SECTION 4.0 CONCLUSIONS

4.1 Shallow Soil

Samples of shallow soil in Makua Valley were collected and analyzed by the analytical laboratory. The laboratory results of a majority of the shallow soil samples collected at Makua do not contain concentrations from military operations above Region IX PRGs. There are low levels of some additional compounds below Region IX PRG levels including: dioxins, pesticides, herbicides, explosives, volatile organic compounds, and semivolatile organic compounds. Many of these compounds are likely the result of grass/brush burning operations. Low levels of dioxins (HpCDD, OCDD, OCDF, HpCDD, HxCDD), and furans (HxCDF) are common in areas such as Makua Military Reservation that have been burned. As a result of burning, it is also common to find low levels of hydrogen cyanide, volatile organic compounds, and semivolatile organic compounds (PAHs). The low levels of cyanide, diethylphthalate, di-n-butylphthalate could be the result of burning operations (Engelbeen, 2002).

Low levels of benzene, toluene, xylene, and MTBE were detected in a few samples. A great majority of these detections by the laboratory were semi-quantified results, labeled with a J flag (Appendix B). These semi-quantified results generally result from concentrations that are very near the ability of the instrument detection. The gasoline component levels are below Region IX PRGs. These gasoline by-products could be the result of fueling or mowing/weed cutting operations at Makua Military Reservation. Low levels of pesticide were reported in some samples (Endosulfan I and II). These pesticides possibly were transported by trade winds across the Waianae Mountains, as there is no recorded use of the pesticides in Makua Valley. These pesticide compounds may also have been introduced from wood treated for termites brought into Makua Valley. Several samples contained low levels of the herbicides (dalapon, 2,4-D, MCPP), which could have been introduced by weed controlling operations. There have been herbicides sprayed at Makua to control weeds along the road.

A few shallow soil samples contained the explosive compounds (nitroglycerin, HMX, RDX, TNT, and DNT). Some low levels of these compounds would be expected at a military training site. Out of nearly 124 shallow samples analyzed for explosives, only six samples had concentrations of compounds above detection limits of the analytical laboratory, and none were above industrial PRGs for explosives.

For the sampling program, out of 123 samples collected, one sample in OB/OD area detected dioxin above threshold levels (0.03 ppb versus PRG of 0.016 ppb), one sample in Objective Elk detected lead above threshold levels (119,000 ppm versus PRG of 750 ppm), two samples in "Makua Stream Firing Area" detected dioxin above threshold levels (2.44 and 2.33 ppb versus PRG of 0.016 ppb). Approximately 24% of samples detected aluminum above industrial PRG threshold levels; however, these concentrations are within the range of Waianae Coast background aluminum concentrations. Of the soil samples, 18 samples detected trace levels of gasoline components and/or pesticides used for termite control operations, but are below PRG levels.

Appendix K contains a comparison of analytical results of shallow soil samples reported by the laboratories to a number of additional screen values other than PRGs, including State of Hawai`i Tier I action levels, U.S. EPA Generic Soil Screening Levels (SSLs), and U.S. EPA Region 5 Ecological Screening Levels (ESLs) for surface soil. Levels of these compounds listed in Appendix K are considered to be low enough that additional assessment of ecological risk is not necessary for off-site receptors.

4.2 Borehole and Lysimeter Data

The soil sample results reported by the analytical laboratory for the shallow boreholes (in the OB/OD area and junk car pit) showed concentrations of aluminum, iron, and chromium above industrial PRG values. These metals are naturally occurring as by-products of weathered basalts in the Waianae Mountain Range. Some low levels of other chemicals were detected and reported by the laboratory, but that are not considered to be present in concentrations that represent a risk

to human health. Compounds reported include perchlorate, dioxin, acetone, acenaphthylene, trichlorofluoromethane, and the pesticides alpha-BHC and gamma-chlordane. Out of 19 subsurface soil samples collected, 1 of 19 samples subsurface samples contained chromium and iron above threshold levels, with a chromium concentration of 490 ppm versus threshold value of 450 ppm. In contrast, background samples along the Waianae Coast for Chromium ranged with a mean of 7.1 to 391 ppm. The sampling was conducted for total chromium (both III and VI together) in this study. The chromium that is mobile and the one of concern, chromium VI is the one that can get into water. Total chromium showed up in no groundwater samples above either threshold values (PRGs or MCLs). Iron concentration of 106,000 ppm versus PRG threshold value of 100,000 ppm, compared to a background sample value along the Waianae Coast for iron ranged with a mean of 98,000 to 100,100 ppm.

Unsaturated zone porewater samples from below the OB/OD area and the junk car pit were collected from the lysimeters installed in the boreholes. Lysimeter porewater samples from the lysimeters installed at depths of 30 and 42 feet below land surface had concentrations of RDX reported by the analytical laboratory above Region IX PRGs for water varying from 33 to 21,000 ug/l, with an average concentration of 5712 ug/l. The compound RDX was not reported by the analytical laboratory for most of the monitoring wells (except rounds 1 and 2 of well MW-4A), so RDX has not yet impacted off-site receptors in groundwater flow. These pore water RDX samples were collected from four samplers installed to intercept water in the unsaturated zone below the OB/OD area. These unsaturated zone samples are shallow varying from 30 to 42 feet, and are 400 or more feet above the groundwater table. The results of modeling runs predict that RDX is not migrating off-site since the RDX would need to travel 400 feet down, and then flow with groundwater over 1.5 miles toward the ocean. This result is confirmed by the sampling results of the downgradient wells. No RDX was detected in sampling of wells MW-5, or wells MW-1,-2,-3A,-3B,-3C, -4A, -4B, -4C, and SP-7 for rounds 3,4,5 and 6.

Appendix K contains a comparison of analytical results of sediment samples reported by the laboratories to a number of additional screen values other than PRGs, including State of Hawai`i Tier I action levels and U.S. EPA Generic Soil Screening Levels (SSLs). Levels of these compounds listed in Appendix K are considered to be low enough that additional assessment of ecological risk is not necessary for off-site receptors as a result of subsurface soil.

4.3 Streambed Soil Samples

Streambed soil samples contained no concentrations of compounds above Region IX PRG industrial soil values Soil samples from streams in Makua Valley (and neighboring Kaluakauila Valley) contained low levels of acetone, alpha-BHC, gamma-BHC 2-butanone, iodomethane, bis-(2-ethylhexyl)phthalate, and 2-butanone. All of these compounds are found at levels that are far below both residential and industrial PRGs, and therefore are not considered hazardous.

4.4 Surface Water Sampling

The data collected from the February 14, 2003, January 23, 2004, and February 27, 2004, flows shows that almost undetectable levels of potential contamination are leaving the Makua Military Reservation in surface water flows. This assessment results from a review of laboratory results for a wide variety of contaminants from a total of 81 samples collected from four streams for three different flow events. From these three events five samples detected pesticides above threshold levels (for example 0.045 ug/l versus drinking water PRG of 0.015 ug/l). Trace concentrations of pesticides are common in surface water throughout O`ahu. Only one sample in 81 detected RDX above drinking water PRGs, with a value of 1.7 ug/l compared to a drinking water PRG of 0.61 ug/l. Some samples have trace levels of dioxin/furan compounds, which were present in the background soil samples from off-site location, and are likely the result of grass burning operations performed over the years at MMR. Two samples detected benzene (gasoline component) above drinking water PRGs (0.44 ug/l versus drinking water PRG of 0.34 ug/l). Trace levels of gasoline components are likely the result of lawnmowers and grass trimmers

operating at MMR. The results of the surface water sampling showed that no pattern of contamination was evident with only trace levels of a few compounds reported in surface water samples by the analytical laboratory.

A comparison was performed of analytical results of sediment samples reported by the analytical laboratory to a number of additional screening values other than U.S. EPA Region IX PRGs, including State of Hawaii Tier I Action Levels, State of Hawaii Basic Water Quality Criteria, U.S. EPA Region 5 Ecological Screening Levels, and Federal Ambient Water Quality Criteria. Levels of compounds dissolved in surface water, such as metals or trace pesticides, are considered to be low enough that additional assessment of ecological risks is not necessary for off-site receptors as a result of stream flow from MMR.

4.5 Background Sampling

A review of these data shows that all radiation measurements collected in Makua Valley are within the range of values normally found on O`ahu; therefore, there is no indication of radiation contamination from operations at Makua Military Reservation.

Off-site soil samples collected from other valleys along the Waianae Coast contained dioxin and furan compounds. Discovery of these dioxin and furan compounds off-site would suggest that these compounds are found throughout the Waianae Coast, and may be due to brush fires or other non-military operations.

4.6 Groundwater Sampling

Except for the detection of thallium in the first round of sampling for well MW-5 (thallium was not detected above MCLs in the second round of sampling for well MW-5), and thallium detected in wells MW-4A and –4B in round 3 (thallium was not detected above MCLs in the 4th, 5th, or 6th rounds of sampling), the groundwater in Makua Valley would meet drinking water standards as established by the U.S. EPA. Thallium, as well as other metals detected in groundwater samples are naturally occurring in Hawaiian rocks and soils, and therefore may also be present in trace amounts in groundwater. The chloride concentrations are somewhat elevated

(taste levels for chloride are 250 mg/l), so that the water in Makua Valley would not taste as good as water from other parts of O`ahu. However, it would be considered drinking water quality.

In well MW-4A, the first groundwater sampling round results reported by the analytical laboratory showed concentrations of 0.62 ug/l RDX, which is 0.01 ug/l above the drinking water PRG of 0.61 ug/l. The second round of data from well MW-4A reported by the laboratory showed concentration of 0.48 ug/l RDX, which was below the drinking water PRG of 0.61 ug/l. No RDX was detected and reported by the laboratory in any monitoring well in rounds 3, 4, 5, and 6. It is likely that trace amounts of RDX may have been introduced during drilling operations, as RDX did not show up in subsequent sampling rounds. This is a common occurrence and the reason that 6 rounds of groundwater samples were collected: to obtain and accurate assessment of groundwater chemistry flowing off-site and potentially impacting off-site receptors.

Analytical results reported by the laboratory of water well samples of groundwater did report a few compounds above Ecological Screening Levels (ESLs). However, based on the few number and relatively low levels of compounds, additional assessment of ecological risk is not required to evaluate the impacts of groundwater flow discharging from the MMR.

4.7 Fate and Transport

The surface water models shows that a high percentage (greater than 80%) of both measured and estimated rainfall in Makua Valley infiltrates to the soil, with a smaller percentage (less than 20%) flowing off the site in the stream flow. Also, a large portion of the bottom of Makua Valley would be flooded by a large rainfall event, such as the 100-year, 24-hour storm.

The groundwater modeling was performed to estimate the fate and transport of RDX in the impact area and the OB/OD area. Groundwater samples collected in the 10 monitoring wells show that groundwater chemistry has not been impacted by RDX. The modeling was conducted to evaluate what the concentrations might be if RDX flows off-site in groundwater flow. Groundwater flow is slow in Makua Valley, and a review of the modeling results shows that

natural processes may degrade or dilute the compounds long before measurable concentrations might reach the coast. However, should RDX impact the groundwater, a review of the modeling results shows that the ten monitoring wells in the Makua Valley would be impacted before off-site receptors are impacted by explosive compounds such as RDX. This is especially true of well MW-5, that is downgradient of the impact area and the OB/OD area.

The levels of potential contaminants found in the study for soil, surface water, and groundwater are of insufficient magnitude to classify MMR as contributing significant contamination off-site. This is because if there were significant contamination at Makua Military Reservation, many more of these samples would have contained higher levels of compounds related to Army training. Trace levels of compounds such as pesticides or gasoline by products are common in groundwater and surface water flow throughout O`ahu. For any site to be contaminated, much higher levels in many more samples would have to be reported by the analytical laboratory. Makua Valley, based on a review of the data collected, is not providing significant contamination to impact off-site receptors.