8.0 SUMMARY AND CONCLUSIONS

The WBG RI Report presents a detailed analysis of environmental data for the site. Conclusions are conveyed through the conceptual model for the nature and extent of contamination and the fate and transport of contaminants. The conceptual model and contaminant exposure models are then used to quantify the risk posed to human health and the environment at WBG. This section of the report summarizes the findings and conclusions of the WBG RI.

8.1 SUMMARY

This section provides a summary of the evaluation of the nature and extent, fate and transport, and human health and ecological risk assessments of environmental contamination at WBG, which are presented in detail in Sections 4.0 through 7.0 of the RI Report.

8.1.1 Nature and Extent

The nature and extent of contamination is examined in five media: surface soils [0 to 0.6 m (0 to 2 ft) bgs], subsurface soils [0.6 to 1.2 m and 1.2 to 1.9 m (2 to 4 ft and 4 to 6 ft) bgs], sediment, surface water, and groundwater. The results of this evaluation are summarized by medium here.

Surface Soils

- Explosives are present at concentrations > 1 ppm at Pads #37, 66, and 67, with the greatest concentrations occurring at Pads #66 and 67. Surface soil samples from Pad #70 were not analyzed for explosives based on negative results in the Phase I study and field screening conducted during the Phase II investigation. Explosive contamination in surface soils is generally confined to the pads.

- Propellants (nitroglycerin and/or nitrocellulose) were present at Pads #5, 37, 60, 61, 66, 67, and 68 with the highest concentration occurring at Pad 66. Concentrations of propellants are generally below 20 mg 1 kg making them a minor contaminant constituent in surface soils.

- Lead is present at concentrations > 100 ppm at every pad except #5, 6, and 70. Although high concentrations of metals are often found with explosives contamination in soil, metal contamination appears to be distributed around the burning pads as well as on the pads. Cadmium is present above background in the highest concentrations (> 20 ppm) at Pads #37, 38, 45, 58, 60, and 61. It was detected at concentrations below 10 ppm or not detected at Pads #5, 6, 40, 59, 62, 66, 67, 68, and 70.

- VOCs and SVOCs evaluated at Pads #37, 60, 66, 68, and 70 were detected in several surface soil samples. Detected PAHs may reflect the burning of materials at the pads.

Subsurface Soils

- Explosives concentrations > 1 ppm are present in the 0.6- to 1.2-m (2- to 4-ft) interval at Pads #60, 62, 66, and 67, and in the 1.2- to 1.9-m (4- to 6-ft) interval at Pads #67 and 68. Pads #60, 66, and 67 have the greatest concentrations of explosives in the subsurface soils. Explosives concentrations decrease with depth.

- Lead occurs at concentrations > 100 ppm at Pad #60, in the 0.6- to 1.2-m (2- to 4-ft) interval only. Cadmium was detected in four Phase II samples, with the highest concentrations observed at Pads #60 and 61. Pads #5, 6, 37, and 70 exhibit no exceedances of background criteria for TAL metals in the subsurface. Pads #38, 40, 58, 59, 61, 66, 67, and 68 all have three or fewer metals above background in the 0.6- to 1.2-m (2- to 4-ft) interval. Pad #62 has six metals occurring above background in the 0.6- to 1.2-m (2- to 4-ft) interval. Two or fewer metals exceed background in the 1.2- to 1.9-m (4- to 6-ft) interval at Pads #59, 60, 62, 66, 67, and 68. As with explosives, metals contamination decreases with depth.

Sediment

- Explosives are not present in sediments at concentrations > 1ppm.
- Two of the four samples collected have eight metal results above background criteria. Most of these exceedances occur in the sample from the extreme eastern end of WBG.
- Eleven PAHs, all at concentrations <1 ppm, were identified in one sample from the upstream end of Mack's Pond.

Surface Water

- No explosives were detected in the surface water sample from Mack's Pond.
- The surface water sample has no metal results that exceed the background criteria. There was one detection of the organic chemical acetone in the surface water.

Groundwater

- Seven of the nine monitoring wells at WBG have minor detections of explosives. The only occurrences of explosives in groundwater > 1 ppb are in WBGmw-006, downgradient from Pad #67, and in WBGmw-009. Of these, WBGmw-006 exhibits the highest concentrations of explosives in WBG groundwater. WBGmw-007 is downgradient from WBGmw-006 and shows no explosives concentrations > 1 ppb.
- Eight detections of analytes occur above background in the filtered samples from nine wells. None of these values exceed MCLs standards for groundwater, although some metals (e.g., manganese) have no MCL or have a secondary MCL.

Slag

- The two slag samples collected at Pad #37 contain high concentrations of aluminum, antimony, arsenic, cadmium, copper, lead, manganese, potassium, sodium, and zinc. The observed concentrations of manganese in surface soil and groundwater throughout WBG may be partially attributed to the widespread use of slag throughout RVAAP as aggregates for roads, driveway, and burning pads.

8.1.2 Fate and Transport

Groundwater

- Organic compounds and explosives detected at the WBG subsurface soils are expected to degrade considerably before leaching to the groundwater; however, site-specific data on natural attenuation were not collected during the RI. These data would be collected as part of focused studies supporting the FS. Potential off-AOC migration of these constituents via groundwater pathway may be limited due to natural attenuation processes in the groundwater and also the impervious nature of the subsurface soils. However, site-specific data have not been gathered to confirm this.

- Heavy metals detected at the WBG subsurface soil are not expected to significantly leach to the groundwater due to their high adsorption coefficients.

Surface Water

Because surface water is the primary medium at the WBG with the potential for off-site contaminant migration, modeling of contaminant fate and transport was performed only for surface water in ditches and creeks. The findings of the surface water modeling are summarized below:

- A conceptual model for overland flow and contaminant transport at WBG was developed. Site-specific information for hydrologic and contaminant variables were used to develop the numerical inputs to the SWMM numerical model. Six metals (e.g., arsenic, chromium, copper, lead, mercury, and zinc); five explosives (e.g., 1,3-trinitrobenzene, 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, HMX, and RDX); and three PAHs [e.g., benzo(*a*)pyrene, phenanthrene, and pyrene] were evaluated using the model.

- The model simulation results were adjusted to match reality, as determined by transformation of observed peak soil concentration data of metals and organics through distribution coefficients at the site. The parameters were adjusted to achieve satisfactory agreement.

- The simulated distribution of contaminants for a typical rainfall year was not significant (i.e., predicted concentrations of contaminants were generally much below the Ohio statewide water quality criteria for the protection of both human health and aquatic receptors) in the surface water system at WBG, which is comprised of overland flow from drainage areas to the drainage ditches and tributaries. Negligible amount of explosives (TNB at 0.013 μg/L, and TNT at 0.000034 μg/L yearly average concentrations) from the WBG site were predicted to be discharging to Sand Creek. Therefore, potential off-site contaminant migration via surface water and sediment pathways at WBG is not expected to pose a problem.

8.1.3 Human Health Risk Assessment

Seven receptors are evaluated for human health risks and hazards at WBG: a security guard/maintenance worker, a National Guard Bureau person, an open industrial worker, a child trespasser, a hunter/trapper, a recreational user, and a resident farmer. Noting that the National Contingency Plan has set the point of departure for excess lifetime cancer risk at 1×10^{-6}, a risk level of 1×10^{-4} is used in this summary to focus on the receptors with the largest risk. The following summarizes the results of the human health risk assessment when chemical data above background are aggregated across the entire WBG site.

- A total of 17 COCs (chemicals with a total risk $>10^{-6}$ or total Hazard Index >1.0) were identified for at least 1 medium/receptor combination.

- Ten of these COCs were identified only for the on-site resident farmer exposed indirectly to surface soils (i.e., through ingestion of venison, beef, milk, and vegetables).

- A total of 14 significant COCs (chemicals with a total risk $>10^{-4}$ or total Hazard Index >1.0) were identified for at least 1 medium/receptor combination.

- No COCs are identified with large risk (total risk $> 10^{-4}$) or total hazard index (HI) > 1.0 for the following receptors exposed to any medium: the security guard/maintenance worker; the National Guard Bureau personnel; the industrial worker; the child trespasser; the hunter/trapper; and the recreational user.

- No COCs with large risk (total risk > 10^{-4}) or total HI > 1.0 are identified for the on-site resident farmer exposed to sediment or surface water.

- Two COCs with total HI > 1.0 are identified for the on-site resident farmer exposed to subsurface soil. Cadmium concentrations result in a dermal HQ of 1.3 and 2,4,6-trinitroluene concentrations result in a child ingestion HQ of 3.2.

- Three COCs with total HI > 1.0 are identified for the on-site resident farmer exposed directly to surface soil. Cadmium concentrations result in a dermal HQ of 1.6, while representative exposure concentrations for 2,4,6-Trinitrotoluene and RDX result in child ingestion HQs of 4.2 and 1.1, respectively.

- Multiple COCs with large risk (total risk > 10^{-4}) or total HI > 1.0 are identified for the on-site resident farmer exposed indirectly to surface soils (i.e., through the ingestion of venison, beef, milk, and vegetables, all pathways with large uncertainties). Significant COCs from these pathways include antimony; arsenic; barium, cadmium; chromium; zinc; 1,3,5-trinitrobenzene; 2,4,6-trinitrotoluene; benzo(*a*)pyrene; dibenzo(*a,h*)anthracene; indeno(1,2,3-*cd*)pyrene; HMX; and RDX.

- Manganese is a COC with total HI > 1.0 for the on-site resident farmer exposed to groundwater. The only manganese concentration (3070 μg/L) detected above background is used as the representative EPC, resulting in a dermal contact HQ of 1.8.

When risks and hazards are evaluated for individual sample locations, several surface soil "hot spots" are identified (see **Figure 8-1** for results from the evaluation of the Open Residential and National Guard land uses). Although a receptor is not likely to spend his/her entire exposure time at a single location (e.g., an on-site resident would not remain in the same location for 350 days/year for 30 years), risk calculations for such an exposure indicate that several "hot spots" would result in risks > 10^{-4} or hazards elevated as high as 3.0 (Note: higher risk/hazard levels are used for evaluation of point-by-point results than aggregate results because of the unrealistic assumption that a receptor will spend the entire exposure duration at one location). The three chemicals with these high concentrations are cadmium (42.8 to 877 mg/kg); 2,4,6- trinitrotoluene (3400 to 3800 mg/kg); and RDX (9500 mg/kg). When evaluated for all seven receptors, "hot spot" locations are identified for areas on or adjacent to:

- Pad #38 (hazards >3.0 for all seven receptors);

- Pad #45 (hazards >3.0 for all seven receptors);

- Pads #58, 60, and 61 (hazards >3.0 for the on-site resident farmer only);

- Pad #66 (hazards >3.0 for all receptors except the hunter/trapper and the recreator; risks >10^{-4} for the on-site resident farmer); and

- Pad #67 (risks >10^{-4} and hazards >3.0 for all receptors except the hunter/trapper and the recreator).

8.1.4 Ecological Risk Assessment

Steps 1 and 2 of the EPA's 8-step process for ecological risk assessment were completed in the Phase II RI. Steps 1 and 2 focus on determination of screening or preliminary risk. Results of the screening ERA may be sufficient for decision making, or a follow-up baseline ERA may be needed. The findings of the screening ERA are as follows:

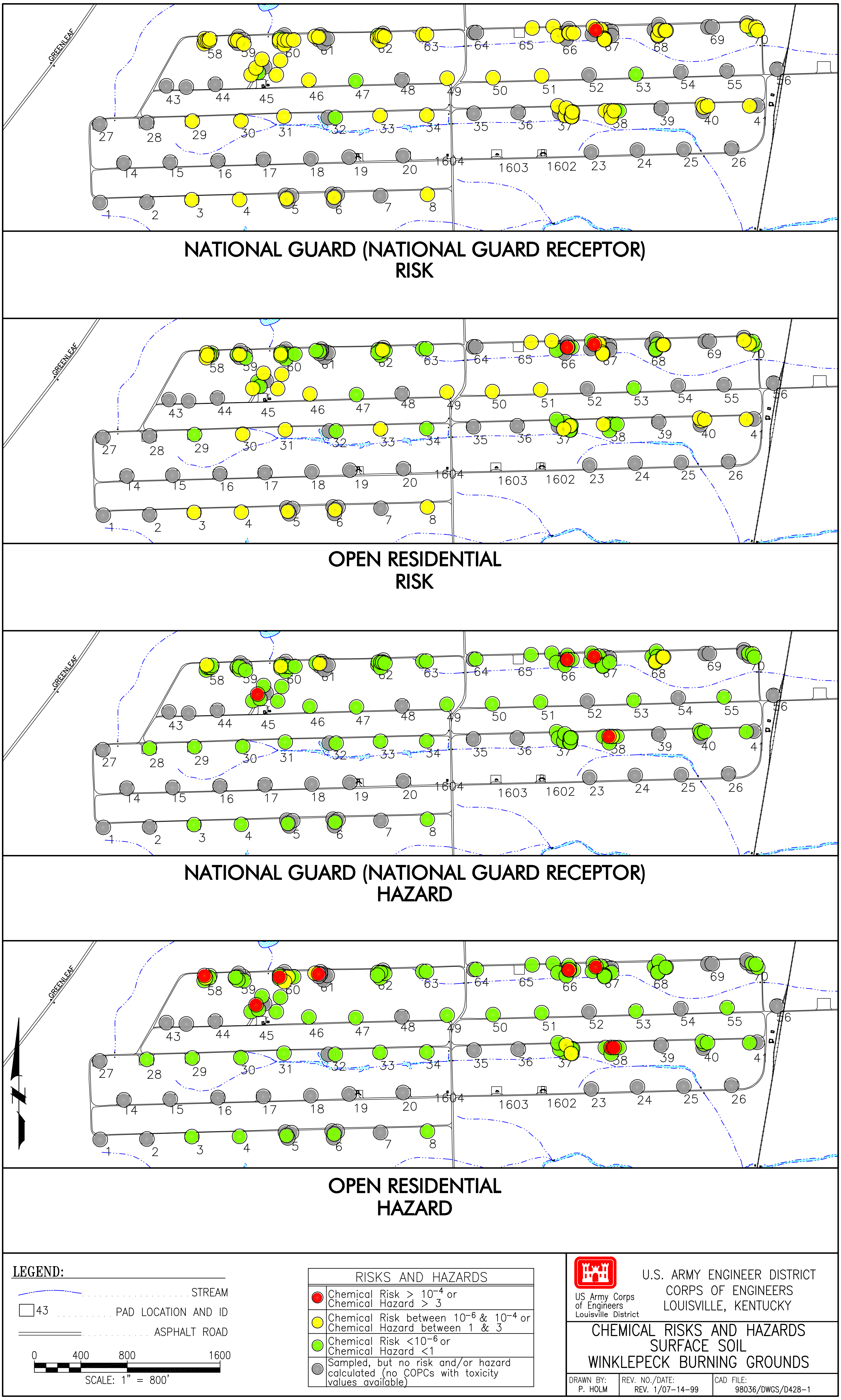

Figure 8-1. Human Health Surface Soil Risks and Hazards for National Guard and Open Residential Land Uses

- Terrestrial habitats dominate the 81 ha (200 acres) of WBG. The habitats consist of patches of early successional or old fields where grasses and weeds grow, deciduous forests where large trees live, and intermediate-size and -age vegetation consisting of bushes and small trees. Aquatic habitats consist of small ditches and creeks where water occurs part of the year. Part of Sand Creek flows inside the WBG boundary . A small pond created by a beaver dam may have year-round water. The only permanent water body is Mack's Pond located about 122 m (400 ft) south of Pads #3 and 4. This variety of habitats is a result of previous physical and possibly chemical disturbances at WBG.

- Biologists documented many species of animal life at WBG. For example, many meadow voles and cottontail rabbits were often observed in the old fields near the burning pads. Red-tailed hawks and red foxes were present and are expected to be feeding on the voles, cottontails, and other small organisms. The general appearance of the vegetation and various wildlife suggest no immediate threat from acute nor chronic exposures. There were a few places where no vegetation was growing; however, because appearances are insufficient to identify ecological risk, an ERA was required.

- Ecological receptors represent a variety of feeding or trophic positions. Vegetation represents the beginning of the food web and earthworms represent soil invertebrates. Plant-eaters (herbivores) are represented by the cottontail rabbit and deer, while invertebrate eaters are represented by the short-tailed shrew and American robin. Three species of meat-eaters or carnivores are included: red-tail hawks, barn owls (a threatened or endangered species), and red foxes. Crayfish represent sediment-dwelling organisms, while fish and aquatic insects, including caddisflies and mayflies, serve as the aquatic receptors. A total of 11 ecological receptors were evaluated.

- The screening ERA found significant ecological risk (HQ >1) from surface soils for the entire WBG as well as each of the smaller pad areas. Ecological risk to one or more of the receptors came from a variety of COPECs. Typical inorganic COPCs were aluminum, cadmium, chromium, lead, and zinc; the primary organic COPCs were 2,4,6-trinitrotoluene, HMX, and RDX.

- Ecological risk differs from pad to pad. Some pads have only a few COPCs while others show many, and some COPCs at the pads have low HQs (e.g., 5) while others have high HQs (e.g., 2000). Because an HQ of 1 is sufficient to suggest ecological risk, EPA does not distinguish between an HQ of 1 or greater (even 2000).

- *Surface soil*: The HQs for surface soil at each pad were grouped into three categories: HQs of 1 to 99, HQs of 100 to 999, and HQs of 1000 and greater. Results of this categorization, illustrated in **Figure 8-2**, show that:

  — One pad, #4, has low risk from the inorganic COPCs aluminum, arsenic, chromium, lead, selenium, and zinc.

  — A total of 46 pads have ecological risk in the 100 to 999 range from, almost exclusively, aluminum.

  — Seven pads have ecological risk in the 100 to 999 range from metals such as aluminum, cadmium, lead, thallium, and zinc, and explosives such as 2,4,6-trinitrotoluene, HMX, and RDX. These risks are found at Pads #8, 40, 45, 61, 62, 67, and 68.

  — Seven pads have ecological risk in the 1000 and greater range from aluminum, cadmium, and lead. These risks are found at Pads #32, 37, 38, 58, 59, 60, and 66.

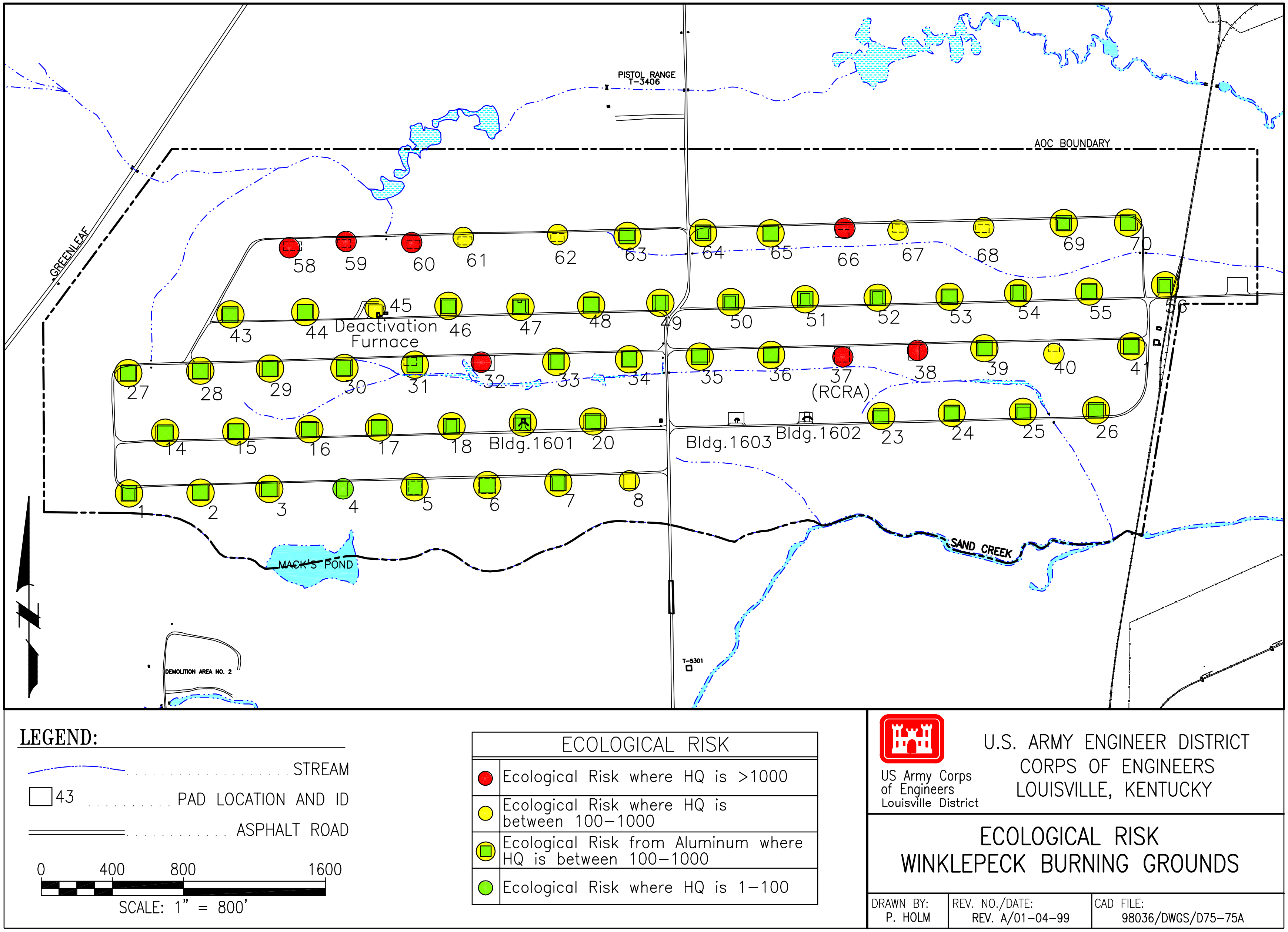

Figure 8-2. Ecological Risk Summary for Winklepeck Burning Grounds

- The pads with the most COPCs and highest HQs are #32, 37, 38, 58, 59, 60, and 66. Dominant COPCs are aluminum, cadmium, and lead for surface soils.

- Based on these and other findings, a baseline ERA will be needed for some locations to better assess risks and to aid in making decisions about the need for and extent of remediation.

- *Sediment*: Twelve COPCs were identified in wet sediment (creeks where water was present when samples were taken): arsenic, copper, manganese, nickel, zinc, benzo(*a*)anthracene, benzo(*a*)pyrene, chrysene, fluoranthene, phenanthrene, pyrene, and acetone. Four COPCs were identified in dry sediment (ditches where water was absent when samples were taken): arsenic, copper, manganese, and nickel. All HQs were relatively low, ranging between 1 and 3.

- *Surface water*: Only one COPC, acetone, was identified. No TRV is noted for acetone; therefore, risk could not be calculated for the sample that came from Mack's Pond.

8.2 CONCLUSIONS

The focus of the evaluation of the nature and extent of contamination at WBG is the Phase II data, which were collected for the specific objective of further defining the contaminant distribution identified during the Phase I RI. Both the Human Health and Ecological Risk Assessments combined the Phase I and Phase II data for statistical evaluation. The conclusions presented here by medium combine the findings of the contamination nature and extent evaluation and both risk assessments with fate and transport modeling (surface water only).

Surface Soil

Explosives are present at concentrations >1 ppm at Pads #37, 66, and 67. Cadmium and lead were detected at relatively high concentrations (>100 ppm for lead; >20 ppm for cadmium) at nearly all of the 14 pads sampled during the Phase II investigation. Pads #60, 66, and 67 exhibit simultaneously high concentrations of metals and explosives, large human health risk (risk greater than 10^{-4} and/or HI > 3), and Pads #60 and 66 exhibit ecological risk at HQ > 1000. These risk analyses show the human health COCs with risk > 10^{-4} or HI > 3 are cadmium, TNT, and RDX, and the COECs are aluminum and lead. Pads #38, 45, 58, and 61 show large human health hazards (HI > 3) from cadmium and Pads #38 and 58 show ecological risk of HQ ranging higher than 1000 for aluminum, cadmium, and lead. High ecological risks (HQ > 1000) are also determined for surface soil at Pads #32 (aluminum), 37 (aluminum and lead), and 59 (lead).

Subsurface Soil

Explosives are present at concentrations greater than 1 ppm at five of the pads sampled during the Phase II investigation, and metals occur sporadically at concentrations above background criteria, with the highest concentrations at Pads #60 and 61. Pads #5, 6, 37, and 70 have no TAL metals above background in the subsurface. Two human health COCs (cadmium and TNT) are identified in subsurface soil. Large human health hazards (HI >3) are observed for cadmium at Pads #38, 45, 58, 60, and 61, while large human health risks (>10^{-4}) were due to high TNT concentrations at Pads #66 and 67. An ERA was not considered necessary for subsurface soil and was not included in the screening ERA.

Sediment

Explosives are not detected above 1 ppm in any sample; metals are detected above background and PAHs are present in one or two sediment samples. No human health COCs with large risk (total risk > 10^{-4}) or total HI > 1.0 are identified for sediment. Low (HQ of 1 to 2) ecological risk from PAHs is identified in the sample from the upstream end of Mack's Pond. Several metals (arsenic, copper, manganese, nickel, and zinc) in sediment taken from ditches and creeks within the burning grounds pose ecological risk (HQ of 1 to 3).

Surface Water

The one sample analyzed from Mack's Pond showed no analytes exceeding background criteria. The SWMM modeling results show that potential off-site contaminant migration via surface water and sediment pathways at WBG is not expected to be of any problem. No COPCs were identified for either human or ecological receptors.

Groundwater

Explosives are detected at concentrations greater than 1 ppm in two wells, and metals are detected in several wells at concentrations below MCLs for drinking water. Manganese, detected in one well at a concentration approximately 3 × background, has a large hazard (HI between 1 and 2) for the residential risk scenario. The background value for this element is more than 6× the human health risk-based screening criterion. Organic compounds and explosives detected in WBG subsurface soils are expected to degrade considerably before leaching to the groundwater. Potential off-AOC migration of these constituents via groundwater pathway may be limited due to natural attenuation processes in the groundwater (e.g., the downgradient well showed no explosives concentrations > 1 ppb). However, site-specific data have not been gathered to confirm this. Heavy metals detected in WBG subsurface soil are not expected to significantly leach to the groundwater due to their high adsorption coefficients. Groundwater is not pertinent for ecological risk evaluation and was not included in the screening ERA.

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