

1 chronic release were to impact the water table, this additional biodegradation within the saturated
2 zone would also serve to prevent impacts to Red Hill Shaft and other groundwater receptors.

3 **9.3 CONCLUSIONS**

4 Two separate holding capacity calculations were performed:

- 5 • The LNAPL holding capacity for a hypothetical large, sudden release that would not result
6 in unacceptable risks to users of groundwater in the vicinity of the Facility. The calculations
7 and results of this analysis are described in Appendix B.
- 8 • The LNAPL holding capacity for a hypothetical small chronic release that would not result
9 in unacceptable risks to users of groundwater in the vicinity of the Facility. This calculation
10 is dependent on the NSZD rate at the Facility and is described in Appendix C.

11 The resulting reasonable conservative volume estimates that would be protective with a high
12 confidence are:

- 13 • A hypothetical sudden future release of approximately 120,000 gallons of LNAPL would
14 have, at most, a minimal impact to groundwater and would not cause an RBDC exceedance
15 in Red Hill Shaft.
- 16 • An indefinite hypothetical chronic release of 2,300 gallons per tank per year (6.3 gallons per
17 tank per day) would be degraded within the vadose zone, resulting in, at most, a minimal
18 impact to groundwater and would not cause an RBDC exceedance in Red Hill Shaft.

19 **10. Summary and Conclusions**

20 All available data to date have been integrated into the current CSM, and the evaluation of data and
21 determination of conclusions are reasonably conservative. The conservatism is based on highly
22 probable outcomes and/or conclusions as identified by current data. The following subsections
23 describe the key points from various sections of this document.

24 **10.1 LNAPL DISTRIBUTION AND PROPERTIES**

- 25 • LNAPL has been observed in the vadose zone below some of the fuel tanks (i.e., in angle
26 borings completed in 1998–2002). Thermal monitoring data show that when LNAPL is
27 indicated in the vadose zone, it is located primarily within the upper one-third of the vadose
28 zone between the lower tunnel and the water table (i.e., within the depth interval of 70–
29 110 ft msl).
- 30 • No LNAPL has been measured on any of the Red Hill monitoring wells. Weathered LNAPL
31 from a release prior to 2005 may be present in the immediate vicinity of RHMW02 or within
32 the saturated zone upgradient from this well.
- 33 • The mixture of dissolved constituents in groundwater and the mixture of constituents in soil
34 vapor samples are consistent with weathered/biodegraded fuel.
- 35 • A 27,000-gallon release of jet fuel from Tank 5 in January 2014 did not appear to impact any
36 of the Facility's monitoring wells or Red Hill Shaft located approximately 1,500 ft
37 downgradient.

10.2 DISSOLVED FUEL CONSTITUENTS IN GROUNDWATER AND ANALYTICAL CONSIDERATIONS

- Dissolved components in groundwater are consistent with soluble (aromatic hydrocarbons) components and polar material (likely metabolites) from fuels consistent with biodegraded jet fuel.
- Available data suggest the presence of weathered LNAPL (i.e., pre-2005) in the immediate vicinity of RHMW02 or within the saturated zone upgradient from this well. Multiple lines of evidence indicate that strictly biodegraded/weathered material (likely not associated with the 2014 release) is present in groundwater and COPC concentrations have generally remained within recent historical ranges.
- Analytical results of dissolved TPH-d alone are not suitable as a diagnostic tool to assess presence of LNAPL in groundwater. Biodegradation products of soluble fuel components are polar and are generally more water soluble than the aliphatic parent compounds. Furthermore, changes in TPH-d concentrations should be carefully evaluated as they can be due to changes in laboratory (methods and laboratory to laboratory) and to inherent limitations of TPH measurement. When TPH-d concentrations change from one monitoring event to the next, the significance of the change should be evaluated in the context of changes in the characteristics of the chromatography and changes in the mixture of individual dissolved constituents.

10.3 INTERIM GROUNDWATER FLOW MODEL

- As described in Section 5.3, dozens of groundwater models, utilizing various conceptualizations and stresses (e.g., boundary fluxes, material properties, heterogeneity considerations, geometries) have been developed and none of these models (with one exception) show groundwater flow from Red Hill to any of the BWS wells, even with extreme pumping conditions. The exception represents a drought condition under which Red Hill Shaft is not pumping and Hālawa Shaft pumps continuously at 16 mgd for several years (steady state conditions). For this case, it took a minimum of 3 years of continuous drought and extreme pumping conditions for groundwater to migrate to Hālawa Shaft from beneath the Facility. While this scenario has been evaluated in an effort to be very conservative, the likelihood of this scenario occurring is negligible.
- When operating under normal pumping conditions (█ mgd), Red Hill Shaft captures all groundwater flow from beneath the tanks underlying Red Hill even when Hālawa Shaft is pumping at 16 mgd and Moanalua Valley wells are pumping at 3.7 mgd.
- All models indicate that groundwater flow from beneath the Facility is toward Red Hill Shaft even when Red Hill Shaft is not pumping.
- A conservative model (shortest travel time) with clinker indicates that flow from RHMW02 to Red Hill Shaft is on the order of 45 days. Slower travel times are over 90 days. The more conservative of these values were implemented into evaluations of mass flux and natural attenuation.

10.4 NATURAL ATTENUATION

- Excess carbon dioxide (measured by carbon traps) and heat are being generated at the Facility, confirming that NSZD of LNAPL is active in the vadose zone. For the entire tank farm, the NSZD rate is likely between 2,600 and 17,300 gallons per year.

- 1 • Soil vapor monitoring and fingerprinting analysis show that rapid weathering of petroleum is
2 occurring in the vadose zone.
- 3 • Both the MNA Primary Lines of Evidence (concentration reduction in the plume) and
4 Secondary Lines of Evidence (geochemical analyses and microcosm studies) confirm that
5 aerobic and anaerobic biodegradation of dissolved petroleum hydrocarbons is occurring in
6 groundwater. Based on available data, the plume attenuation half-lives for dissolved
7 constituents are likely on the order of 10–100 days.

8 **10.5 RISK-BASED DECISION CRITERIA**

- 9 • Contaminants of potential concern were previously agreed upon by the AOC Parties and
10 include benzene, ethylbenzene, toluene, total xylenes, naphthalene, 1-methylnaphthalene,
11 2-methylnaphthalene, TPH-g, TPH-d, TPH-o, 2-(2-methoxyethoxy)-ethanol, and phenol.
- 12 • RBDC have been developed for these COPCs as conservative, initial screening criteria that
13 are protective of drinking and domestic water use.

14 **10.6 MASS FLUX AND SENTRY WELL CONSIDERATIONS**

- 15 • Mass flux considerations are widely used in evaluating potential impacts to pumping wells
16 from chemical concentrations in aquifers (monitoring wells).
- 17 • A mass flux approach is being utilized to evaluate potential impacts from COPCs in
18 groundwater to Red Hill Shaft. This approach will also be utilized in establishing sentry well
19 trigger levels as part of the release response plan. Utilization of mass flux of COPCs from
20 upgradient sources, Red Hill Shaft pumping rates, and RBDC help to ensure that drinking
21 water at Red Hill Shaft (and other wells) is adequately protected.
- 22 • Sentry well locations will be further evaluated after the current synoptic water level
23 information is evaluated along with the final contaminant fate and transport model.
24 Consideration will be given to transient fluctuations related to potential gradient changes due
25 to changes such as pumping or recharge.

26 **10.7 RELEASE SCENARIOS**

- 27 • The current understanding of LNAPL distribution and attenuation rates at the Facility have
28 been used to evaluate the possible environmental impacts of a hypothetical future chronic or
29 sudden release of jet fuel from the Facility.
- 30 • Based on the observed attenuation of LNAPL in the vadose zone and at the water table, an
31 undetected chronic release of 2,300 gallons per year per tank would be biodegraded in the
32 vadose zone, prior to reaching groundwater.
- 33 • Based on the LNAPL retention capacity in the subsurface (estimated based on data from
34 prior releases), a sudden release of approximately 120,000 gallons of LNAPL would likely
35 be retained in the vadose zone and/or at the water table without causing an exceedance of
36 RBDC at Red Hill Shaft. Within the range of uncertainty, a sudden release of less than
37 38,000 gallons would be very unlikely to cause an impact. Depending on the release location
38 (e.g., a higher elevation within a tank and/or a higher numbered tank further away from Red
39 Hill Shaft) and accounting for uncertainty regarding LNAPL retention capacity, it is possible
40 that a release as large as 700,000 gallons would not cause an exceedance of RBDC at Red
41 Hill Shaft. However, there is less confidence that the higher-end release volume would be
42 protective.

- To reduce monitoring variability, unnecessary changes to sampling methods and laboratory analysis procedures should be avoided. Due to inherent limitations of TPH measurement, indicators of new releases should be based on multiple lines of evidence. Changes in TPH-d concentrations between monitoring events should be evaluated in the context of changes in the characteristics of the chromatogram and changes in the mixture of individual dissolved constituents.

10.8 PATH FORWARD

The information provided in the CSM and this technical memorandum will help with a better current understanding of potential environmental issues given that additional data has been collected since the signing of the AOC. Given the results of the interim environmental analysis of current data, conditions are reasonably bounded by the current monitoring well network. Additional monitoring wells are planned to be installed to further improve resolution of site conditions. As new data become available (e.g., synoptic water level study data), those data will be integrated into an updated CSM for use in developing the *Investigation and Remediation of Releases Report (IRR)*, *Groundwater Flow Model Report*, and the *Contaminant Fate and Transport Model Report*. These reports can be used to further inform stakeholders on potential risks and to identify options for managing those potential risks. Specifically, the information presented in the CSM and this technical memorandum will be used to assist with the IRR and subsequent decision-making pursuant to the AOC. The IRR will include an evaluation and determination of the feasibility of alternatives (e.g., enhanced monitored natural attenuation, capture zone analysis) for investigating and remediating potential releases from the Facility to the maximum extent practicable. If another leak occurs prior to the completion of the environmental investigation and decisions regarding remedial alternatives for potential releases from the Facility, the current GWPP (DON 2014) will be followed accordingly.

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