Groundwater Flow Model Report, Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM, O‘AHU, HAWAI‘I

Administrative Order on Consent in the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket Number RCRA 7003-R9-2015-01 and DOH Docket Number 15-UST-EA-01, Attachment A, Statement of Work Section 6.2, Section 7.1.2, Section 7.2.2, and Section 7.3.2

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EXECUTIVE SUMMARY

The March 2020 groundwater flow modeling effort was developed to evaluate the flow of groundwater from beneath the Red Hill Storage Facility (the Facility) and compute the source water zones of water supply wells Red Hill Shaft and Hālawa Shaft under various pumping conditions. This effort has been conducted in support of the Investigation and Remediation of Petroleum Product Releases and Groundwater Protection and Evaluation project at the Red Hill Bulk Fuel Storage Facility ("Facility"), Joint Base Pearl Harbor-Hickam (JBPHH), Hawai'i. The Facility is owned by the United States (U.S.) Navy (DON; "Navy") and operated by Defense Logistics Agency (DLA).

This report has been prepared to address Statement of Work Section 7.1 of the *Administrative Order on Consent* (AOC) *In the Matter of Red Hill Bulk Fuel Storage Facility* (EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01) (EPA Region 9 and DOH 2015). The AOC was issued by the U.S. Environmental Protection Agency (EPA) Region 9 and State of Hawai'i Department of Health (DOH) (EPA Region 9 and DOH 2015) to the Navy/DLA in response to a release of an estimated 27,000 gallons of Jet Fuel Propellant (JP)-8 from one of the Facility's underground fuel storage tanks (Tank 5) that was confirmed and reported to DOH on January 23, 2014. The tanks are located above a major groundwater aquifer, which is used to feed both Navy and City and County of Honolulu drinking water supply wells and shafts.

Following Regulatory Agency approval of this flow model report, the models will be further developed and used to evaluate fate and transport of potential dissolved fuel components in groundwater to help ascertain potential risk to water supply wells as a result of a potential range of releases from the Facility under a range of reasonably conservative pumping conditions within the model domain, and to assist with management decisions related to monitoring and to infrastructure improvements to address potential future fuel releases.

The model domain extends in the northwest to southeast direction from Waimalu Valley to Kalihi Valley, and in the southwest to northeast direction from the ocean and Pearl Harbor, up to but not including a dike-intruded area in the Ko'olau mountains just south of the topographic divide. The model extends vertically from the land surface down to the freshwater/saltwater interface.

The basalt aquifer in the study area behaves as a homogeneous system on a regional scale, with high hydraulic conductivities. Horizontal anisotropy is also high in the direction of lava flow. The basalt is unconfined underneath most of the Facility but is overlain by saprolite and valley fill underneath the valleys, and by a caprock unit farther to the coast. The caprock is composed of alluvial sediments and marine deposits with interspersed Honolulu Volcanic tuff.

Groundwater flow occurs from recharge areas in the mountains to discharge areas in Pearl Harbor and the ocean. Due to the high hydraulic conductivity of basalt, the water table underneath the Facility is flat with very small gradients. Higher water levels due to mounding or perched conditions may be noted in the saprolite and valley fill. Freshwater is confined within the basalt underneath the caprock as it flows toward the sea. Outflow occurs due to pumping, flow to springs, and as diffuse discharge through the caprock into Pearl Harbor and the ocean.

Groundwater flow models described in this report were constructed using all available pertinent regional and local data over the Facility obtained from literature, continued field investigations, and previous modeling studies as described in the Red Hill *Conceptual Site Model* (CSM) report (DON 2019). Water levels from the synoptic study conducted in 2017–2018 were used in model calibration and verification, as those data are considered the most accurate information available (especially

related to controlled pumping events). The information was processed using a transfer function-noise (TFN) analysis to remove signatures from barometric pressure and ocean/earth tide fluctuations for water level targets with various pumping conditions at Red Hill Shaft and Hālawa Shaft.

Water level targets establish a base flow condition for the model but do not provide information on flow directions. In an anisotropic system such as in basalt, the flow direction is a function of head gradients as well as anisotropy of the medium. Therefore, water level difference targets were also constructed from these data such that water level gradients can be indirectly established. Also, unit step response functions were derived from TFN processing for pumping at Red Hill Shaft and Hālawa Shaft, which provided hydraulic conductivity information between the observation wells and the respective shaft to establish anisotropy.

The calibrated models were used to evaluate migration of groundwater from beneath the Facility under various regional pumping conditions, as well as to evaluate the source water zones of Red Hill Shaft and Hālawa Shaft, using particle tracking analyses methods.

A multimodel approach was used to evaluate the impact of various conceptual representations, parameter uncertainties, and errors in water level data, especially acute in flat water table environments as exist in the model domain's basalt. With this approach, multiple models were created to assist in evaluating uncertainty and its impact on groundwater migration behavior of interest.

The modeling effort has been conducted with input from various subject matter experts (SMEs). A strong effort was made to address various concerns expressed by SMEs on data and modeling that arose as part of the 2018 interim modeling effort (DON 2018, Appendix A) as well as during ongoing meetings. The models were constructed and used in a conservative manner to err on the side of caution. Simplifications of the CSM in the numerical framework reflect reasonably conservative assumptions considering modeling objectives and available data. Alternate conceptualizations and parameterizations were explored to evaluate the impact of uncertainty and error across a range of conceptualizations to help bound flow condition. Pumping regimes tested for migration behavior were selected to establish conservative capture zones. Low porosity values were used for particle tracking simulations to provide conservative travel times. Migration behavior was analyzed in a steady-state flow field, thus neglecting storage buffering impacts. Subsequent modeling efforts will use these flow models as a basis to evaluate solute transport. These flow models will also be used to further evaluate different scenarios (e.g., pumping rates relative to capture zones).

The models indicated that groundwater from beneath the Facility was captured by Red Hill Shaft when it was pumping at a rate of [redacted] million gallons per day (mgd), which is within its regulatory permitted pumping limits. The models also provided travel time ranges for various scenarios of concern. The shortest travel time (from the Facility tanks closest to Red Hill Shaft) to Red Hill Shaft ranged from 16 to 56 days, whereas the longest travel time (from the Facility tanks farthest from Red Hill Shaft) to Red Hill Shaft ranged from 69 to 228 days.

When Red Hill Shaft is not pumping, groundwater migration underneath the Facility is generally to the west and then turns to the northwest toward Pearl Harbor. There is larger uncertainty of flow direction with distance from the Facility when Red Hill Shaft is not pumping, and the water can be captured by Hālawa Shaft, and/or by other downgradient water supply wells and discharge points. The model also indicated that wells located in Moanalua Valley would not be impacted from a potential future release from Red Hill. When Red Hill Shaft is not pumping, the shortest travel time from the Facility tanks to other receptors ranged from 137 to 883 days, while the longest travel time from the Facility tanks to other receptors ranged from 170 to 1,938 days. These travel times indicate advective

flow of water and are not for solute transport, which would also include mechanisms of dispersion, retardation, and decay.