Sentinel and Monitoring Well Installation Work Plan Addendum #1

Red Hill Bulk Fuel Storage Facility,
Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

Naval Facilities Engineering Command, JBPHH HI,
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This Sentinel and Monitoring Well Installation Work Plan (SMWIWP) Addendum #1 identifies four modifications to coring and well construction procedures of the SMWIWP (DON 2022b) that the Navy is implementing:

- Item #1 – Dual Borehole Approach
- Item #2 – Requirements for Conductor Casing
- Item #3 – Change in Well Design Conductor Casing Diameter
- Item #4 – Tunnel Well Drilling

The changes provide flexibility and additional resources for drilling so that the new proposed monitoring wells supporting the investigation of hydrogeology and groundwater quality in the vicinity of Red Hill can be completed sooner once property access and permits are received, while still meeting the intent of the SMWIWP.

1. Item #1 - Dual Borehole Approach

The current practice described in SMWIWP Section 3.3.1 is to drill overburden first, using hollow-stem auger, sonic, or casing advance drilling methods, followed by air hammer or coring if needed; then grout the core hole to prevent a vertical conduit resulting from potential deviation during over-drilling; and followed by over-drilling the well installation borehole. Conductor casing is then installed as described in Section 3.3.5, followed by rock coring and water level testing and parameter profiling as described in Sections 3.3.6 and 3.3.7. This process results in significant delays during drilling, since hundreds to thousands of gallons of water are often injected over 5–10 foot intervals during coring, and then water levels must equilibrate before the presence or absence of perched water conditions can be confirmed.

The Navy will proceed as described in SWMWIP Section 3.3.1, which further states: "Alternatively, rock coring and geophysical logging may be conducted in one borehole, and perched water investigations and well installation may be completed in a separate borehole drilled with air rotary drilling methods at the same approximate location."

Coring and well construction will be conducted in separate boreholes separated by approximately 15 feet, while achieving the proposed well objectives presented in the SMWIWP (see Section 2.1 and Table 2-1). Coring and installation of sentinel wells provide data that can be used to better characterize groundwater flow, groundwater chemistry, and collect lithologic data to further define the presence of valley fill, caprock and other features that may affect groundwater flow. The changes are being implemented based on the following considerations:

- Additional drillers may be available that provide either coring services or air drilling services but not both services, which will increase available drilling resources.
- Screened intervals are selected based on water level elevation for water table conditions, or based on hydraulic connection to the basal aquifer for confined conditions. The well design for well installation is not influenced by coring operations.

- Coring introduces large volumes of water into the formation, which complicates investigation of vadose zone perched water and interpretation of the results from water level testing.
- Investigation of perched water or presence of contamination or free product is faster, more reliable, and more accurate when drilling with air drilling methods, since little or no water is introduced.
- Conclusions about the presence of perched water or contamination and the need for conductor casing can be better substantiated during air drilling due to the fact that little or no water is introduced with air methods.
- Core holes are test borings and do not require a well construction permit. This will expedite drilling and well installation efforts by reducing stagnancy in efforts to collect data and allowing more than one drilling company's involvement, as certain drillers can conduct well installation but not coring.
- The goals and data objectives of the original SMWIWP, including the commitment to protect the basal aquifer, will continue to be met.
- The Navy will still be complying with Hawai'i State Department of Land and Natural Resources regulations as defined in the *Hawaii Well Construction and Pump Installation Standards* (DLNR 2004).

Change. The Navy will conduct coring and well construction in separate boreholes separated by approximately 15 feet. Either well construction or coring may proceed first depending on rig schedules and site logistics. Geophysical logging and water level testing for perched water investigations may be conducted in either borehole depending on the order of operations, specific data needs, and hole stability.

2. Item #2 – Requirements for Conductor Casing

SMWIWP Section 3.3.5 states "Conductor casing will be installed in situations where it is required to prevent the vertical migration of contaminated groundwater. Where vadose zone conductor casing is required, a 17.5-inch-diameter borehole will be advanced using air hammer, air rotary, mud-rotary, or bucket auger, and a 10-inch-diameter schedule 40 low carbon steel conductor casing will be installed and sealed in accordance with DLNR regulations. The drill rig, or other equipment will suspend the casing above the bottom of the borehole during the grouting operation and curing time. The conductor casing will be centered within the borehole with the use of centralizers spaced at intervals no more than 40 ft apart." It further states that conductor casing is required to seal off zones where perched groundwater is encountered. The SMWIWP also allows for the use of sand-cement grout to seal off zones where perched water is encountered and then resume with drilling after the grout has set.

Conductor casing has been installed during the coring process to seal off zones of perched groundwater prior to coring into the basal aquifer. In some cases, and especially where conductor casing is installed to deeper depths, smaller-diameter pipe has been required to stabilize the coring assembly within the conductor casing. Drill cuttings have subsequently accumulated between the core pipe and conductor casing, making retrieval of the smaller-diameter pipe from the borehole difficult and time-consuming. In the case of RHMW16, the borehole was nearly abandoned with 78 feet of steel pipe lost downhole after drilling into the basal aquifer. This would have prevented proper grouting and abandonment. After significant downtime, the steel pipe was eventually retrieved from RHMW16, allowing for well installation. The core pipe also became stuck inside the conductor casing at RHMW17, and there was risk of losing that well. Additionally, multiple perched water zones have been encountered at some drilling locations that require sealing and grouting to isolate those zones, minimize inflow from the perched water zones, and avoid potential problems as described above.

The current SMWIWP evolved from the *Draft Delineation Well Work Plan* (DON 2022a), which was designed to define the extent of contamination in areas where there was a reasonable chance that contamination or free product might be encountered. The SMWIWP program is designed for wells to characterize the aquifer and serve as early warning of a fuel release in more distant areas that are expected to be unimpacted.

To avoid complications where conductor casing is installed to deeper depths, intervals of suspected perched water with significant inflow identified during drilling will be grouted and redrilled to reduce or eliminate inflow to the borehole. A borehole video camera will be used to identify depth intervals and estimate the rate of inflow. At a depth of approximately 10 feet above the basal aquifer water table elevation, an assessment will be made of the quality and rate of inflow of any suspected perched water. If it is determined that groundwater meets regulatory standards and there is no elevated potential to contaminate the basal aquifer, drilling either the core hole or the well construction borehole may advance into the basal aquifer, and a seal will be installed at approximately 10–15 feet above the basal aquifer as soon as the core hole is logged or the well installation is complete. If contamination is encountered, or if the vertical flow rate is unacceptable, the flow will be mitigated with the use of conductor casing.

Change. In cases where perched groundwater is encountered, no evidence of contamination has been observed (i.e., via photoionization detector [PID] readings [see SMWIWP Appendix B], visual or olfactory observations, drilling location site use, and history/background) and where evaluation of borehole water level conditions indicate only minimal potential for flow to the basal aquifer, the Navy will advance drilling to total depth into the basal aquifer.. Inflow to the borehole will be minimized or sealed using grouting procedures, and conductor casing will be used where there is an unacceptable potential for borehole water to contaminate the basal aquifer, based on water level testing and/or evidence or presence of contamination (i.e., bailer test for presence of free product, PID headspace measurements [above baseline of 10 parts per million by volume] as described in SMWIWP Appendix B, Section 2.2).

3. Item #3 – Change in Well Design Conductor Casing Diameter

SMWIWP Section 3.3.5 provides a well design with 10-inch-diameter conductor casing inside a 17.5-inch borehole and a 4-inch-diameter well inside the 10-inch-diameter conductor casing. The design was originally implemented near potentially impacted areas to allow the potential for telescoping down to a smaller conductor casing and well casing in the event that more than one conductor casing is needed. Including the use of smaller-diameter conductor casing installed inside smaller-diameter boreholes is potentially faster and more cost-efficient and potentially expands the list of available drillers who can complete the work.

Change. The Navy will include the option to install a smaller-diameter conductor casing (e.g., 8-inch-diameter in a 12.5-inch borehole), which still allows for installation of 4-inch-diameter well casing. Modifications to this design may be required; however, all designs will meet regulations or approved variances for well construction defined in *Hawaii Well Construction and Pump Installation Standards* (DLNR 2004) and the intent of the SMWIWP and well objectives.

4. Item #4 – Tunnel Well Drilling

SMWIWP Section 3.4.1 states "If perched water or evidence of contamination is not observed, coring will be conducted until the target depth (approximately 125 ft below the tunnel floor) is reached. After rock coring is complete, the borehole will be reamed or over-drilled to total depth with a conventional rotary drilling rig to increase the borehole diameter to a minimum of 5.375 inches."

SMWIWP Section 3.4.1 also states "If perched water or zones of contamination are identified, then permanent conductor casing will be installed using 5-inch Schedule 40 low-carbon steel conductor casing to minimize the potential for perched water or contaminated media to migrate downward and impact the basal aquifer, which is a drinking water source. An 8-inch-diameter borehole will be required for the length of the conductor casing (length to be determined), and a 4.88-inch-diameter borehole will be required below the conductor casing."

Change. Drilling an 8-inch-diameter borehole in basalt to install a 5-inch Schedule 40 low-carbon steel conductor casing is not possible in the lower access tunnel due to the drill rig's limitations. Drilling will be conducted using an electrically powered hydraulic drill rig equipped with rock coring and wet rotary drilling capabilities. Checks will be made to identify the presence of perched groundwater or contaminated unconsolidated material while PQ coring using inspection bailer samples and jar headspace photoionization detector (PID) measurements, as described in Section 3.3.3 of the *Draft Delineation Well Installation Work Plan* (DON 2022a). Drilling will proceed as follows.

No Signs of Perched Water or Contamination

- If perched water or evidence of contamination is not observed, PQ coring will be conducted until the target depth is reached, approximately 15 ft below the basal aquifer water level.
- After PQ rock coring is complete, the 4.875-inch-diameter borehole will be reamed to total depth using a reaming tool with a pilot bit to increase the borehole diameter to a minimum of 5.375 inches, as shown on Figure 1.

Perched Water and No Signs of Contamination

- If perched water is suspected in the vadose zone and there are no signs of contamination, the interval of suspected perched water will be sealed off by grouting the borehole interval to below the floor surface with neat cement, cement-bentonite grout, or sand-cement slurry. The interval will be re-drilled with the original 4.875-inch-diameter bit.
- If grouting the suspected interval is successful in stopping the inflow of perched water, drilling of the 4.875-inch borehole may proceed.
- At a borehole elevation of 30 ft mean sea level (msl), drilling will pause, and the core and any fluids in the borehole will be evaluated for contamination as indicated by PID readings of core and bailer tests.
- If there are no indications of contamination, the borehole will be cleaned out and advanced into the basal aquifer without installing conductor casing, and a 2-inch-diameter well will be constructed as shown on Figure 1.

Continued Perched Water or Suspected Perched Water Contamination

- If grouting of the 4.875-inch hole is unsuccessful in stopping the inflow of perched water, or perched water with contamination is suspected in the vadose zone, the 4.875-inch borehole may be reamed to a 6-inch-diameter hole to 3 ft below the base of the suspected perched water, and the suspected interval of perched water will be grouted to just beneath the floor surface using a tremie pipe. The interval will be re-drilled with the original 4.875-inch-diameter bit.
- If grouting the suspected interval is successful in stopping the inflow of perched water, drilling with the 4.875-inch-diameter dill bit will proceed.
- At a borehole elevation of 30 ft msl, drilling will pause, and the core and any fluids in the borehole will be evaluated for contamination as indicated by PID readings of core and bailer tests.

- If there are no indications of contamination, the borehole will be reamed to 5.375-inch diameter.
- When the 5.375-inch borehole reaches an elevation of 30 ft msl, drilling will pause, and any fluids in the borehole will be evaluated for contamination.
- If results indicate contamination of the basal aquifer will not occur, the borehole will be advanced using a 4.875-inch-diameter bit, and the 2-inch-diameter PVC well will be constructed with 1.25-inch annulus in the screened interval and a minimum of 1.5 inches of grouted annulus in the intervals with seals, in accordance with well construction standards specified by DLNR (2004), as shown on Figure 2.

5. References

Department of Land and Natural Resources, State of Hawaii (DLNR). 2004. *Well Construction and Pump Installation Standards*. 2nd ed. Honolulu, HI: Commission on Water Resource Management. February.

Department of the Navy (DON). 2022a. *Draft Monitoring Well Installation Work Plan for Red Hill Shaft Delineation Wells Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Systems Command, Hawaii, JBPHH HI. March.

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