: Pages 2-14 to 2-16 discuss the groundwater chemistry results for the monitoring wells through the end of 2015 and refer to Appendix D. The text in this section and the plots of groundwater concentrations in Appendix D should be revised to include the results from the first quarter of 2016. The tables in Appendix D present the most recent results whereas the plots and the work plan text do not. The latest results should be included in the work plan because: 1) they are already available and 2) they show that the rise in TPH-d at Red Hill monitoring well RHMW02 observed in the 2015 data continues into 2016, yielding the highest value yet seen, 6,500 micrograms per liter (µg/L).

8. Section 2.3.2.2: Page 2-16, Lines 5 and 6 state "previous TPH-d peak did not correspond to any release for the USTs." This statement should be analyzed more closely. The USTs have had a history of unreported releases and a release could have occurred in 2012 that was not reported.

9. Section 2.3.2.2: Page 2-16, Lines 26 and 27 state "if TPH-d concentrations significantly increase, the monitoring frequency should be increased to monthly." The definition of "significant" increase should be provided in the WP. The BWS considers the increasing concentrations of TPH-d in monitoring well RHMW02 to be significant and, therefore, it is recommended that the monitoring frequency be increased to monthly for this well and those nearby.

10. Section 2.3.2.3: Page 2-17, Lines 4 through 16 state increasing trends in soil vapor concentrations above action levels are required to trigger additional actions. Although the soil vapor concentrations above action levels were observed in the shallow zone below Tank 5, no additional actions were taken because Tank 5 is currently empty. This approach should be reconsidered as the increases in the shallow zone below Tank 5 are likely due to the presence of LNAPL in the

subsurface. Vadose zone characterization work in the area should be conducted to determine the horizontal and vertical extent of the LNAPL plume.

11. Table 1: Pages 2-18 through 2-23 – Specific references should be provided in order for the BWS to review the documents used to develop this table and confirm the accuracy of the information. The summarized information does not provide reference information and there does not appear to be reference information in Section 9, References.

12. Section 3: the significance of the historic Hawaiian town sites and the other culturally sensitive historic sites within Halawa Valley should be discussed in this section.

13. Section 3.6.1: Lines 20 through 25 describe two aquifer types, basal and caprock. This text should be revised to explain that perched groundwater is present at many locations, including the basalt and valley fill units in the Red Hill vicinity. The explanation should include what is known about perched water occurrences at Red Hill.

14. Section 3.6.1: Lines 39 through 41 should be revised to explain that Hunt (1996) also stated that the effects of the geohydrologic barriers may diminish along the inland direction and that he chose North Halawa Valley as a geohydrologic barrier on the recommendation of a colleague, not on the basis of direct evidence about groundwater head or geologic observations.

15. Section 3.6.2: The sentence on Lines 17 through 20 should be removed. The 2007 report contains no direct evidence that shows the North Halawa valley fill unit near Halawa shaft extends below the water table or that geologic materials at the regional water table have a low permeability. The report in question only assumed that a low permeability valley fill unit is present at the water table near Halawa shaft.

16. Section 3.6.2: The sentence spanning lines 23 and 24 should be revised to state that there is no evidence that the Halawa shaft is "cross-gradient" from the RHBFSF. The report in question assumed that the regional gradient was to the southwest and this assumption was contradicted by the TEC (2010) letter report.

17. Section 3.6.2: Lines 31 and 32 state "This well extracts an average of 4 million gallons per day (mgd) and up to 18 mgd of groundwater". These pumping rates contradict the pumping rates stated in WP Section 2.1.1: Line 32 and should be revised to be consistent with each other and accurate.

18. Section 3.6.2: Figure 6, which is used to justify some of the proposed well locations, requires extensive revision before it begins to reflect available data and previous work. Its depictions of the assumed width and depth of the valley fill and saprolite in the North and South Halawa valleys do not take into account the available data thus

is misleading and could lead to incorrect choices for proposed well locations. The depicted widths of Halawa valley fills a this cross-section location are exaggerated by at least 50% beyond those shown in Sherrod et al. (2007) or Stearns (1939). A brief physical visit to South Halawa valley will reveal that deep valley fill (greater than 50 feet in thickness) is confined only to the eastern branch of South Halawa Stream and does not extend to the western branch. The depicted depths of valley fill and saprolite also appear exaggerated and Figure 6 should be revised to reflect Plate 1 of Izuka (1992) and Figure 25 in Wentworth (1942). Please see Figure 1 in our letter "Board of Water Supply (BWS) Comments to the Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility" dated May 27, 2016 (BWS 2016), which presents part of Wentworth's Figure 25.

Figure 6 shows that the proposed monitoring well RHMW11 intersects the western part of the exaggerated width for valley fill in South Halawa valley. Based on the available data, physical visits to this area, and reports cited above, this proposed well is more likely to intersect Koolau basalt than South Halawa valley fill. Consequently, the proposed location should be reconsidered using Figure 6 after the recommended revisions above. The Navy should also consider adding the CWRM's Halawa Deep Monitor Well to the cross-section.

At present Figure 6 only shows a combined valley fill and saprolite unit. What are the other units and where do they occur?

The BWS Halawa Shaft is projected into the valley fill in Figure 6 which is factually incorrect. Figure 6 should be revised to show that the shaft is northwest of the valley fill in North Halawa valley as shown in cross-section A-A' on Plate 1 in Izuka (1992). A perpendicular projection of the dot representing the shaft in the inset to Figure 6 still places the shaft outside of the valley fill to the west or northwest. The current placement and depiction of a well instead of a shaft are likely to only confuse readers. Figure 6 presently appears to imply that Halawa shaft can actually withdraw large amounts of water (6 to 10 million gallons per day) from the valley fill.

19. Section 3.6.2.1: The last sentence in this section should be revised to state that contaminated groundwater from the RHBFSF could not affect water quality in these two streams, but lateral migration of LNAPL through the vadose zone could affect water quality in these two streams.

20. Section 3.6.2.1: Figure 7 states that it is a geological cross-section. However, it does not show any geology and should instead be characterized as a schematic or longitudinal profile.

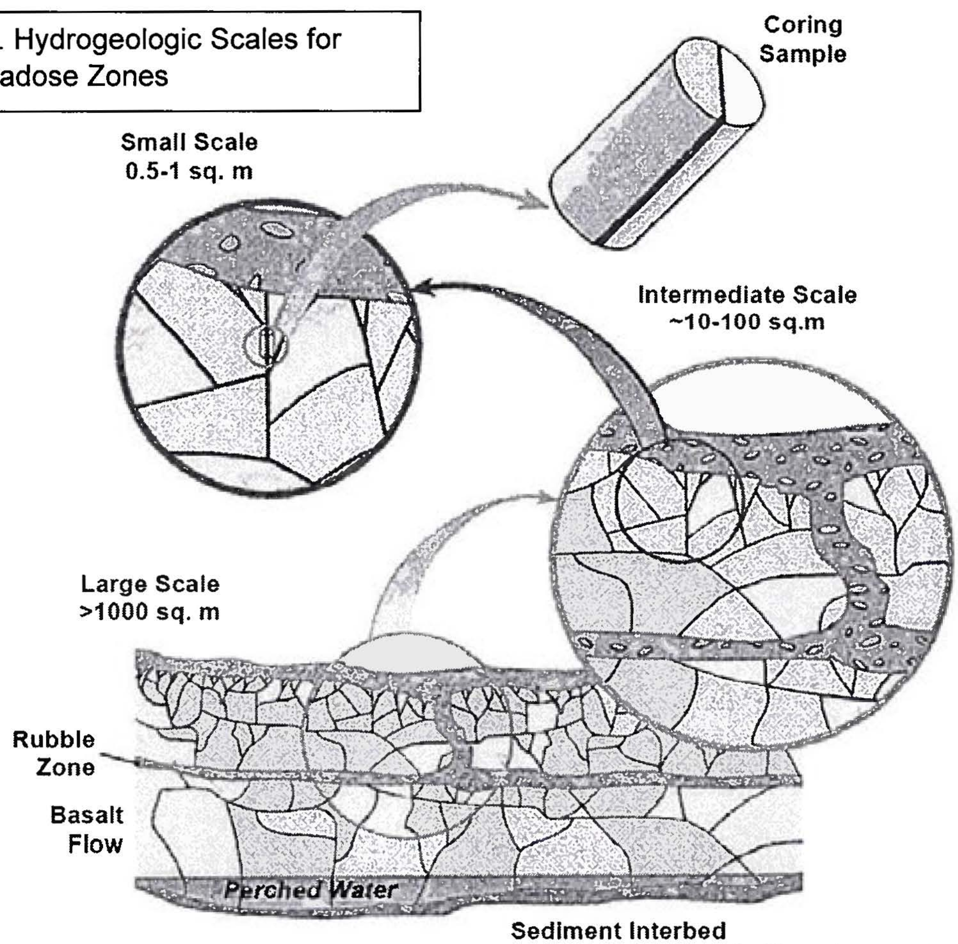
21. Section 3.6.2.2: The text in lines 2 through 17 should be removed from this section and placed in the following section, which describes hydraulic conductivity. The sentence spanning lines 14 and 15 should be revised to remove the words "and unresolvable" as this is not true. Groundwater flow patterns can be resolved wherever there are a sufficient number of wells are suitably located for the system in

question.

22. Section 3.6.2.2: The text in between lines 36 and 43 needs to be thoroughly revised to state that the effects of Halawa shaft pumping are not yet well understood and to include a discussion of the observed head changes from the recent USGS pump test that showed pumping changes at Halawa shaft did cause head changes in Red Hill monitoring wells. All text about valley fill barriers should be removed or revised to state that there is yet no direct evidence of barrier behavior by the valley fill units.

23. Section 3.7.4: Lines 10 through 14 are misleading and should be removed. The statements about low vertical permeability in the basalts presented here and in Sections 3.6.2.3 and 3.7.3 may well be true at small scales on the order of 1 meter^2, but such statements are readily contradicted by the fact that recharge occurs at rates between 10 and 25 inches per year in the Red Hill vicinity (see Oki, 2005 and Giambelluca 1983 for example). The authors appear to be solely focused on the micro-scale, whereas recharge and contaminant migration occur at the intermediate to large scales (Figure 1 below, which is adapted from Figure 3 in Fabyshenko et al., 2000). If the massive components of a'a flows are so impermeable, how can

Figure 1. Hydrogeologic Scales for Basalt Vadose Zones



recharge occur at such a large rate over such a large area? If recharge is negligible at Red Hill, why has the Navy invested so much into the system of collection trenches, sumps, and treatment units to handle infiltrating water? If the vertical permeability is so low as to impede vertical flow, why aren't they preventing the fuel contamination from migrating through the vadose zone into the groundwater, causing rising concentrations in vapor below Tank 5 and at monitoring well RHMW02? Relatively rapid migration of infiltrating water through massive basalt flows for small, intermediate, and large scales has been well established elsewhere (Fabyshenko et al., 2000; Fabyshenko et al., 2001; Baker et al., 2004), and the authors are encouraged to study these reports. As neither water nor fuel appear to have any problem moving vertically through the basalt vadose zone, this text should be revised to account for the large mass flux of water migrating through extensive areas of the basalt vadose zone.

24. Section 3.7.4: Lines 14 through 22 should be revised to remove the any mention of compartmentalization for monitoring well RHMW07. Such compartmentalization is questionable given that fuel contaminants have been detected in its groundwater and further, such conditions appear to be rarely observed in and around the RHBFSF. The section should also be revised to describe that vapor, LNAPL, dissolved contaminants, or some combination are readily migrating vertically through the vadose zone causing the observed increases in groundwater concentrations at RHMW02 and at the soil vapor monitoring points beneath Tank 5 during the last year or so.

25. Section 3.7.4: Lines 36 to 38 should be removed because fluids are already moving relatively freely through the vadose zone and the risk of remobilization can be successfully managed. The so-called "naturally existing confining layers" are not interfering with the large mass flux of infiltrating water that becomes recharge. Carefully planned, implemented, and supervised drilling and construction will prevent perched water and contaminants from being remobilized.

26. Section 3.7.4: Lines 39 and 40 should be deleted and replaced with text that describes how the vertical distribution of LNAPL pockets can be determined from a series of vertically distributed soil vapor monitoring points alongside and beneath Tank 5. Lines 41 to 43 on page 3-28 and Lines 1 to 2 on page 3-29 should be removed and replaced with a discussion of how vapor concentrations in the vadose zone can be used to identify which elevations likely contain LNAPL pockets large enough to warrant remediation. As vapor appears to have little problem moving horizontally, soil vapor extraction will likely be a successful remediation alternative.

27. Section 3.7.4: Lines 3 to 7 on page 3-29 should be removed. Dissolved oxygen levels in groundwater are not relevant to degradation in the vadose zone, which is the focus of this section. This section should be revised to state that measurements of gaseous oxygen in the vadose zone will be collected from the soil vapor monitoring points to see if there is sufficient oxygen to support degradation of fuel in

the vadose zone.

28. Section 3.7.4: Lines 8 through 12 on page 3-29 should be deleted as they are unsupported conjecture. Successful modeling requires a basic understanding of the processes and features controlling water and contaminant migration in the vadose zone, and, as explained above, there is ample site-specific evidence that fluids, whether infiltrating water or contaminants, are migrating through the vadose zone. The work plan should be revised to acquire the necessary data and understanding of the key processes and features at the correct scales.

29. Section 4.1: Lines 4 to 9 should be removed because previous studies only assumed that the valley fill units impede groundwater flow. This text should be revised to state that the role of the valley fill units remains an important data gap that must be resolved by work in Tasks 1 and 4.

30. Section 4.1: Task 1: Line 40 states "NAPL has not been observed in measurable quantities in any of the monitoring or supply wells". Define "measureable" and discuss NAPL readings observed to date.

31. Section 4.2: This section should be revised to include installation of soil vapor monitoring wells at different elevations alongside Tank 5 to: 1) determine which elevations have high or low fuel vapor concentrations, and, 2) to track the migration of contaminants through the vadose zone such as the migration indicated by the groundwater and vapor data from the last year or so.

32. Table 3: COPC List for AOC statement of Work Sections 6 and 7 Investigation – Discuss justification as to why lead scavengers (1,2-dichloroethane and 1,2-dibromoethane) are not being sampled for at Red Hill Shaft (RHMW2254-01) and why lead scavengers (1,2-dichloroethane and 1,2-dibromoethane) are only being analyzed for a period of one year of investigation groundwater sampling if results are non-detect.

33. Section 4.4: Task 4: Our initial comments for this section were sent to EPA and DOH in a letter "Board of Water Supply (BWS) Comments to the Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility" dated May 27, 2016 (BWS, 2016).

34. Section 4.4: Task 4 should be revised to include a priority ranking of the proposed well locations and a process (decision tree) about how decisions will be made to change well location and well installation order based on new data acquired during the drilling program. For example, the decision tree should describe the changes to well locations and order given the following possible findings at proposed RHMW11 and the ability to add monitoring well locations as needed:
    - What if RHMW11 groundwater head is found to be lower than heads at upgradient wells (e.g., RHMW02, RHMW06) but higher than head at Halawa

shaft?

- What if RHMW11 groundwater head is found to be significantly higher than the nearest upgradient and downgradient heads (such as would be expected for a compartmentalized zone in the aquifer)?

- What if RHMW11 does not intersect valley fill units below the water table?

Such a decision process may not be needed for all the proposed monitoring wells, but it should be added to address the long-standing questions about groundwater flow direction and rate between RHFSF and Halawa shaft. This task should also include a discussion of how groundwater gradients will be calculated under the dynamic pumping stresses and of how a decision will be made as to whether valley fill units in Halawa or Moanalua valleys will or will not prevent contaminant migration toward the water supplies.

35. Section 4.4: The WP acknowledges that the groundwater system near the RHBFSF is very dynamic in time, thus Task 4 should be revised to include long-term monitoring of heads in the extended well network using transducers to provide sufficient data for model calibration in Section 4.5.

36. Section 4.4: The synoptic water level measurements should only be made after all measuring points at the monitoring wells have been surveyed to an appropriately high degree of accuracy.

37. Section 4.5: This section should be revised to make the following changes:
    - State that modeling will begin once data have been collected and analyzed from the extended monitoring well network;
    - The conceptual and numerical models will assume valley fills units do not impede groundwater flow from the RHBFSF toward Halawa shaft and the Moanalua wells until the field characterization demonstrates otherwise;
    - The boundary conditions described in this section and Appendix H should reflect the data collected from real-time measurements of heads across the model domain. At a minimum, the boundary conditions should conservatively assume groundwater flow is from the RHBFSF toward Halawa shaft or instead create boundary conditions that are sufficiently distant that they allow groundwater flow directions between the RHBFSF and the nearby water supplies to be determined by local stresses such as pumping at those water supplies and hydrogeologic features.

38. Section 4.6: This section should be revised to include determining the different-sized areas around the tanks that will be contaminated by LNAPL and dissolved contaminants for different sizes of fuel releases.

39. Section 4.7 and Appendix F: Page 4-10, Lines 34 and 35 and the Introduction in Appendix F state that a detailed and comparative analysis of remedial alternatives will not be conducted until the investigation is completed. The detailed and comparative analysis can only be performed if the extent and disposition of the NAPL and the dissolved hydrocarbon plume is fully characterized. The WP/SOW, however, does not include any provision for NAPL characterization, any provision for vertical characterization of the dissolved plume, and does not provide for a phased approach for delineating the horizontal extent and magnitude of the dissolved plume. It would be beneficial to understand how a more detailed and comparative analysis will be performed without even a conceptual plan for locating and delineating the NAPL. Please revise this section to explain clearly how the remedial alternatives can be evaluated in a useful manner in the absence of identifying where the contamination to be removed is located in the subsurface.

40. Section 4.7: This section indicates that remedial alternatives will be evaluated using the nine NCP criteria. It seems appropriate that Appendix F would have laid out the framework for the evaluation of the remedial technologies using these criteria. Since minimal effort was applied to this preliminary and tentative remedial analysis, Appendix F could have been used to define each criterion and how the structure of the analysis would be developed. For example, will "No. 7 – Cost" include development of a cost estimate based on future or present values? Will the cost evaluation include capital expenditures, O&M costs, laboratory analyses, impacts to facility operations, etc.? Will the cost analysis include actual engineer estimates based a conceptual design or just an application of published cost data from literature? Please revise this section to define each criterion and describe in detail the evaluation framework to be used.

41. Section 5.5.2: With a reduced COPC analyte list, how can an accurate risk assessment be performed? Lines 30 and 31 state "COPC concentrations that exceed the DOH EALs may be further evaluated in a Tier II baseline risk assessment." It seems in should be a requirement that any COPC concentrations that exceed the DOH EALs should be further evaluated and that at a minimum a Tier II baseline risk assessment should be performed for each COPC exceedance.

42. Appendix F: The list of remedial alternatives is incomplete. Consideration of all available reasonable technologies should be included in the analysis. This should incorporate enhancements to the core technologies. For example, heat- or steam-enhanced SVE could significantly accelerate NAPL recovery such that an evaluation separate from just traditional SVE would be warranted. Some other technologies to consider may include bioaugmentation, wellhead treatment, vacuum-enhanced NAPL recovery, stabilization/fixation, and interception barriers. Table F1 should include all technologies that were at least considered, even if the resulting "not recommended" designation is applied.

43. Appendix F: Any evaluation of remedial technologies should include a discussion and possible analysis of combined technologies. This is particularly important when evaluating technologies applied to quite different remedial goals (e.g. dissolved-phase treatment technologies versus NAPL recovery from the vadose zone), or adjusting the treatment technology to optimize cost and energy expenditure during the application (e.g. use of SVE to remediate NAPL and conversion to bioventing for residual mass removal).

44. Appendix H: Lines 25 to 30 page H-7 – see comment for Section 3.6.2 Lines 17 through 20 and for Section 4.1: Lines 4 to 9.

45. Appendix H: Lines 33 to 34 page H-7 – see comment for Section 3.6.2 Lines 23 and 24.

46. Appendix H: Lines 5 to 11 page H-8 should be revised to include mechanisms expected to accompany different sizes of fuel releases. For example, a large fuel release could lead to LNAPL flowing into one of the streams adjacent to the RHBFSF.

47. Appendix H: Lines 23 to 34 page H-8 should be revised to discuss the detections of fuel contaminants in the RHMW06, RHMW04, RHMW07, OWDFMW01, and the CWRM's Halawa Deep Monitor Well.

48. Appendix H: Lines 14 to 21 page H-11 – see comment for Section 3.6.2.2.

49. Appendix H: Section 3.4 should be revised to state that the 2007 model assumed valley fill units were present in Halawa valley and impeded groundwater flow and did not test that assumption, unlike the modeling work reported in Oki (2005). This section should be revised to state that the calibration used head data found to be erroneous because of surveying errors and so is questionable. Also, text should be added stating that the model's boundary conditions were too close to the area of interest and constrained groundwater flow throughout the domain. Figure H-4 should be removed because this model's results are based on erroneous calibration data, improperly specified boundary conditions, and untested and unsupported assumptions about the dimensions and properties of the valley fill units.

50. Appendix H: Section 3.5 Lines 27 to 29 should be revised to state that biodegradation of fuel contaminants in groundwater only occurs in parts of the aquifer with the appropriate geochemistry and the high groundwater flow rates (advection) may drive contaminants away from these favorable zones before much mass has been degraded, potentially leading to contamination of clean parts of the aquifer.

51. Appendix H: Section 4.2. This section should be revised according to the comments for Section 4.5.

52. Appendix H: Section 4.4 should be revised to follow the approach in Oki (2005) and determine whether calibration results are significantly different between a simulation without the valley fill units and a simulation with the valley fill units. If the differences are relatively small, then the model without the valley fill units should be chosen as the most conservative for predictive simulations. The calibration should be checked to ensure that the model creates simulated groundwater flow rates and directions that agree with results from the base case and no valley fill scenarios in Oki (2005).

53. Appendix H: Section 4.6 requires much more detail on the sensitivity analyses that will be performed to ensure that the model reflects an appropriate combination of choices of boundary conditions, dimensions and properties of the valley fill units (if any), and initial conditions.

54. Appendix H: Section 5 should be revised to examine a range of different fuel releases and release points. For example, a large fuel release could migrate many tens or several hundreds of feet laterally within the vadose zone before migrating down to the aquifer. Thus, the modeling should include releases into groundwater from an envelope surrounding the tanks.

55. Appendix H: Section 5.2 the last sentence on lines 20 to 21 should be revised to discuss what is meant by "reasonable" and also to discuss how the rate estimation will be carried out in the absence of data showing the extents of the geochemical zones favorable to degradation and how the uncertainty in the advective transport will be quantified and incorporated. For example, it is likely that the rate of advection is large enough to limit the residence time for contaminants within the geochemically favorable zones. This section should state that a range of conservative degradation rates will be used in the simulations, including a rate of zero.

56. Appendix H: Section 5.5.1 should be revised to reflect the statements made by AECOM and EPA during the May 10th meeting that the fate and transport modeling will assume that all of the fuel from each of the release scenarios will be present in the groundwater at the start of the simulations.

57. Appendix H: Section 5.5.5 should be revised to explain how the rate fitting process will deal with uncertainties in extent of and residence time in the geochemically favorable zones and in advection rates.

58. Appendix H: Section 5.8 should be revised to provide more detail on what will and will not be included in the sensitivity analyses.

59. During the AOC meeting on May 10, 2016, Navy representatives stated that they would provide a list of all fuel types/fuel additives that are currently stored or were

historically stored at the RHBFSF. The BWS requests that this information be provided to the BWS by June 10, 2016. The BWS also requests that the Navy begin testing all groundwater samples for those additives.

Thank you for the opportunity to comment. If you have any questions, please feel free to call me at (808) 748-5061.

Very truly yours,

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