BOARD OF WATER SUPPLY

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October 24, 2018

Mr. Omer Shalev
United States Environmental Protection Agency
Region IX
Underground Storage Tank Program Office
75 Hawthorne Street
San Francisco, California 94105

And

Ms. Roxanne Kwan
State of Hawaii
Department of Health
Solid and Hazardous Waste Branch
2827 Waimano Home Road
Pearl City, Hawaii 96782

Dear Mr. Shalev and Ms. Kwan:

Subject: Board of Water Supply (BWS) Comments on the Navy's 2018 Conceptual Site Model Report, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, dated July 27, 2018

The BWS is participating as a subject matter expert (SME) under paragraph 1.1 of the Red Hill Bulk Fuel Storage Facility (RHBFSF) Administrative Order on Consent (AOC) Statement of Work (SOW) by reviewing various work products prepared by the Navy under the AOC and also by attending AOC technical meetings. The BWS reviewed the above reference report and offers the following comments.

This report describes the Navy's most recent (2018) Conceptual Site Model (CSM) for the migration of fuel contaminants dissolved in groundwater as a light non-aqueous phase liquid (LNAPL) in the subsurface at the RHBFSF. The Navy CSM report comprises seven modules that describe the physical setting in Moanalua and Halawa Valleys, RHBFSF construction and operation, release and migration of fuel LNAPL, conceptual models of the vadose zone (subsurface between ground level and water table) and saturated zone (subsurface below the water table), fate and transport of dissolved and LNAPL contamination, and a model for exposure to fuel contaminants.

As we explain below, our review reveals errors, omission of important data, and unwarranted supposition. Many of the findings presented in the executive summary are either unsupported or contradicted by available evidence. Given that they are based on a combination of unfounded and non-conservative estimates, the report's conclusions should not be used as an input to the AOC parties tank upgrade alternative (TUA) selection process unless and until these flaws are corrected. We request that the United States Environmental Protection Agency (EPA) and Hawaii Department of Health (DOH) (collectively, "Regulatory Agencies") take all steps necessary to protect our sole-source aquifer and our drinking water by requiring that the Navy revise the CSM report to focus on the copious data from the several synoptic water level studies, and correct these errors so that the CSM and the numerical models upon which it is based provide a conservative estimate of environmental risk from the RHBFSF fuel tanks.

The following is a non-exhaustive list of several examples of these shortcomings based on evidence found in the 2017-2018 synoptic water level survey. In all cases, the water level data contradict the Navy's conclusions made in the CSM. Consequently, we request that the Regulatory Agencies direct the Navy to go back to the site-specific data and correct their CSM report before completing the final groundwater flow model. Failing to do otherwise will ensure that the final model is neither defensible nor representative of what is actually occurring in Moanalua and Halawa Valleys.

General Comments

1. Example 1: Groundwater levels. The Navy repeatedly states that groundwater at the RHBFSF flows to the southwest toward Red Hill Shaft (see Executive Summary comment f below). Plotting of the groundwater levels together for two-week periods reveals that hydraulic gradients are very flat with little differences in heads with groundwater flow directions being site dependent and including directions to the north, northwest, and south with respect to Red Hill ridge, especially when Red Hill Shaft is not pumping. Figures 1 and 2 in Attachment A of this letter show groundwater levels corrected for barometric effects over two consecutive two-week periods during which Red Hill Shaft does not pump for several days and then pumps the remainder of the periods. We make the following observations from the data:

    a. Red Hill Shaft pumps for only part of each day during nearly the entire duration of the synoptic water level survey. When pumping ceases, head at the shaft rapidly returns to its non-pumping level that often exceeds heads at monitoring wells RHMW04, RHMW06, and OWDFMW01.

    b. Heads at monitoring wells RHMW03 and RHMW01 are essentially equal and higher than the head at monitoring well RHMW02 in early October

2017 (please see Figure 2 in Attachment A). Heads at monitoring wells RHMW02 and RHMW05 are nearly identical for the majority of the time.

c. All four of these wells have heads that are higher than monitoring wells RHMW06, RHMW04, RHMW09, OWDFMW01, and Red Hill Shaft when it is not pumping.

d. When pumping ceases at Red Hill Shaft, the shaft water level matches the head at monitoring well RHMW08 almost exactly, more closely than any other monitoring well. Yet this monitoring well is located nearly twice as far from the Red Hill Shaft pump house than monitoring well RHMW05 and almost the same distance as monitoring wells RHMW01 and OWDFMW01. Monitoring well RHMW08 is relatively far from the shaft's infiltration gallery, especially the end with the highest historical inflow rate (and inferred hydraulic conductivity). The CSM and final groundwater flow model should address how this almost exact match affects the conceptualization of the basalt aquifer as well as groundwater capture.

e. The CSM states that the general transport of the Contaminants of Potential Concern (COPC) from the RHBFSF tanks is in the southwest direction toward Red Hill Shaft. This statement is based on the Navy's modeled water levels and not measured water levels. As demonstrated during the EPA and DOH presentation during the August 16, 2018 groundwater modeling working group meeting, the Navy model(s), which predict a hydraulic gradient in the southwest directly, are not credible or believable. As previously mentioned by the BWS, the analysis of measured water levels shows that the hydraulic gradients are very flat with little differences in heads with groundwater flow directions being site dependent and including directions to the north, northwest, and south with respect to Red Hill ridge, especially when Red Hill Shaft is not pumping. The BWS recommends that the Navy use only analysis of measured water levels in the CSM to characterize the direction and magnitude of the hydraulic gradients between the RHBFSF monitoring wells.

2. Example 2: Barometric effects on groundwater heads. CSM report Table 6-5 and the accompanying text state that RHBFSF monitoring wells, except for RHMW07, have no response to changes in barometric pressure. This conclusion is unsubstantiated and is likely not correct.

   a. Our preliminary analysis of water levels in the RHBFSF area indicates that water levels in the RHBFSF monitoring wells are affected by low-amplitude barometric pressure fluctuations in the atmosphere. Figure 3 (Attachment A) shows hydrographs measured between September 27 and

October 5, 2017 when Red Hill Shaft was not pumping. The hydrographs show oscillations in the water level at monitoring wells RHMW07, RHMW02, OWDFMW01, and RHMW06. (Note that the fluctuations in water level elevations are greater for monitoring well RHWM07 than for the other three wells). Contrary to the Navy's analysis, our preliminary analysis shows that all four monitoring wells respond to changes in barometric pressure and that the barometric efficiency calculated for each monitoring well is dependent on the time interval used for analysis. The BWS recommends that the Navy provide additional information to describe the assumptions and procedures used to calculate barometric efficiency in Table 6-5 and to document what is meant by "no response."

b. Our preliminary analysis investigated removing the barometric pressure's effect on water levels (Toll and Rassmusen, 2007; Rassmusen and Crawford, 1997; Butler et al., 2011; Spane, 2002) using the 9 days in late September 2017 and early October 2017 of water level data. Barometric measurements collected at a nearby USGS gage; Aiea US Navy (187-B), Oahu, HI (USGS, 2018) were used with the Kansas Geological Survey's Barometric Response Function software (Bohling and others, 2011) to remove barometric effects on monitoring well RHMW07 (Figure 4 in Attachment A) as well as the other monitoring wells described in the CSM report.

3. Example 3. Drawdown is caused by Red Hill Shaft pumping. The several dozens of interim models appear to show that Red Hill Shaft captures the groundwater beneath the RHBFSF fuel tanks. The large data set collected during the 2017-2018 synoptic water level survey shows that the models are far from reproducing the observed hydraulic gradients, and therefore are not adequate for predicting capture zones that are based on hydraulic gradients.

   a. The Navy CSM report describes drawdown calculations defined by comparing heads at one-time period to another time period about 4 days later (Time 1, when Red Hill Shaft was off and Time 2, when Red Hill Shaft was pumping at a high rate). The results, which are shown in Figure 6-13 in the CSM report, indicate drawdowns on the order of 0.4 ft between these two pumping extremes. By doing this, the Navy is essentially using head measurements collected at different times during the pumping of Red Hill Shaft, which exaggerates the hydraulic gradient towards Red Hill Shaft. In other words, the Navy is using the head at a monitoring well when Red Hill Shaft is not pumping and comparing to the head at Red Hill Shaft when it is pumping. When Red Hill Shaft is pumping the head in the monitoring well would actually be lower and therefore the hydraulic gradient artificially forced from the RHBFSF toward Red Hill Shaft.

b. However, drawdowns can be computed on a daily basis using the synoptic water level data to give much more realistic estimates of the amount of drawdown, how it varies with time, and can provide useful statistics for any period. The BWS defined drawdown as the difference between troughs and peaks for each day using barometrically corrected water level data. Figure 5 in Attachment A shows an example of monitoring well RHMW02 with the peaks indicated by "+" and troughs by "." during the period February 18 to 28, 2018.

c. The BWS calculated maximum differences (as calculated between peaks and troughs shown in Figure 5 in Attachment A) observed over two periods of roughly 10 days when Red Hill Shaft was pumping relatively consistently: February 18 to March 1, 2018 and December 8 to 18, 2017 for monitoring wells RHMW01, RHMW02, RHMW03, OWDFMW01, RHMW06, and RHMW07 and computed an average maximum for each well. Average maximum drawdown during the February to March 2018 time period was 0.16 ft for monitoring well RHMW01, 0.11 ft for monitoring well RHMW02, 0.09 ft for monitoring well RHMW03, 0.08 ft at monitoring well RHMW06, 0.03 ft at monitoring well RHMW07, and 0.13 ft at monitoring well OWDFMW01. Average maximum drawdown during the December 8 to 18, 2017 time period was 0.20 ft for monitoring well RHMW01, 0.14 ft for monitoring well RHMW02, 0.12 ft for monitoring well RHMW03, 0.10 ft at monitoring well RHMW06, 0.04ft at monitoring well RHMW07, and 0.16 ft at monitoring well OWDFMW01. Thus, averaged maximum drawdown values over these two periods with relatively consistent pumping at Red Hill Shaft are far smaller than the drawdowns presented by the Navy in the CSM report in Figure 6-13. Drawdowns in Figure 6-13 were calculated using the highest water levels associated with maximum recovery, which occurred on January 15, 2018, and from the lowest water levels, which occurred on January 19, 2018. The BWS recommends that the CSM also include a figure that shows drawdowns that are more reflective of daily conditions. The BWS believes that the averages of daily drawdown are better suited than maximum drawdown values for estimating a capture zone for Red Hill Shaft. The Navy should make clear how they intend to pump so that the all SMEs can understand how Red Hill Shaft is affecting groundwater underneath the RHBFSF fuel tanks and elsewhere.

d. These preliminary results call into question whether Red Hill Shaft is, in reality, capturing the amount of groundwater from beneath the RHBFSF fuel tanks that is predicted by the Navy's model. We recommend that the Navy to perform a full examination of average maximum drawdown and ensure that their final model is able to represent it accurately. The BWS believes that when it comes to choosing between actual observations or several dozen models that provide a poor match to observed hydraulic gradients, we recommend that the Regulatory Agencies and other decision makers put aside the models and focus on the data.

4. Example 4: Monitoring well RHMW07 and the regional aquifer. The CSM report presents text and figures intended to explain that this monitoring well has some connection to the regional aquifer based on the similarities in head values at monitoring wells RHMW02, OWDFMW01, and RHMW06 (please see Figures 6-1 and 6-2 of the CSM report). BWS analysis of all available evidence casts considerable doubt on the Navy's presumption that monitoring well RHMW07 provides water levels that are representative of the regional basalt aquifer.

    a. The average maximum drawdowns at monitoring wells RHMW07 are roughly 0.03 ft (0.36 inches), far smaller than what was estimated at the other monitoring wells in Example 3 above.

    b. Figure 6 in Attachment A shows that there is essentially no correlation in the water levels at monitoring well RHMW07. However, the water levels from the other three monitoring wells (RHMW06, OWDFMW01, and RHMW02) are correlated.

    c. During the October 2017 groundwater modeling working group meeting, the explanation for the similarities in rising and falling head values between monitoring wells RHMW07, RHMW02, RHMW06, and OWDFMW01 was seasonal variations in recharge. The BWS recommends that the Navy investigate correlations between rainfall and head changes at these monitoring wells.

    d. The BWS recognizes that recharge and associated changes in water levels may not be directly related solely to the amount of precipitation per event, but rather related to a combination of historical and current precipitation. The BWS explored the relationship between the quarterly groundwater levels shown in Figures 6-1 and 6-2 of the CSM report and cumulative precipitation from daily precipitation records at climate stations in the Moanalua valley (USGS, 2018d). Cumulative precipitation was calculated for different windows of time (between 1 and 12 months) and plotted against quarterly groundwater levels provided by DON (2018) after being lagged by different lags (between 0 and 12 months). For each combination of lag and time window the correlation between water levels and corresponding cumulative precipitation values was calculated. The agreement between cumulative precipitation and quarterly groundwater levels is high with correlation coefficients between 0.85 and 0.90. Figure 7 in Attachment A shows the window of time and lag that has the highest correlation to the quarterly levels. In the case of monitoring well RHMW07, the cumulative period is 12 months and the lag is 4 months, while for monitoring wells RHMW02 and RHMW06 the lag is 2 months and the cumulative periods are 10 and 9 months, respectively.

e. Our exploratory analyses indicates that monitoring well RHMW07 may not be directly connected to the regional aquifer and therefore may not be a suitable well for determining the effects pumping effects by Red Hill Shaft on water levels in the vicinity of monitoring well RHMW07. Therefore, the BWS recommends that the Navy expand the CSM to investigate BWS aforementioned concerns and to evaluate whether the monitoring well network should include another monitoring well near RHMW07 to help determine whether monitoring well RHMW07 water levels are representative of the regional aquifer.

Specific Comments

1. Executive Summary

   a. The Navy states that "The LNAPL tends to preferentially migrate toward the predominant dip direction of 10–12 degrees to the south-southwest (between 190 and 210 degrees)." This statement appears to be conjecture because there is no evidence to show that migrating LNAPL only follows the strike of the lava flows. Instead there is evidence to the contrary. Monitoring well RHMW02 is not located south-southwest of Tank 5, yet groundwater concentrations exceeded the effective solubility values for total petroleum hydrocarbons – diesel (TPH-d) immediately after the leak was reported and several times in the period from 2015 to 2016. Furthermore, SMEs from the DOH and EPA demonstrated that measured strikes for lava flows around and on Red Hill ridge were between 225 and 250 degrees during the August 16, 2018 groundwater modeling working group meeting (Meeting No. 13).

   b. The Navy states that "Once the LNAPL encounters the water table, its vertical migration potential is minimized due to the density difference between LNAPL and water." This statement is misleading and should be corrected because LNAPL can invade significant distances below the water table if the LNAPL invading pressure is sufficiently high, which is likely the case when there is a large fuel release.

c. The Navy states that "The thermal study conducted in October 2017 shows evidence that residual LNAPL is primarily limited to a depth of 30 feet (ft) beneath the top of wells RHMW02 and RHMW03 (inside the lower access tunnel) and is being biodegraded." While biodegradation may be occurring, the remainder of this statement is unfounded because thermal data has yet to be demonstrated as a reliable indicator of LNAPL location in the subsurface, as explained by the DOH's SME on August 16, 2018. The Navy's conclusion appears to be contradicted by the available evidence that LNAPL migrated to the water table after the Tank 5 January 2014 release and at multiple times between 2005 and 2014. The Navy's conclusion places inappropriate weight on the small temperature differences calculated for monitoring well RHMW02 compared to monitoring well RHMW01 given that the slightly elevated temperatures calculated for this well are a function of the choice of background well. Even if there are slightly elevated temperatures in the vadose zone around monitoring well RHMW02, the fuel undergoing degradation may have come from the fuel leak of unknown volume from Tank 6 reported to the DOH in 2002. The impacts of the Tank 6 leak is not adequately vetted in the Navy CSM report. The only clear evidence of elevated temperatures in the subsurface is at monitoring well RHMW03, which is relatively distant from Tank 5.

d. The Navy states that "General transport of COPCs in the dissolved plumes is in the southwest direction toward Red Hill Shaft." Data from the 2017-2018 synoptic water level survey show a consistently flat hydraulic gradient beneath the RHBFSF fuel tanks because groundwater levels differ by roughly 0.1 ft. When it is not pumping, the water level at Red Hill Shaft often exceeds water levels at monitoring wells RHMW04 and RHMW06, which are to the northeast of Red Hill Shaft, and monitoring well OWDFMW01 by small amounts (see Figure 1 in Attachment A). When the shaft ceased pumping for more than one week in late September and early October 2017, the shaft water level also exceeded water levels in those three wells and at monitoring wells RHMW08 and RHMW09 (see Figure 1 in Attachment A). Water levels at monitoring wells RHMW02, RHMW01, and RHMW03 exceed the non-pumping level at Red Hill Shaft and at monitoring wells RHMW06, RHM04, RHMW09, and RHMW08 by only 0.2 to 0.25 ft. These observations do not support and are contrary to an observed hydraulic gradient in the southwest direction. Moreover, given that groundwater flow direction is dependent not only on the direction of the hydraulic gradient but also the orientation of the preferential flow pathways in the basalt, the Navy's statement that the flow is in the southwest direction is unsubstantiated.

e. The Navy states that "Migration to the southeast and northwest is limited by the extent of lower-permeability materials (valley fill and saprolite) extending below the water table in the valleys bounding the Facility." This is conjecture and should be removed or labeled as conjecture. The vertical and areal extent of the saprolite has yet to be adequately characterized and remains a very important data gap. The BWS has already shared concerns about the problems with the geophysical survey and the Navy's interpretation of the data (Lau, 2018). Similarly, DOH and EPA expressed similar concerns in the groundwater meeting in August 2018. (We refer you to the comments made by the EPA and DOH SMEs on August 16, 2018 in the groundwater working group meeting about the errors made in estimating the saprolite depth). Regarding the issues of saprolite extent, the BWS suggests that the Navy discusses how pumping at Halawa Shaft caused changes in Red Hill monitoring well water levels during the 2015 and 2017-2018 synoptic water level surveys.

f. The Navy states that "Based on thermal Natural Source-Zone Depletion (NSZD) studies, long term monitoring, and other studies indicate that LNAPL has reached residual saturation within approximately 30 feet beneath the tanks and has not reached groundwater." We agree with the EPA and DOH SMEs that this statement is unfounded.

g. The Navy states that "Geologic information about the formation of lava tubes indicates that these will not act as preferential pathways for contaminants to flow between Red Hill and City and County of Honolulu Board of Water Supply (BWS) water supply wells." The Navy has not provided sufficient field data to demonstrate this conclusion. The BWS suggests that the Navy provide appropriate evidence to support the claim that lava tubes do not serve as preferential flow paths for transport.

h. The Navy states that "Seismic studies indicate that extensive saprolite zones exist beneath stream valleys on both sides of Red Hill (including South Hālawa Stream and Moanalua Valley) and that these extend significantly below the water table, acting as a barrier to groundwater contamination." This statement should be removed or modified for two reasons. One reason is explained in provided in comment e above. Another reason is that the seismic data does not provide any information on whether any portion of the saprolite acts as a hydraulic barrier (Lau, 2018).

i. The Navy states that "While the geology is heterogeneous beneath Red Hill resulting in localized hydraulic gradients, overall flow appears to be highly influenced by clinker zones that provide a preferential pathway to

Red Hill Shaft." We agree that clinker zones provide preferential flow pathways, however, the location, orientation, and size of these preferential flow pathways in the Red Hill area vary largely and are unknown. The Navy has not provided any field data to justify their assumption that the only preferential flow pathway created by a clinker zone or multiple clinker zones is from the RHBFSF fuel tanks to Red Hill Shaft. The BWS recommends that the CSM describe completely how different placements and orientations of clinker zones could potentially affect the simulated hydraulic gradients and the size of the capture zone for Red Hill Shaft.

2. Figures 6-1 and 6-2 of the CSM Report: Both figures have errors in the plotted values and so should either be removed or revised.

    a. Figure 9 in Attachment A combines hydrographs for monitoring wells RHMW07 and RHMW02 using both quarterly values reported by DON and available USGS synoptic and static observations. To facilitate comparison, Figure 9 in Attachment A uses the same groundwater elevation ranges and vertical marks used in Figure 6-1 of the CSM report. Visual comparison of Figure 9 in Attachment A and Figure 6-1 in the CSM report shows that monitoring well RHMW02 values in Figure 6-1 of the CSM report are shifted by three months (for example, the 18.2 ft value for October 23, 2017 shows the reported values around January 2018 in Figure 6-1 of the CSM report). Figure 9 in Attachment A also shows the apparent discrepancy between the monitoring well RHMW07 static levels and synoptic levels reported by the USGS and the quarterly levels reported in the CSM report between July and October 2017. In this period, the linear interpolation between quarterly values in the CSM report is constantly below the envelope of synoptic and statics levels reported by the USGS, whereas it shows a much closer agreement in April 2015.

    b. Figure 10 in Attachment A combines hydrographs for monitoring wells RHMW07 and RHMW06 using both quarterly values reported by the Navy and USGS observations using the same vertical marks used in Figure 6-2 of the CSM report. In this case, the elevation range (16 to 20 ft) for monitoring well RHMW06 is not the same as the one reported in CSM report Figure 6-2 (13.5 to 17 ft) where values are shifted by 3 ft. Similarly, the linear interpolation between quarterly values reported by the Navy in the CSM report is constantly below the envelope of synoptic and statics levels reported by the USGS.

3. Figure 6-5 of the CSM report: There is a duplicate and incorrectly located head value and label for the Halawa Deep monitoring well.

4. Section 6.10.4: The Navy presents the results of analyses to estimate the hydraulic conductivity of basalt between Red Hill Shaft and the monitoring wells. Their analyses yielded transmissivity values commensurate with far higher hydraulic conductivity values than were used in the interim groundwater flow model. Yet there is no discussion on how these estimates of hydraulic conductivity would affect the purported capture of groundwater beneath the RHBFSF fuel tanks by Red Hill Shaft pumping. This is a critical oversight and should be addressed before the groundwater flow model is finalized.

5. Sections 7.1.2 and 5.1.3 and 6 in Appendix B-7: The Navy states that available data suggest the presence of weathered LNAPL (i.e., pre-2005) in the immediate vicinity of monitoring well RHMW02 or within the saturated zone hydraulically upgradient from this monitoring well. Again, this conclusion appears to be mere conjecture because the Navy has presented no evidence that the weathered LNAPL observed at this monitoring well was released prior to 2005. The rapid rise in TPH-d concentrations to exceed the effective solubility of jet fuel (ATSDR, 2016) at this well during January 2014 and the essentially simultaneous increases in soil vapor concentrations at the central and deep (distal) soil vapor monitoring points appear to demonstrate that LNAPL from the January 2014 release migrated rapidly through the vadose zone and reached groundwater. It is possible that some weathering of the LNAPL released in 2014 occurred as the fuel migrated through the vadose zone to the aquifer.

6. Appendix B.1: The Navy states that NSZD is active in the vadose zone near the RHBFSF fuel tanks based on measurements of carbon dioxide concentrations and temperature differences. The BWS does not disagree that some degradation of past and ongoing fuel releases occurs in the vadose zone. However, the depletion rates may not be significant for either past, ongoing, or future releases. The purported temperature differences at monitoring wells RHMW01 and RHMW02 are very small and most likely the result of the choice of background well. Figure 1.5 in Appendix B.1 of the CSM report does show temperatures are significantly higher between 10 and 80 feet of depth whereas temperature roughly declines linearly with depth at monitoring wells RHMW01 and RHMW02. In contrast, the temperature with depth relation at monitoring well RHMW05 differs greatly from the other monitoring wells, making it a questionable choice for background well, perhaps because of conduction from the lower access tunnel to about 20 feet of vertical depth and from about 80 to 100 feet of vertical depth.

7. Appendix B.4: The Navy states that "Taken together, analysis of RHMW02 to RHMW01 and RHMW02 to Red Hill Shaft represents the probable range of plume attenuation rates for COPCs in groundwater at the Facility (i.e., an attenuation half-life of 5–14 days or 7–92 days). Based on the current available

information, it is difficult to conclude which estimate is more reliable." This conclusion is based on an assumption that groundwater flows from monitoring wells RHMW02 to RHMW01 (and then to Red Hill Shaft), a situation created in the interim model but not present in the groundwater level data from the 2017-2018 synoptic water level survey. Examination of Figure 3 in Attachment A, which depicts the mean level for each monitoring well based on the thousands of observations collected over the survey period, shows no difference in mean water levels at the two wells (18.4 ft at both wells). Hydrograph plots show that heads at monitoring wells RHMW01 and RHMW03 can be equal (Figure 2 in Attachment A) and exceed those at RHMW02 (Figure 2 in Attachment A). If there is no discernable flow path, it is not valid to derive degradation rates from the differences in concentrations between wells. As in the past, we recommend that the Navy install more groundwater and vadose zone monitoring wells to adequately define the distribution of fuel in the vadose zone and the directions of groundwater flow in the shallow aquifer.

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

Very truly yours,

ERNEST Y.W. LAU, P.E.
Manager and Chief Engineer

CC: Mr. Steve Linder, United States Environmental Protection Agency, Region IX
Mr. Mark Manfredi, NAVFAC Hawaii

Enclosure: Attachment A – Figures 1 – 10

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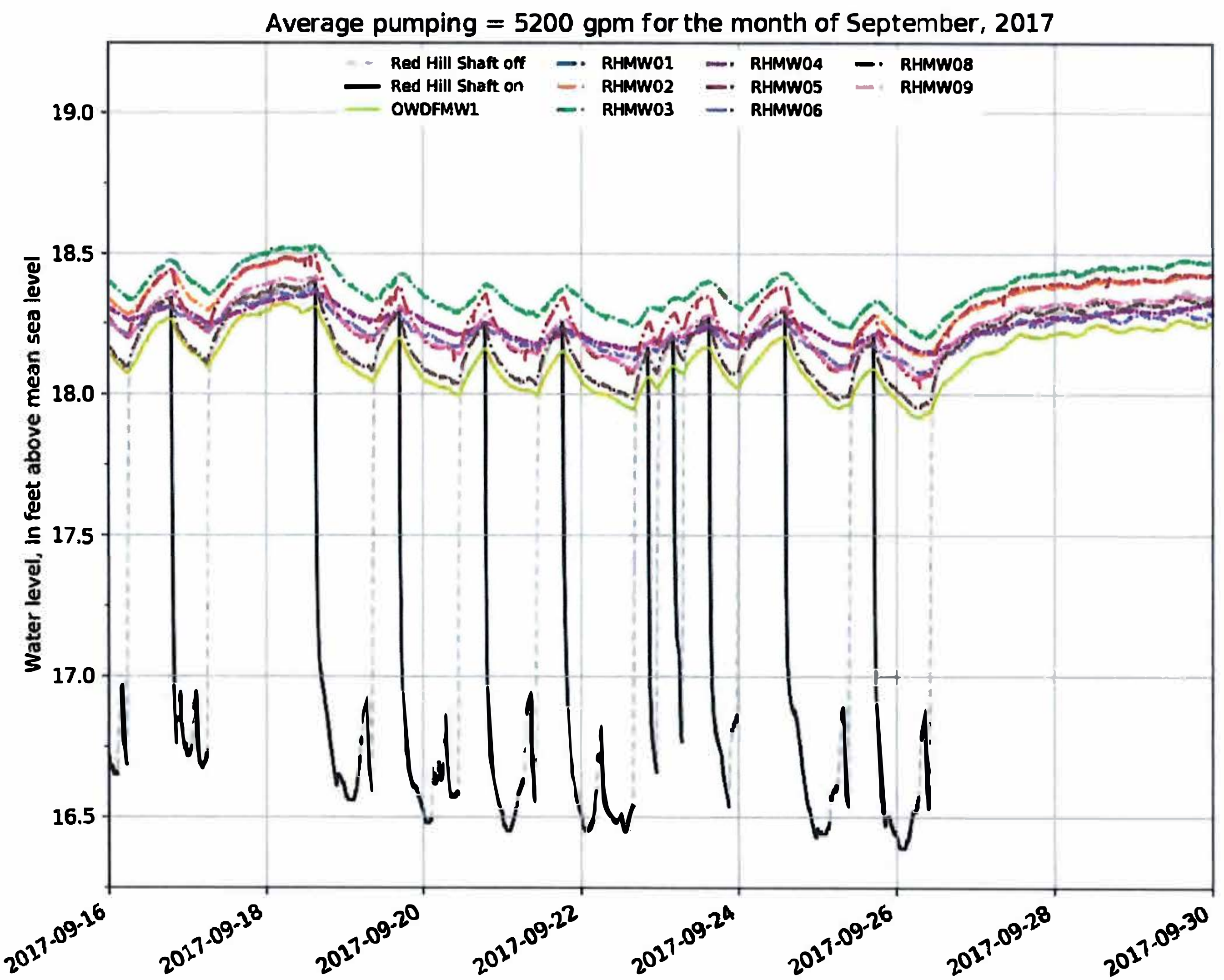

Figure 1. Water levels during late September 2017 corrected for barometric effects.

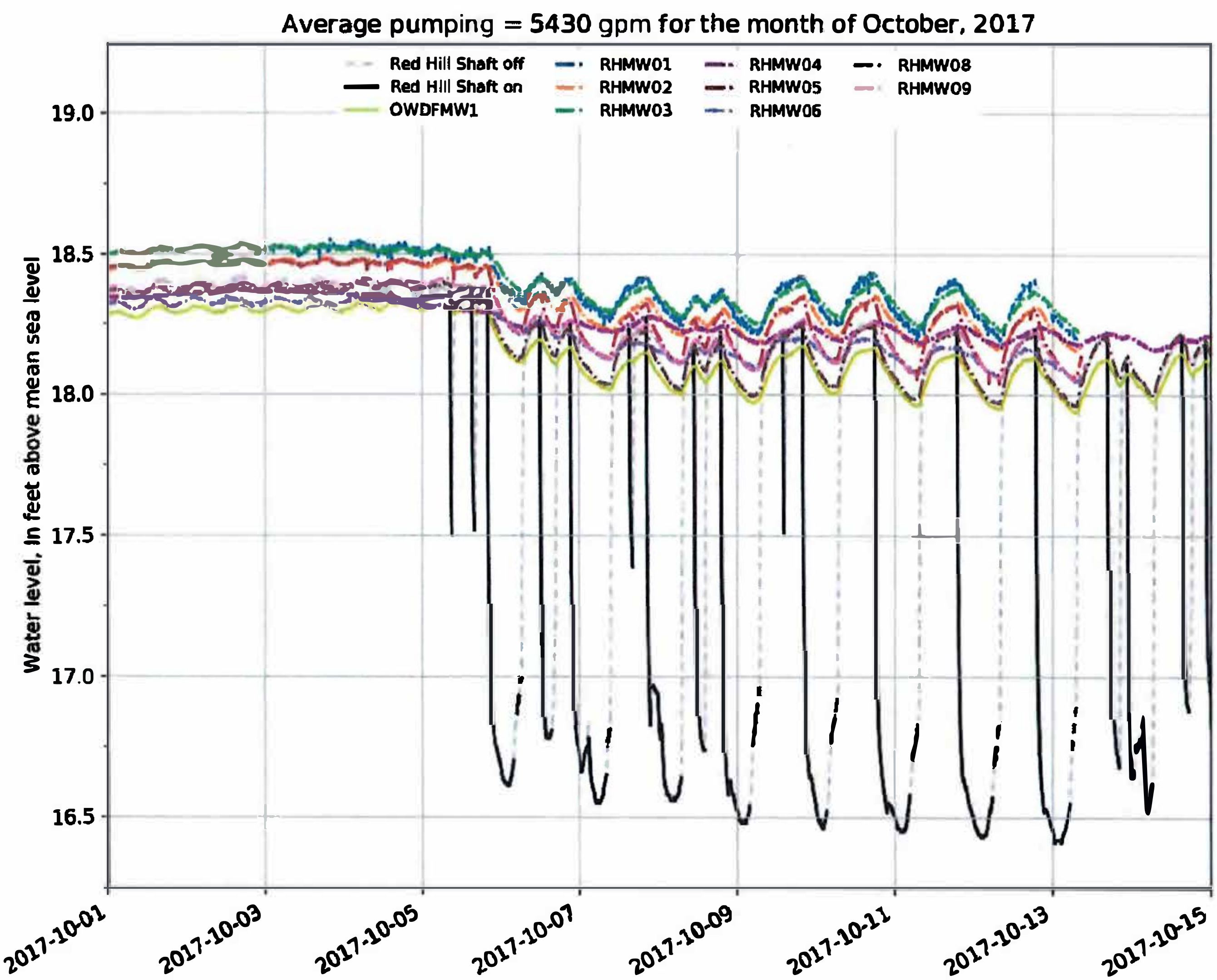

Figure 2. Water levels during early October 2017 corrected for barometric effects.

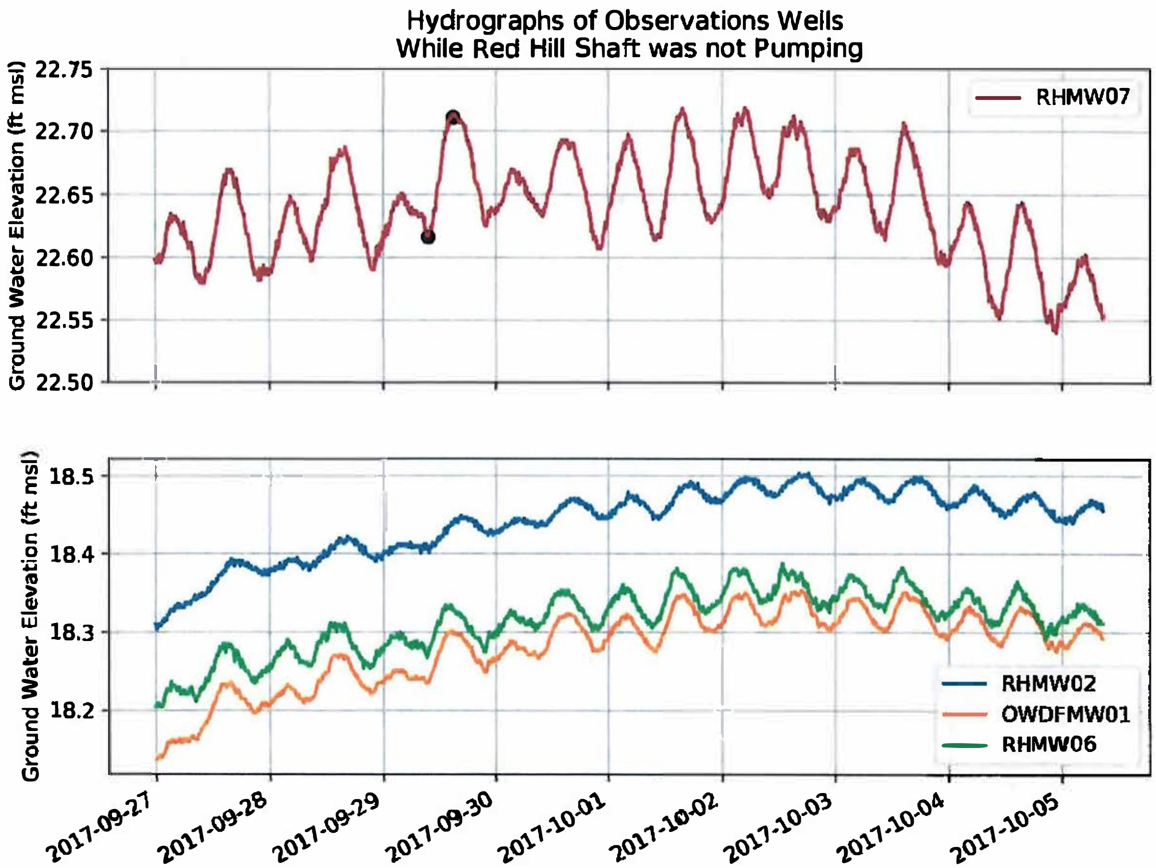

Figure 3. Observed Water Levels for 9-day period where Red Hill Shaft was not pumping in late September and early October 2017

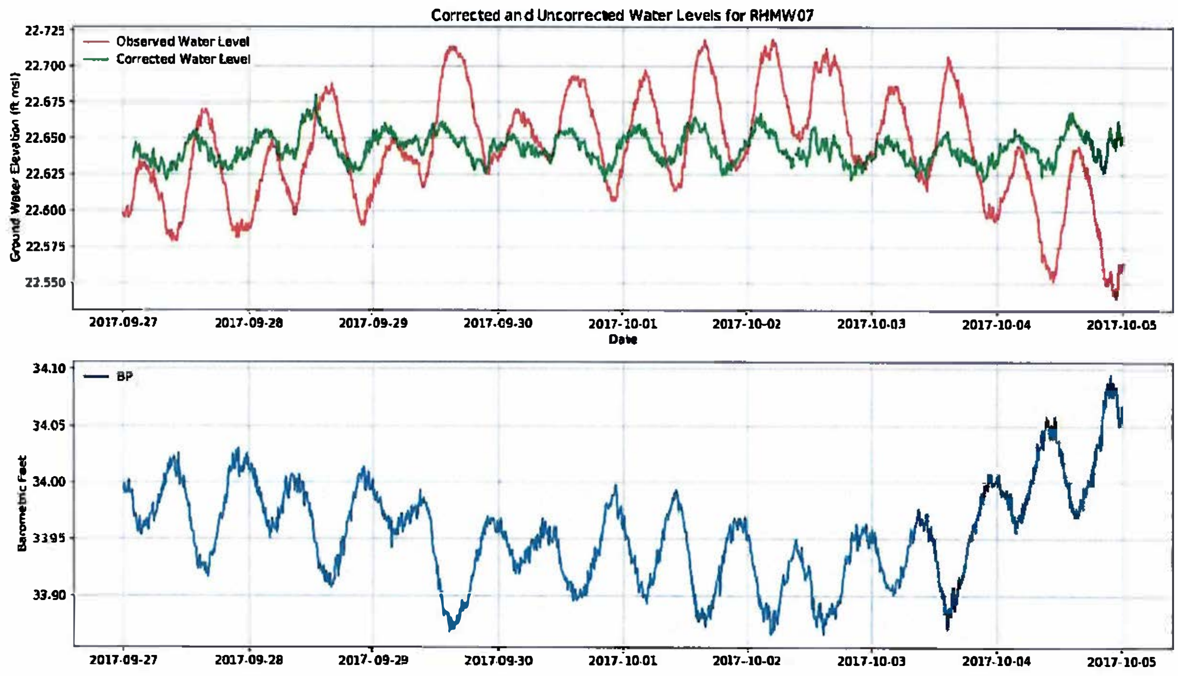

Figure 4. Corrected and Uncorrected water levels for well RHMW07 between late September and early October 2017

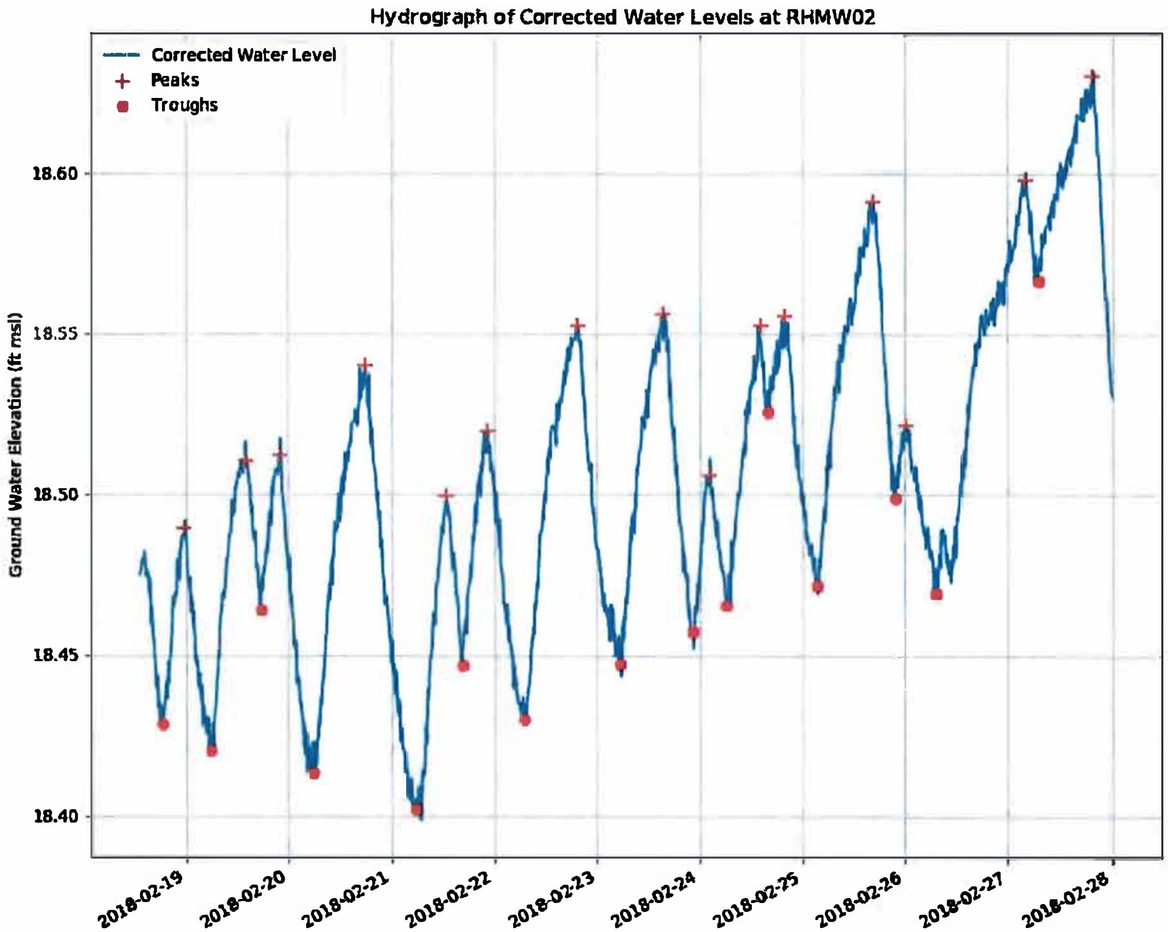

Figure 5. Peaks and troughs of corrected water level at well RHMW02 associated to drawdown caused by Red Hill Shaft

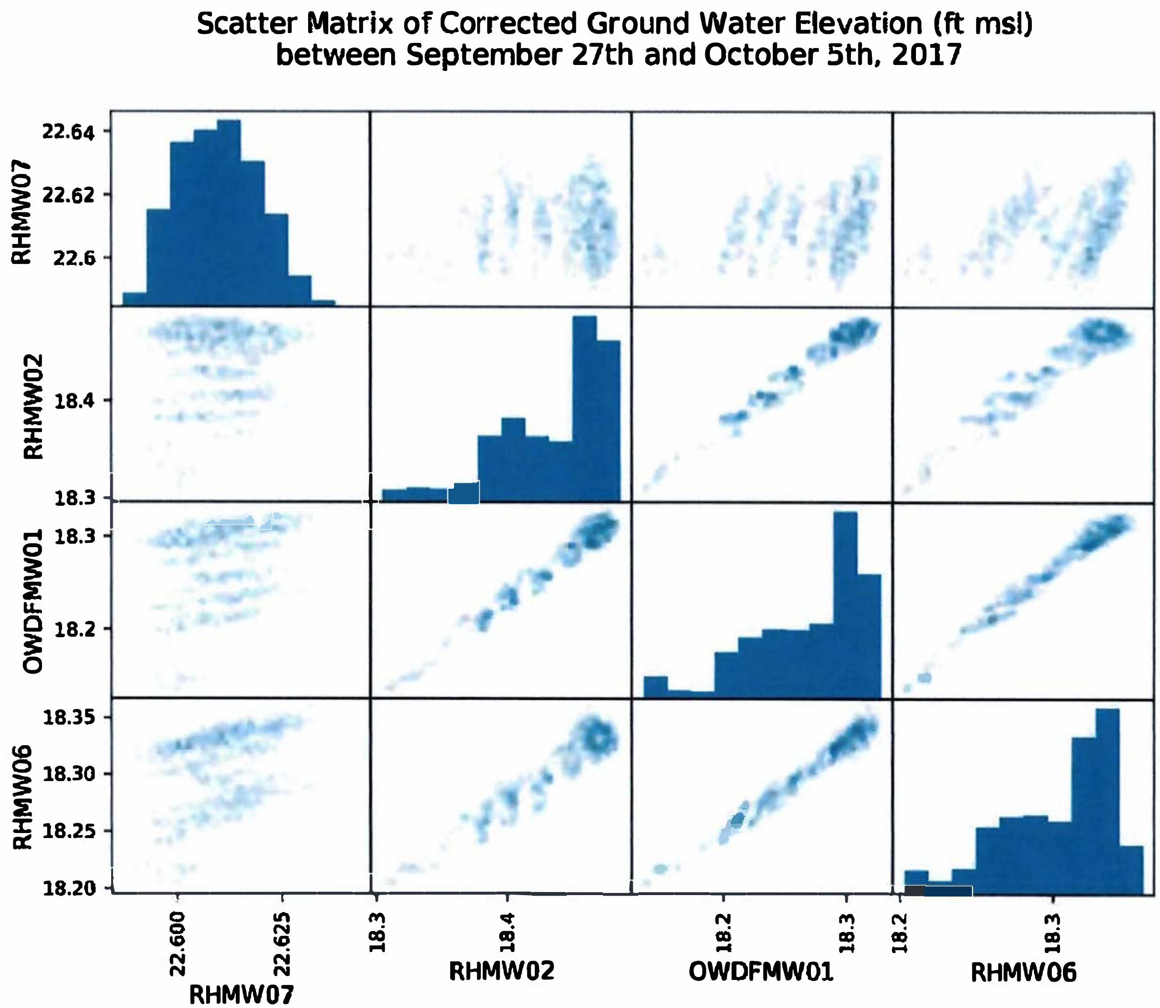

Figure 6. scatter matrix for the corrected water levels at the observation wells in late September and early October 2017 while Red Hill Shaft was not pumping

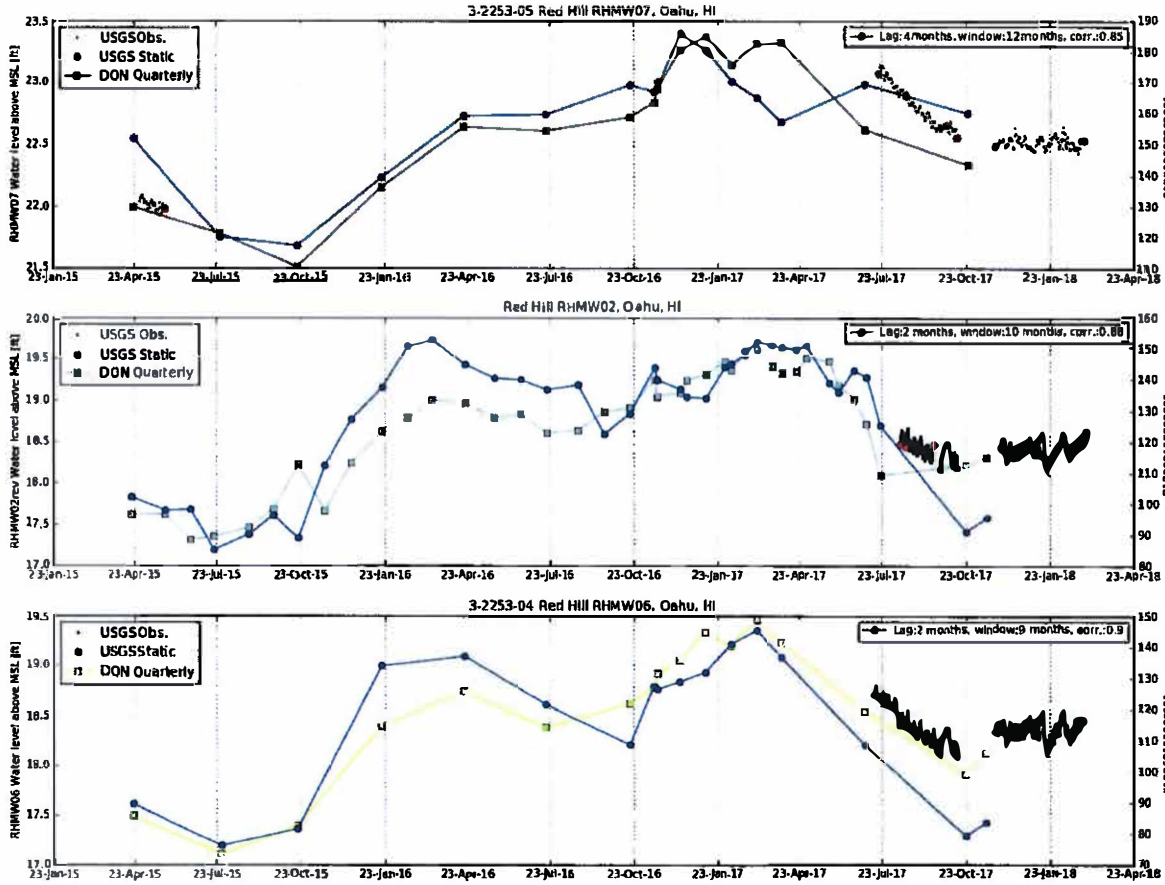

Figure 7. Comparison Hydrographs for RHMW07, RHMW02, and RHM06 and cumulative precipitation

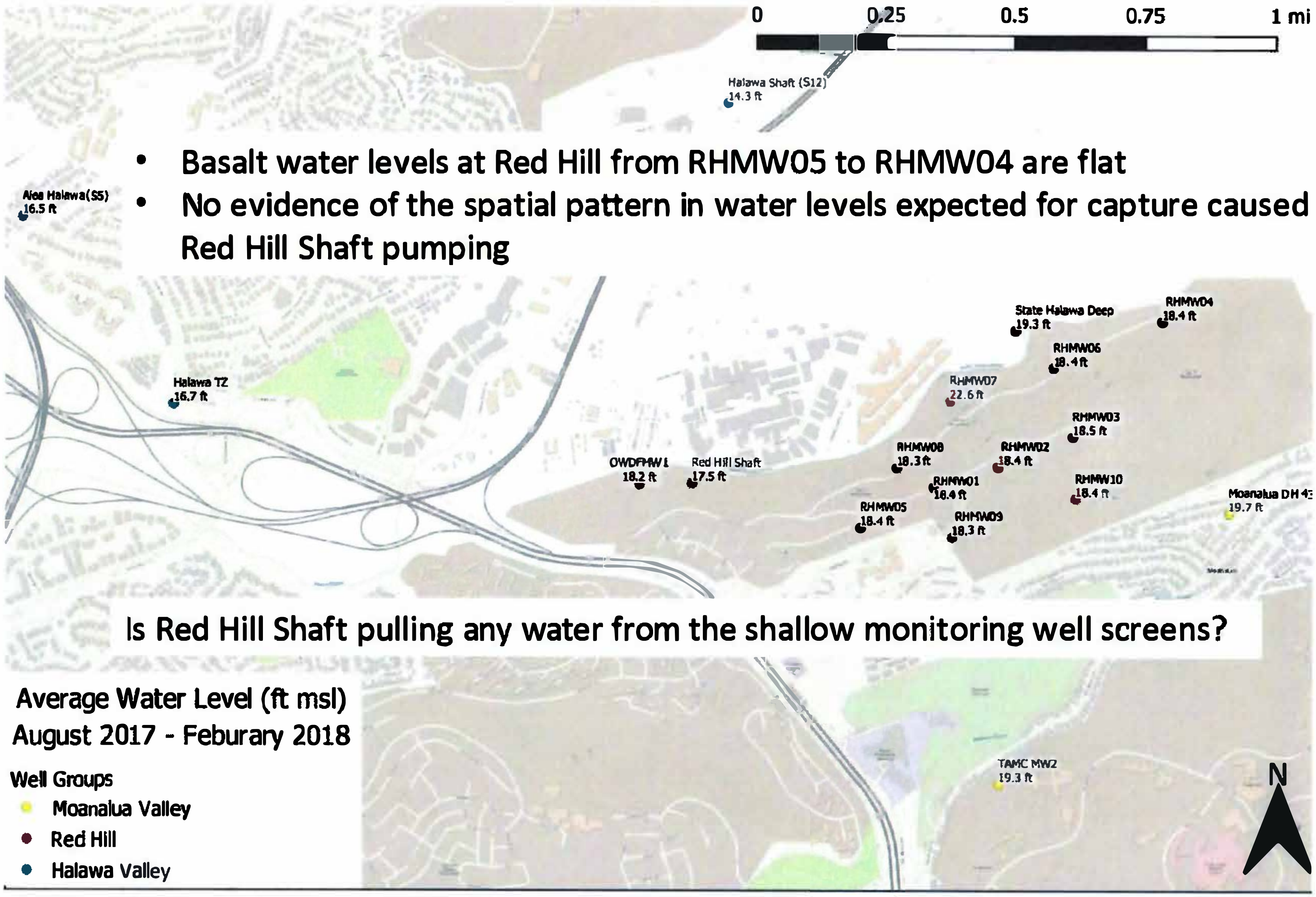

Figure 8. Mean groundwater levels during the 2017-2018 synoptic water level survey.

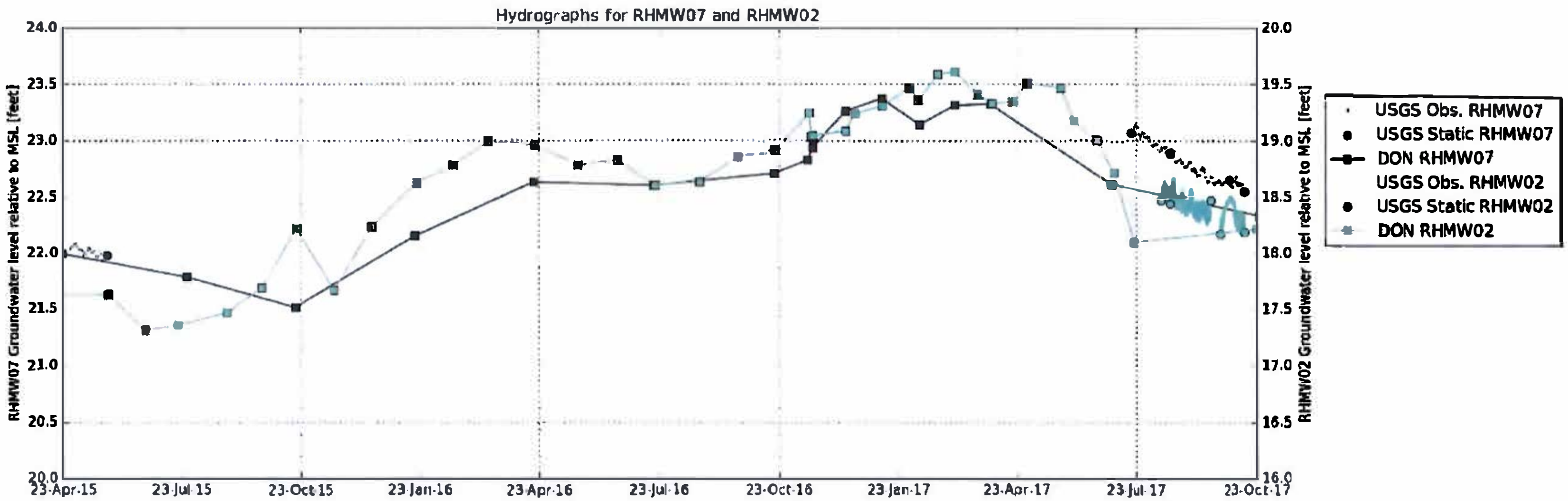

Figure 9. Hydrographs of RHMW07 vs. RHMW02 matching the same extent of Figure 6-1.

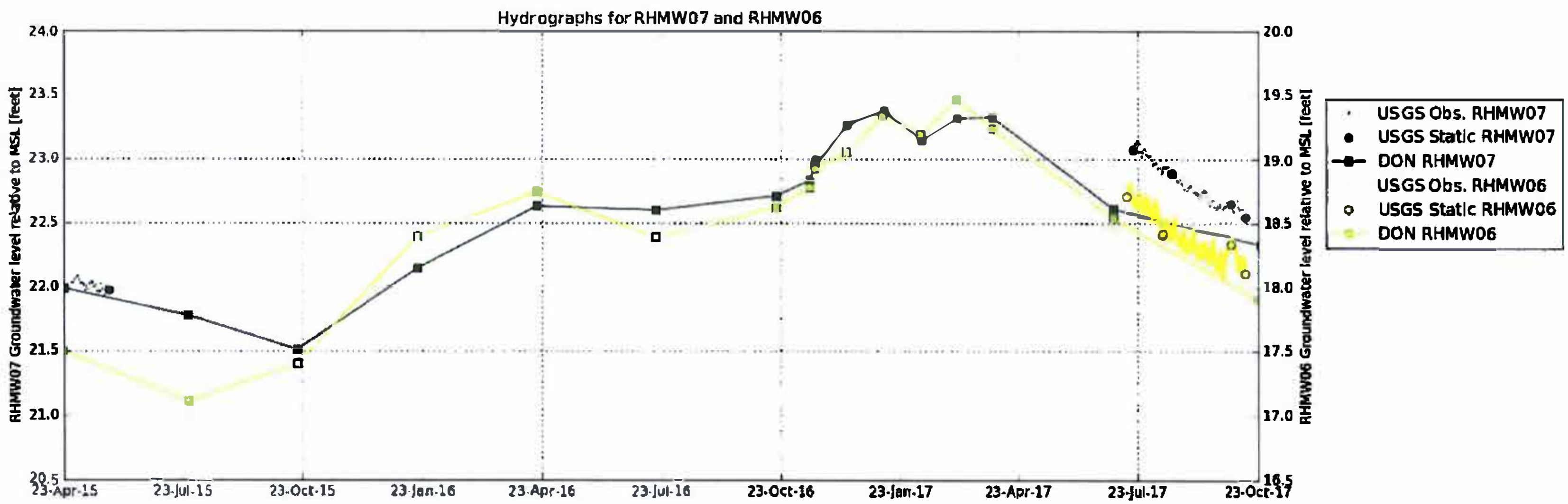

Figure 10. Hydrographs of RHMW07 vs. RHMW06 matching the same extent of Figure 6-2