BOARD OF WATER SUPPLY

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January 25, 2018

Mr. Omer Shalev
United States Environmental Protection Agency
Region IX
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and

Ms. Roxanne Kwan
Solid and Hazardous Waste Branch
State of Hawaii
Department of Health
919 Ala Moana Blvd., Room 212
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Dear Mr. Shalev and Ms. Kwan:

Subject: Board of Water Supply (BWS) Comments on the Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7 Groundwater Modeling Working Group Meeting No. 6 Held December 20, 2017

The Honolulu Board of Water Supply (BWS) offers the following comments on the above referenced meeting. A copy of the Navy slide presentation from the December 20, 2017 meeting is included in Attachment A for your reference and so our comments on particular slides in our specific comments section below can be correlated by the reader. We have a number of major concerns about the interim groundwater modeling described during the meeting:

1. The Navy's approach for developing the interim groundwater flow model does not adequately improve our understanding of the direction and rate of groundwater flow within the aquifers around the Red Hill Facility. The Navy's plans to develop a groundwater flow model that has been primarily calibrated using a series of "steady state" approximations with uniform hydraulic properties for the basalt, uniform properties for the saprolite, and model layers that have not been adequately vetted are not supported by the BWS for the following reasons:

    - The Navy's plan to calibrate to average water levels calculated from multiple transient water levels measured at a well greatly increases the size of the tolerance limit a model can have and still be considered to be calibrated. A

tolerance limit is the maximum difference (referred to as error by the Navy) allowed between the modeled and measured water level at a well that is considered a satisfactory match. The BWS advocates the development of a transient model that is calibrated using a series of measured water levels at a well with error of plus or minus a few tenths of a foot instead of the Navy's development of steady-state models that are calibrated using water level measurements with a tolerance limit of ± 2 feet at an observation well and a tolerance limit of ± 4 feet at a pumping well.

- The Navy's assumption that the basalt zones in Red Hill are fully interconnected and have uniform properties in each model layer creates a situation that promotes simulated hydraulic capture of groundwater beneath the Red Hill underground storage tanks by Red Hill Shaft. Numerous studies have shown that the spatial variability of the aquifer hydraulic properties is a primary factor that makes it difficult to predict contamination migration and hydraulic containment of a plume. Despite repeated concerns from BWS that data from Red Hill indicate significant spatial variability in the basalt hydraulic properties, the Navy continues to overlook the risk of contamination with a groundwater model that ignores the possibility of preferential flow paths created by lava tube and clinker zones. The BWS recommends that the Navy provide a more realistic representation of the basalt properties than the representation used in previous regional-scale models of groundwater flow.

- The Navy's planned modeling approach of assuming extensive saprolite deposits in North and South Halawa Valleys based on a single measurement of saprolite thickness at well RHMW11 is not appropriate nor consistent with the objective of evaluation risk of contamination migrating to Halawa Shaft. Similarly, the Navy's assumption that all saprolite has a low-permeability is not supported by the scientific literature and so cannot be justified without hydraulic tests performed in the saprolite. The BWS advocates that assumptions regarding saprolite should be conservative relative to its impact to prevent contamination migration away from Red Hill until additional characterization of the saprolite shows otherwise.

- The Navy's plan to use model layers of constant thickness measured from the water table has not yet been properly justified. The BWS recommends that the Navy justify the model layering with respect to the screen intervals of the observation wells and the shafts, hydraulic gradients measurement between wells assigned to the same model layers, cross-sections showing differences in the physical and hydraulic features of the basalt, evaluations of possible vertical hydraulic gradients, and vertical profiles of total dissolved solids concentrations.

2. The Navy's approach does not include the type of uncertainty analysis that the BWS has advocated since the groundwater modeling meeting #3 in August 2017. There were no data presented in the December 2017 work group meeting that have changed our position that an uncertainty analysis should be performed to account for the uncertainty

associated with the representation of key model features such as recharge rates, the hydraulic properties of the basalts, the location of the saprolite, and the permeability of the saprolite.

3. The Navy's approach assumes that the financial and institutional resources for groundwater remediation will be available for an unknown but potentially very long period of time. The BWS believes that the Navy has not yet demonstrated that this is a reasonable assumption. The BWS recommends that the Navy develop a groundwater model that can evaluate both hydraulic capture by Red Hill Shaft as well as the risk from contaminant migration to Halawa Shaft.

4. The Navy has still not explained important details about how they will calibrate the interim model. Such details may have a large impact on what the model will likely predict.

5. The Navy has not yet provided any data from their groundwater database. Without access to the site data, BWS' ability to evaluate the Navy's assumptions and modeling approach is considerably less than what it otherwise would be given access to the groundwater database.

Specific Comments

- Slide 5: The Navy continues to focus the interim groundwater modeling on capture of fuel contaminated groundwater by the Red Hill Shaft even though the Regulatory Agencies asked that the interim model be used to inform the tank upgrade alternative (TUA) selection process. The interim model should be able to provide answers to multiple questions and therefore exhibit fate and transport information as well as inform the TUA decision. We believe that if the interim model is to be fit for the purpose of informing the TUA selection, this model should provide flow and transport model results needed to understand the conditions under which contaminated groundwater will migrate from Red Hill to Halawa Shaft and Moanalua Wells given the uncertainty existing about the features and processes most important to driving contaminant migration. Assuming pumping at Red Hill Shaft will capture all contamination does not help select a TUA.

- Slide 5: Given the absence of comments from the Environmental Protection Agency (EPA) and Hawaii Department of Health (DOH) during the December 2017 meeting, the Parties appear to be confident that operating Red Hill Shaft as a pump and treat system will protect Halawa Shaft, Moanalua Wells, and other water resources. The BWS asks that the Parties demonstrate that there is scientific evidence to support such confidence by collecting the data and conducting the necessary pilot studies to validate its pump and treat approach. Pump and treat alone is not a long-term solution for protecting our water resources without simultaneously installing a TUA capable of interstitial monitoring and tank wall inspection in our opinion.

- Slides 24 to 26: The average trends computed for the wells appear to show rising water levels in the basalt aquifer whereas the long-term record shows that there is a persistent downward trend. We urge the Navy to follow Dr. Oki's recommendation to de-trend the groundwater level data.

- Slide 30: The question about whether the Navy used historical water levels that were or were not corrected for the errors in surveying the tops of casings at monitoring wells should be answered before proceeding with the modeling. If the original analysis did not have corrected groundwater elevations, then the data should be corrected, checked for quality, and the analysis redone.

- Slide 31: BWS disagrees with the discussion of water level measurement error. The slide confuses (and mixes) real temporal variability that occurs in the water levels with error added from the measurement process. Fluctuations in the water levels at a groundwater well caused by seasonal changes in the aquifer, e.g., recharge and pumping rates, and by daily changes, such as barometric fluctuations, are not sources of error. These temporal variations in the water levels are real because they are caused by changes in stresses to the aquifer. The inability of a groundwater model to reproduce the measured water level values is an error in the model and not in the measurements. The Navy's treatment of real seasonal and daily fluctuations as errors that should be grouped together with measurement error is part of the Navy's flawed and incomplete conceptual model of the groundwater flow system.

- Slide 32: Temporal variations in water levels reflect seasonal changes and are only "errors" when computing an average for a steady-state calibration. We reiterate that the calibration approach should focus on matching heads and gradients over time rather than for a steady-state average because the steady-state approach is based on groundwater water level data with much larger "error" bars than the transient approach. The error bars of 1 to 3 feet proposed by the Navy are unnecessarily large and will likely yield predictions that are neither realistic nor defensible.

- Slide 40: Errors of +-2 feet at observation wells and +-4 feet at pumping wells seem very high for calibration especially given the extremely flat gradients in the aquifer. This doesn't give confidence that calibrating to water levels will be worth much. We recommend that the calibration approach most heavily weight the differences in groundwater levels observed at Red Hill monitoring wells and Halawa Shaft (as well as at other water supplies). Also, we request that the Navy attach the highest weighting to groundwater elevations at Halawa Shaft, Moanalua Wells, and Kalihi Shaft because these are vital water supplies.

- Slide 40: BWS, United States Geological Survey (USGS), DOH, and University of Hawaii subject matter experts all agreed that groundwater level measurements at shafts do represent the groundwater levels in the formation, so levels at Halawa Shaft and Kalihi Shaft should be classified as both important and representative.

- Slide 43: BWS requests that the Navy correct the estimated spring flow rates by following the approach described by Dr. Oki of the USGS in which flow rates are calculated as a function of nearby observed groundwater levels.

- Slide 44: The statement made by Dr. Panday of GSI that they will not calculate the usual statistics for transient calibration but rather rely on a visual judgement is very concerning. The BWS asks that the transient calibration be quantified according to standard groundwater modeling practice, i.e., determine statistics of the differences between observed and simulated values, including Root Mean Square Error, Mean Error, Mean Absolute Error and Normalized Root Mean Square Error based on the range in observed heads,) and demonstrating that these differences are neither spatially nor temporally biased.

- Slide 49: BWS requests that the Navy revise its approach to calculate "recharge factors" according to guidance provided by Dr. Oki.

- Slide 56: The refined areas of the quadtree mesh appear to presume that valley fill/saprolite extends into the saturated portions of the aquifer far inland from the site. Again, there is only the geologic log from RHMW11 that indicates saprolite beneath the water table. The approach is based upon what seems like a pre-conceived assumption of deep valley fill/saprolite that is not supported by much data and is not conservative regarding risk to Halawa Shaft.

- Slide 58: Where layers 2 and 3 are used to represent saprolite, the thickness of the layers becomes very important and there are insufficient data from Well RHMW11 to determine the areal and vertical extent of the saprolite.

- Slide 69: The Navy's proposed ranges for hydraulic properties should be revised to reflect the scientific literature for Oahu. First, the range of saprolite hydraulic conductivity should match the range of roughly less than 1 foot per day to several hundred feet per day reported by Hunt (1996). Second, the horizontal hydraulic conductivity anisotropy ratio is too narrow. Estimates of this ratio are based solely on models, primarily models with coarse spatial refinement. Since the anisotropy ratio is model-based, its full range should be included in the calibration, specifically, the calibration should test whether a ratio value of 1 is any less valid than the proposed ratio value of 3.

- Slide 69: The interim modeling approach proposed during the meetings contradicts statements about Red Hill hydrogeology made by the Navy's contractor. John Thackston of AECOM indicated that the hydraulic conductivity of the basalt aquifer along the Moanalua side of Red Hill Shaft is "ten times larger" than the hydraulic conductivity near the Red Hill Shaft pumps (Halawa side). Mr. Thackston based his conclusions on the different inflow rates reported along the Red Hill Shaft length during its construction. In contrast, Dr. Panday stated during this meeting that they will assume a constant hydraulic conductivity for the basalt aquifer in the interim

model. This statement contradicts Mr. Thackston's statement that there is large variability in basalt hydraulic conductivity. This contradiction should be resolved because the extent of the Red Hill Shaft's capture zone will likely be affected by such a large variation in hydraulic conductivity. We ask that the Regulatory Agencies direct the Navy to investigate the effects of spatial variations in hydraulic conductivity in the basalt aquifer on capture zone extent and efficacy.

- Slide 69: During the meeting, we asked whether the Navy will or will not force the model to include a saprolite "barrier" along the Halawa Valleys if the calibration results demonstrate that the calibration is not sensitive to the presence or absence of the saprolite. We recommend that the Navy describe their plan for inclusion of the, as-yet, unjustified saprolite "barrier" and ensure that they conduct and report simulations without the saprolite.

- Slide 70: Why is the flux along the northeast boundary only applied to layer 5? This recharge from the Koolau range should also directly reach model layers 2-4 and thus the modeling should reflect this. The assumption of vertical equilibration in the model, as stated by Dr. Panday, may not be valid given the assumed vertical to horizontal anisotropy ratio of 1/1000.

- Slide 77: The control points along the northwest model boundary and the single point along the H3 Freeway near Halawa Shaft appear to artificially bend the groundwater contours in a south-westerly direction near Halawa Shaft that might otherwise be more westerly. What is the basis for the head values assumed for these control points? Picking a control point near a potential receptor well seems dubious.

- Slide 81: The apparent "steep gradient south of RHMW07" could more credibly be explained by the measurement at RHMW07 as a water level that is not representative of the regional flow in the basalt. Prior to including RHMW07 in the model calibration, the Navy's conceptual model should be updated to explain the steep hydraulic gradient.

We continue to ask that the Navy distribute meeting handouts and other information documents two weeks prior to the start of each meeting to ensure subject matter experts, the BWS, and other stakeholders are afforded the opportunity to thoroughly review the materials ahead of time. We also request that the Navy and its contractors provide copies of all materials disclosed at the meeting that they committed to share with subject matter experts.

Thank you for the opportunity to comment. If you have any questions, please feel free to call Erwin Kawata at 808-748-5080.

Very truly yours,

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Attachment A

Navy Slide Presentation Dated December 20, 2017

References

Hunt Jr., C. D. 1996. Geohydrology of the Island of Oahu, Hawaii. Professional Paper 1412B. U.S. Geological Survey.