7. SCREENING ECOLOGICAL RISK ASSESSMENT

An ecological risk assessment (ERA) defines the likelihood of harmful effects on plants and animals as a result of exposure to chemical constituents. There are two types of ERAs: screening and baseline. A screening ERA (SERA) depends on available site data and is conservative in all regards. A baseline ERA (BERA) requires even more site-specific exposure and effects information, including such measurements as body burden measurements and bioassays, and often uses less conservative assumptions. A SERA is needed to evaluate the possible risk to plants and wildlife from current and future exposure to contamination at the LL 1. The need for and nature of a BERA will be assessed following completion of the SERA.

The initial regulatory guidance for the ERA is contained in EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume II, Environmental Evaluation Manual* (EPA 1989c) and in subsequent documents (EPA 1991c, 1992d). Further discussion on the scientific basis for assessing ecological effects and risk is presented in *Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document* (EPA 1989d). Other early 1990s guidance is provided in the *Framework for Ecological Risk Assessment* (EPA 1992c). A second generation of guidance consists of the *Procedural Guidance for Ecological Risk Assessments at U.S. Army Exposure Units* (Wentsel et al. 1994) and in its replacement, the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al. 1996). In addition, the recently published *Ecological Risk Assessment Guidance* (EPA 1997b, 1998c) supersedes *RAGS, Volume II* (EPA 1989c). This latter guidance makes the distinction between the interrelated roles of screening and baseline ERAs. Briefly, screening ERAs utilize conservative assumptions for exposures and effects, while a baseline ERA means increasingly unit-specific, more realistic (and generally less conservative) exposures and effects. Newly published EPA guidance (EPA 1997b) was used because it provided the clearest information on preliminary or screening ERAs. A Technical Memorandum (SAIC 2001) proposed the specific methods and data to be used for the LL 1 SERA. The state of Ohio utilizes these documents and has specific requirements for certain data, as will be discussed later.

These documents discuss an overall approach to considering ecological effects and to identifying sources of information necessary to perform ERAs. However, they do not provide all the details. Thus, professional knowledge and experience are important in ERAs to compensate for this lack of specific guidance and established methods. This professional experience comes from a team of risk scientists, who are representatives from the RVAAP, USACE, Ohio EPA, and SAIC.

The following sections present the scope and objectives (Section 7.1); the procedural framework (Section 7.2); and the four steps to complete the screening, hereafter referred to as the ERA: problem formulation (Section 7.3), exposure assessment (Section 7.4), effects assessment (Section 7.5), and risk characterization (Section 7.6). Uncertainties (Section 7.7) and the summary (Section 7.8) comprise the final two sections of the SERA.

7.1 SCOPE AND OBJECTIVES

The scope of the SERA is to characterize, in a preliminary way, the risk to plant and animal populations at LL 1, including its aquatic environments, from analytes that are present in the surface soil, sediment, and surface water. This is done for both current and future conditions. Unlike the HHRA, which focuses on individuals, the ERA focuses on populations or groups of interbreeding individuals. In the ERA process, individuals are addressed only if they are protected under the Endangered Species Act (ESA).

The SERA used site-specific analyte concentration data for surface soil, sediment, and surface water from LL 1. Risks to ecological receptors were evaluated by performing a three-step screening process in which, after each step, the detected analytes in the media were either eliminated from further consideration and deemed to pose negligible risk or carried forward to the next step in the screening process to a final conclusion of being a contaminant of potential ecological concern (COPEC). COPECs are analytes whose concentrations are great enough to pose potential adverse effects to ecological receptors. The screening steps are described in detail in Section 7.3.4. COPECs are usually the starting point for more definitive BERAs. The Ohio EPA intends to issue new ecological risk guidance in 2001, and the Army is conducting ground-truthing investigations of plants and animals at WBG near LL 1 and will publish the results in a separate report. These documents will influence the next step at LL 1.

The objective of the SERA was to identify whether any of the detected analytes in surface soil, sediment, and surface water at LL 1 posed sufficient potential risk to ecological receptors to warrant the analytes being classified as COPECs. This was done for the most important pathways involving soil, sediment, and surface water and receptors that would be exposed to the media. Deep groundwater is not a medium of concern for ecological receptors. However, shallow groundwater is expected to flow into the drainage ditches and ponds on LL 1. Groundwater is treated as surface water once it surfaces and mixes with existing surface water.

7.2 PROCEDURAL FRAMEWORK

According to the *Framework for Ecological Risk Assessment* (EPA 1992c), the ERA process consists of three interrelated phases: problem formulation, analysis (composed of exposure assessment and ecological effects assessment), and risk characterization. In conducting the SERA for LL 1, these three phases were completed by performing four interrelated steps. As explained above, definitive or more recent guidance (EPA 1997b) indicates two levels of rigor: screening and more definitive or baseline. Each has the following parts

- **Problem Formulation:** Problem formulation establishes the goals, breadth, and focus of the ERA and provides a characterization (screening step) of chemical stressors (chemicals that restrict growth and reproduction or otherwise disturb the balance of ecological populations and systems) present in the various habitats at the site. The problem formulation step also includes a preliminary characterization of the components, especially the receptor species, in the ecosystem likely to be at risk. It also includes the selection of assessment and measurement endpoints as a basis for developing a conceptual model of stressors, components, and effects (Section 7.3).

- **Exposure Assessment:** Exposure assessment defines and evaluates the concentrations of the chemical stressors. It also describes the ecological receptors and defines the route, magnitude, frequency, duration, and spatial pattern of the exposure of each receptor population to a chemical stressor (Section 7.4).

- **Effects Assessment:** Effects assessment evaluates the ecological response to chemical stressors in terms of the selected assessment and measurement endpoints. The effects assessment results in a profile of the ecological response of populations of plants and animals to the chemical concentrations or doses and to other types and units of stress to which they are exposed. Data from both field observations and controlled laboratory studies are used to assess ecological effects (Section 7.5).

- **Risk Characterization:** Risk characterization integrates exposure and effects or the response to chemical stressors on receptor populations using HQs, which are ratios of exposure to effect. The results are used to define the risk from contamination at LL 1, in contrast to background (naturally occurring) risk, and to assess the potential for population and ecosystem recovery (Section 7.6).

The SERA is organized by the four interrelated steps of the EPA framework. Sections 7.3 through 7.6 detail the technical issues and data evaluation procedures associated with each step. Section 7.7 evaluates the degree of reliability or uncertainty of these methodological steps and the data used. Finally, Section 7.8 provides the summary.

7.3 PROBLEM FORMULATION

The first step of EPA's approach to the ERA process, problem formulation (data collection and evaluation), includes

- determination of the scope of the assessment (as discussed in Section 7.1);

- formulation of an ecological conceptual site model of LL 1 based on existing information and reasonable assumptions, including habitats, populations, and any threatened and endangered (T&E) species (Section 7.3.1);

- selection of EUs (Section 7.3.2);

- descriptions of habitats, biota, and T&E species (Section 7.3.3);

- identification of preliminary chemicals of potential ecological concern (Section 7.3.4);

- selection of assessment and measurement endpoints for the ERA (Section 7.3.5); and

- summary of preliminary COPECs (Section 7.3.6).

7.3.1 Ecological Conceptual Site Model

The ecological conceptual site model of LL 1 has been developed for the SERA using available site-specific information and professional judgment. The constituent source, exposure media, receptors, and the routes by which they are exposed to constituents are described below. Figure 7-1 shows the ecological conceptual site model. Each part is briefly explained below.

- **Constituent Source and Source Media.** Constituent sources at LL 1 were defined in the RI report. Chemical constituents from these sources are now present in surface soil, sediment, and surface water. Groundwater is shown in the conceptual model for the sake of completeness.

- **Release Mechanisms.** These mechanisms include plant/animal uptake and, to a lesser extent, volatilization. Leaching to surface water and to groundwater may be an additional release mechanism.

- **Exposure Media.** Sufficient time (more than 10 years) has elapsed for the soil and sediment constituents in original sources to have migrated to potential exposure media, resulting in possible exposure of plants and animals that come into contact with these media.

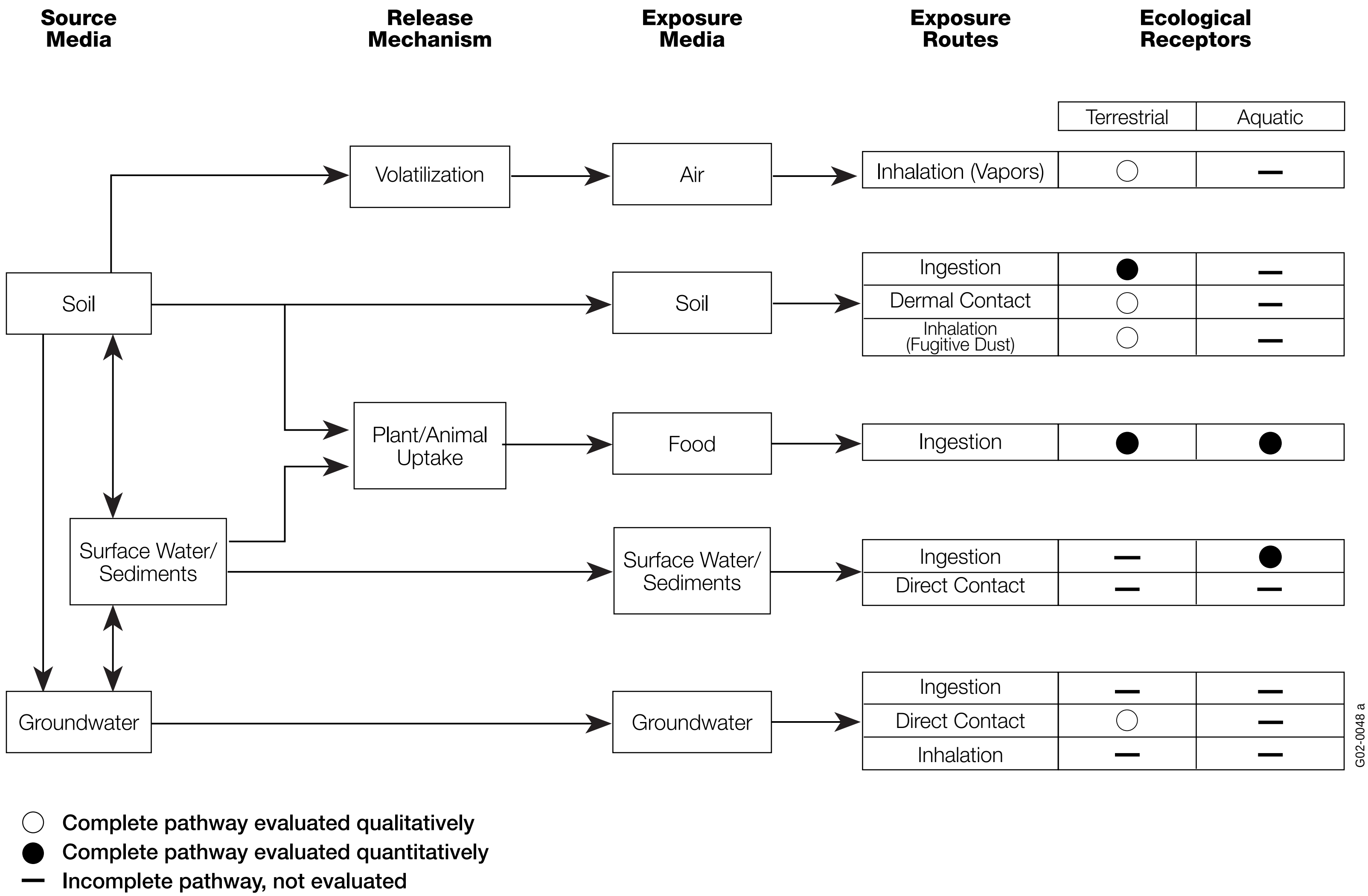


Figure 7-1. Exposure Pathways for Terrestrial and Aquatic Receptors.

Sediment and surface water are also present in the drainage ditches and small ponds at LL 1. Deep groundwater is not considered an exposure medium because ecological receptors are unlikely to contact groundwater at its depth of greater than 5 ft bgs. Shallow groundwater, once it surfaces, is assumed to be the same as surface water. Air is not considered an exposure medium because potential volatile organics are believed to have dissipated. Thus, surface soil, sediment, surface water (for direct exposure), and biota (e.g., indirect exposure via the food chain) were retained as the exposure media for this SERA.

Exposure Routes. Terrestrial animals potentially may come into contact with soil by means of incidental ingestion, dermal contact, and inhalation of dust. Aquatic organisms are exposed directly from the sediment and water.

Ingestion of soil and biota by animals are two principal exposure routes evaluated quantitatively for terrestrial animals. The exposure of animals to constituents in soil by dermal contact and inhalation is likely to be a small fraction of these two routes. Furthermore, the available toxicity data are almost exclusively for the ingestion pathway (e.g., Sample et al. 1996). By contrast, direct exposure to constituents in surface soil, sediment, and surface water are principal pathways for plants and earthworms, sediment-dwelling organisms, and fish, respectively. A principal exposure route is contact of biota with soils at LL 1. Plants are exposed directly by root uptake from soil and serve as throughputs to animals. The exposure pathways are evaluated quantitatively using site measurements and published exposure parameters.

Ecological Receptors. Terrestrial and aquatic animal receptors are recognized in the ecological conceptual site model (Figure 7-1) and are presented and discussed in Section 7.4.1.

7.3.2 Selection of Exposure Units

From the ecological assessment viewpoint, an EU is the investigation area and some of the surrounding area where ecological receptors are likely to gather food, seek shelter, reproduce, and move around. As a result of these activities, ecological receptors potentially are exposed to the site constituents. Thus, the EU is defined on the basis of the existing habitat and land use, observed and assumed patterns of behavior of the receptors, and the spatial area of the site and the RVAAP habitats relative to the home range and foraging areas of the receptors. The spatial boundaries of the ecological EUs are the same as the spatial boundaries of aggregates defined for nature and extent, fate and transport, and the human health risk assessment (Figures 4-1 and 4-2). These proposed EUs are

Terrestrial EUs:

- Water Tower area;
- Buildings CB-3 and CB-801;
- Buildings CB-4, CB-4A, CA-6, CB-6A, and associated settling basins;
- Buildings CB-10 and CB-13 (CB-13A, CB-13B);
- Buildings CB-14, CB-17, and CA-15; and
- Perimeter Area.

Sediment EUs:

- Outlets A and B channels,
- Outlet C channel and Charlie's Pond,
- Outlets D, E, and F channel and Criggy's Pond,
- North Area channel, and
- Off-AOC channel.

Surface Water EUs:

- Outlets A and B channels,
- Outlet C channel and Charlie's Ponds,
- Outlets D, E, and F channels and Criggy's Pond, and
- Off-AOC channel.

The distinction between EUs is based on location and history of the units. Each of the EUs is spatially separated. The exact history of waste applications and spills at each EU is uncertain. This uncertainty regarding waste applications and spills provides further justification for the distinction between the EUs.

7.3.3 Ecological Surveys and Description of Habitats and Populations

This section provides a description of the ecological resources at LL 1. Habitats and plants are discussed in Section 7.3.3.1; animals are discussed in Section 7.3.3.2; aquatic habitats are discussed in Section 7.3.3.3; and protected species are discussed in Section 7.3.3.4.

7.3.3.1 Terrestrial habitats and plant communities

LL 1 occupies a total area of about 465.6 acres (Figure 4-1 and Table 7-1). This area includes forests and woodlands, shrublands, grasslands, wetlands, old railroad beds, paved and unpaved roads, and other bare areas at former building locations that were demolished during the first phase of remediation. The vegetated areas provide habitat for the many plants and animals at the RVAAP. Each of the 10 types of plant communities is briefly described below.

Table 7-1. Plant Communities and Other Habitat Recorded at Load Line 1

Plant Community Type	Acres	% area
Plantations	10.8	2.3
Lowland or submontane deciduous forest	235.7	50.6
Seasonally flooded cold-deciduous forest	55.8	12.0
Dry mid-successional, temperate, cold-deciduous shrubland	45.8	9.8
Semipermanently flooded, cold-deciduous shrubland	2.1	0.5
Medium-tall sod temperate or subpolar grassland	1.6	0.4
Semipermanently flooded, temperate or subpolar grassland	4.1	0.9
Tall temperate or subpolar perennial forb vegetation	54.6	11.7
Permanently flooded temperate or subpolar hydromorphic rooted vegetation	6.2	1.3
Other areas (railroad beds, roads, demolition areas)	48.9	10.5
Total	465.6	100.0

The information contained in the RI is the best available information about wetlands at LL 1. There is no other readily available information that could provide information about the quantity and quality of wetland in the AOC. A wetland assessment would be required to determine the specific quantity and quality of wetlands that may be affected by remedial actions.

Plantations (planted timber stands)

The plantation community is characterized by nearly pure stands of eastern white pine (*Pinus strobus*), which is usually planted in rows. The forest canopy is closed, and very little herbaceous vegetation is present on the forest floor. This community is a relatively minor component of the RVAAP forests. This community occurs in a very small area of the LL 1 AOC covering ~10.8 acres, or 2.3% of the total area of LL 1 (Table 7-1).

Lowland or submontane cold-deciduous forest, Acer rubrum successional forest

This transitional forest community is very common at RVAAP. It is characterized by a high abundance of red maple (*Acer rubrum*) often in nearly pure stands. Green ash (*Fraxinus pennsylvanica*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), and sugar maple (*Acer saccharum*) often are present but never are dominant. In some cases, the canopy is very dense, and little to no ground cover is present. In other cases, the canopy is somewhat open, and old field species such as blackberry (*Rubus allegheniensis*), goldenrod (*Solidago* spp.), dogbane (*Apocynum cannabinum*), and self-heal or heal-all (*Prunella vulgaris*) form a dense herbaceous layer. In general, stand age is fairly even. This forest type makes up ~235.7 acres, or 50.6% of LL 1 (Table 7-1).

Seasonally flooded cold-deciduous forest, Quercus palustris – (Quercus bicolor) seasonally flooded forest alliance

This forest alliance is characterized by species tolerant of seasonally saturated or inundated conditions. Standing water (e.g., vernal pools) is often present in the spring and early summer. By late summer and fall, these areas generally are dry. Pin oak (*Quercus palustris*), swamp white oak (*Quercus bicolor*), and red maple (*Acer rubrum*) are the dominant tree species. American elm (*Ulmus americana*) is frequently present in the understory. The shrub and herbaceous layers frequently consist of northern arrowwood (*Viburnum recognitum*), spicebush (*Lindera benzoin*), jack-in-the-pulpit (*Arisaema triphyllum*), skunk cabbage (*Symplocarpus foetidus*), marsh marigold (*Caltha palustris*), and sedge species (*Carex* spp.). This alliance is present over large areas in the eastern portion of RVAAP. Note that much of the forest south of Smalley Road is younger than the forest to the north. This forest type makes up ~55.8 acres, or 12.0% of LL 1 (Table 7-1).

Dry, mid-successional, temperate, cold-deciduous shrubland

The dry, mid-successional, temperate, cold-deciduous shrubland community describes a plant grouping at RVAAP that is frequently encountered in previously disturbed areas (e.g., former agricultural fields and other disturbed areas) that have had sufficient recovery time for invasion by shrub species. This community is present throughout RVAAP and covers large (> 10 acres) as well smaller areas (< 1 acre). It is characterized by shrub species covering more than 50% of the area with relatively few large trees (> 7 m or ~20 ft in height). Common shrub species include gray dogwood (*Cornus racemosa*), northern arrowwood (*Viburnum recognitum*), blackberry (*Rubus allegheniensis*), hawthorn (*Crataegus* spp.), and multiflora rose (*Rosa multiflora*). Typical pioneer tree species include red maple (*Acer rubrum*), wild black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), and black locust (*Robinia pseudoacacia*). A dense herbaceous community is present with common species such as goldenrod (*Solidago* spp.), dogbane (*Apocynum cannabinum*), self-heal or heal-all (*Prunella vulgaris*), yarrow (*Achillea millefolium*), strawberry (*Fragaria virginiana*), black-eyed Susan (*Rudbeckia hirta*), sheep sorrel (*Rumex acetosella*), and fescue grasses (*Festuca* spp., mostly *Festuca arundinacea*). This community is also commonly referred to as an "Old Field Community." This shrubland formation makes up ~45.8 acres, or 9.8% of LL 1 (Table 7-1).

Semipermanently flooded, cold-deciduous shrubland, Cephalanthus occidentalis semipermanently flooded shrubland alliance

This shrub swamp alliance is dominated by woody species including buttonbush (*Cephalanthus occidentalis*), winterberry (*Ilex verticillata*), swamp rose (*Rosa palustris*), common elder (*Sambucus* *canadensis*), northern arrowwood (*Viburnum recognitum*), willows (*Salix* spp.), and dogwoods (*Cornus* spp.). Pin oak (*Quercus palustris*) and red maple (*Acer rubrum*) are found in less inundated border areas. Herbaceous species include false nettle (*Boehmeria cylindrica*), mad-dog skullcap (*Scutellaria laterifolia*), water parsnip (*Sium suave*), beggar-ticks (*Bidens* spp.), manna grass (*Glyceria* spp.), sedges (*Carex* spp.), cinnamon fern (*Osmunda cinnamomea*), rice cut-grass (*Leersia oryzoides*), and smartweeds (*Polygonum* spp.). Floating aquatics, such as duckweed (*Lemna* spp.), are common in deepwater areas. In addition, *Sphagnum* hummocks occasionally grow around shrub stem-bases. This alliance occupies shallow water areas (e.g., depressions, ponds, floodplains) throughout the eastern United States. In some environments, it is a dense shrub-thicket, and in others it is open shrubland with open water areas. This shrubland formation makes up ~2.1 acres, or 0.5% of LL 1 (Table 7-1).

Medium-tall sod temperate or subpolar grassland, maintained grassland

This community refers to areas at RVAAP that were seeded with grass in the past and are currently maintained in a grassland condition through periodic mowing. This community is generally not located near buildings and is not part of the lawns associated with landscaping around buildings. This grassland formation makes up ~1.6 acres, or 0.4% of LL 1 (Table 7-1).

Semipermanently flooded temperate or subpolar grassland, Typha (angustifolia, latifolia) - (Scirpus spp.) semipermanently flooded herbaceous alliance

The cattail marsh alliance occurs along pond edges, roadside ditches, and shallow basins and is very common throughout the United States. The alliance is dominated by pure stands of narrow-leaf (*Typha angustifolia*) and broad-leaf (*Typha latifolia*) cattails. Sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), and broad-leaf hydrophytic herbs also are common. Saturated or inundated conditions prevail during much of the growing season. This grassland formation makes up ~4.1 acres, or 0.9% of LL 1 (Table 7-1).

Tall temperate or subpolar perennial forb vegetation, dry early successional herbaceous field

This community describes a frequent plant grouping at RVAAP that is present in recently disturbed areas that have not had sufficient recovery time for significant invasion by shrub species. It is characterized by a dense herbaceous community, with common species including goldenrod (*Solidago* spp.), clasping-leaf dogbane (*Apocynum cannabinum*), self-heal or heal-all (*Prunella vulgaris*), yarrow (*Achillea millefolium*), strawberry (*Fragaria virginiana*), black-eyed Susan (*Rudbeckia hirta*), sheep sorrel (*Rumex acetosella*), and fescue grasses (*Festuca* spp., mostly *Festuca arundinacea*). Young shrubs frequently are present but cover less than 50% of the area. Trees are rare. Common shrub species include gray dogwood (*Cornus racemosa*), northern arrowwood (*Viburnum recognitum*), blackberry (*Rubus allegheniensis*), and multiflora rose (*Rosa multiflora*). This herbaceous formation makes up ~54.6 acres, or 11.7% of LL 1 (Table 7-1).

Permanently flooded temperate or subpolar hydromorphic rooted vegetation, Nuphar lutea – Nymphaea odorata permanently flooded herbaceous alliance

This alliance occurs in permanently flooded areas such as shallow ponds or lakes with depths generally less than 0.5 m. Hydromorphic-rooted plants, such as spatterdock (*Nuphar lutea*) and white water lily (*Nymphaea odorata*), dominate the community. At RVAAP ponds, spatterdock is much more common than white water lily. Duckweed species (*Lemna* spp.) and pondweed species (*Potamogeton* spp.) also are common. Criggy's Pond is an example of this alliance. This formation makes up ~6.2 acres, or 1.3% of LL 1 (Table 7-1).

Other areas

Old railroad lines, roads (paved and unpaved), and former building sites represent areas currently devoid of vegetation that exist within LL 1. These areas occupy a total of 48.9 acres, or 10.5% of LL 1 (Table 7-1).

Sensitive habitats

The Ohio Department of Natural Resources (ODNR) and the U.S. Fish and Wildlife Service (USFWS) did not identify any sensitive habitats on or near the LL 1 during their natural heritage data searches.

7.3.3.2 Animal populations

The plant communities at RVAAP and LL 1 provide habitat that supports many species of animals. Studies conducted at RVAAP in 1992 and 1993 by the ODNR, Division of Natural Areas and Preserves, identified numerous animal species on the arsenal property (ODNR 1993). ODNR biologists conducted surveys at the site specifically for mammals, birds, reptiles and amphibians, fish, crayfish, mussels and clams, aquatic and terrestrial snails, damselflies and dragonflies, and moths and butterflies. Results of the ODNR surveys included 27 mammals, 154 birds, 12 reptiles and 19 amphibians, 47 fish (including 6 hybrids), 4 crayfish, 17 mussels and clams, 11 aquatic snails, 26 terrestrial snails, 37 damselflies and dragonflies, 58 butterflies, and 485 moths. Several game species are managed through hunts scheduled during the fall months.

7.3.3.3 Aquatic habitats

A total of five drainage ditch channels, four of which were located within the LL 1 boundary (Outlets A and B channel, Outlet C channel, Outlets D/E/F channel, and North Area channel) and one off-AOC channel, were located approximately 3,000 ft to the northeast of LL 1's northern boundary. The approximate lengths of these drainage ditch channels are as follows: Outlet A channel (0.286 miles), Outlet C channel and Charlie's Pond (0.677 miles), Outlets D/E/F channel and Criggy's Pond (1.67 miles), North Area channel (0.13 miles), and off-AOC channel (2.09 miles).

The four drainage ditches on LL 1 receive storm water runoff from surrounding areas as well as from LL 1. The off-AOC channel receives no runoff or inputs from LL 1 and is the only channel that contains water year-round. The other permanent water is found in Criggy's Pond. Intermittent or ephemeral water is found in the other pond as well as in the two other channels: Outlet A channel and Outlet C channel. Water was not obtained from the two short channels: North Area channel and Outlets D/E/F channels. Riparian vegetation is most pronounced in two places: Outlet C channel and Charlie's Pond and the off-AOC channel.

The drainage aggregates for Outlets D/E/F and Criggy's Pond will also be evaluated as part of the facility surface water investigation. The facility surface water investigation is intended to systematically document the presence/absence of Ravenna site-specific contaminants at specific locations and any movement of those contaminants from AOCs to other locations, including off-site.

Other aquatic habitats

Two ponds are present on LL 1: Criggy's Pond and Charlie's Pond. Outlet C channel flows into Charlie's Pond. Outflow from Charlie's Pond flows via Outlet C channel into Criggy's Pond. Criggy's Pond is located along the eastern border of LL 1 and is the larger of the two ponds. Criggy's Pond is approximately 4.695 acres, whereas Charlie's Pond is only about 0.0988 acre.

7.3.3.4 Threatened and endangered species

The relative isolation and protection of habitat at RVAAP has created an important area of refuge for a number of plant and animal species considered rare by the state of Ohio. To date, 54 state-listed species are confirmed to be on the RVAAP property (see Appendix R, Table R-1). There are no federal-listed plants or animals currently known to occur at RVAAP. In addition to the state-listed species, there are five rare plant communities and/or significant natural areas and three other biological items of interest (turkey vulture roosts, great blue heron roosts, and flocks of wild turkeys). In the risk assessment, the common barn owl (*Tyto alba*) was selected to represent not only the common top trophic level in the terrestrial food chain, but also T&E organisms. This information was obtained by OHARNG 2001b, who maintains the files of correspondence with USFWS and the National Hertiage Program regarding the preence of T&E species at such places as LL11.

Special Interest Unit 4 covers approximately 145 acres within the LL I AOC (OHARNG 2001a). This Special Interest Unit includes all or parts of Forest Compartment 7 (specifically cutting units 7-A3, 7-D3, 7-E3, and 7-G3). Plant communities include a sphagnum thicket, oak-maple swamp forest, mixed swamp forest, dry fields, buttonbush swamp, wet meadows, cat-tail marsh, a pond, and seeps.

State-listed plant species in Special Interest Unit 4 include weak sedge *(Carex debilis* var. *debilis),* straw sedge *(Carex straminea),* round-leaved sundew *(Drosera rotundifolia),* simple willow-herb *(Epilobium strictum),* tall St. John's wort *(Hypericum majus),* blunt mountain-mint *(Pycnanthemum muticum),* and large cranberry *(Vaccinium macrocarpon)* (OHARNG 2001a). Other noteworthy plant species include ridged yellow flax *(Linum striatum)* and little ladies'-tresses *(Spiranthes tuberosa).* The only state-listed animal species in Special Interest Unit 4 is a moth, the graceful underwing *(Catocala gracilis).*

Special Interest Unit 4 was not designated by Andreas (1993) as an important natural area, but it has a large number of rare plants and a mature stand of mixed swamp forest (OHARNG 2001a). One of the most diverse communities in the Arsenal is the scalped field on either side of B & O Wye Road. The scalped field was severely disturbed during the construction of roads in the Arsenal. Special Interest Unit 4 supports at least 140 species of plants including 5 that are state listed. Several species were found here and nowhere else in the Arsenal. The seeps and swales support many wetland plants, including round-leaved sundew *(D. rotundifolia)* and large cranberry *(V. macrocarpon).* Sphagnum moss is common near B & O Wye Road, forming a bog-like habitat.

A mixed swamp forest community occurs at the southeastern end of the Special Interest Unit 4 (OHARNG 2001a). Pin oak *(Quercus palustris)* is the dominant oak but fair amounts of swamp white oak *(Quercus bicolor)* and some northern red oak *(Quercus rubra)* occur in these woods. Some large beech *(Fagus grandifolia)* are here as well. Buttonbush *(Cephalanthus occidentalis)* occurs in the swales and forms small pockets of buttonbush swamps. The canopy, subcanopy, shrub, and herbaceous layers are well represented in this community. The potentially threatened straw sedge *(carex straminea)* occurs at the southern end of the swamp forest. A powerline right-of-way crosses the northern part of the forest. The potentially threatened species, weak sedge *(Carex debilis* var. *debilis)* and blunt mountain-mint *(Pycnanthemum miticum)* occur along this powerline right-of-way.

Criggy's Pond has younger swamp woods around it (OHARNG 2001a). The pond itself has many species commonly found in swamps along its edge. Blunt mountain-mint grows in this swampy edge. The carnivorous aquatic plant, greater bladderwort *(Utricularia vulgaris),* is frequent in the pond. Schneider (1993) reported pointed water-meal *(Wolffia papulifera),* an uncommon species, to occur in this pond.

7.3.4 Identification of Preliminary Constituents of Potential Ecological Concern

The identification of preliminary COPECs began with the SRCs that were identified using the background and frequency of detection/weight of evidence screens described in Chapter 4.0. This pre-screening entailed comparing the EU-specific maximum concentrations against ecological screening values (ESVs) specified by Ohio EPA for protection of generic life. The pre-screening step is described in more detail below.

The results of analysis of environmental media samples were organized and evaluated by EU. Analytes that were not detected (i.e., were less than analytical blank concentrations and/or method detection limits) were dropped in Section 4.0. More specifically, an analyte must have been detected in more than 5% of the samples. Additionally, a background screen was conducted, as explained in Section 4.0. Regarding blanks, the maximum sample concentration must be more than 10 times the highest blank concentration for all common laboratory contaminants (e.g., acetone, 2-butanone, methylene chloride, toluene, and the phthalates) or 5 times the highest blank concentration for other chemical constituents. Inorganic constituents that are considered essential nutrients were retained for further assessment.

Chapter 4.0 presents the list of constituents detected in surface soil, sediment, and surface water at LL 1, along with an indication of whether they were retained for further evaluation. Detected analytes from the background and frequency of detection/weight of evidence screens (Chapter 4.0) were identified as SRCs and were carried forward to the pre-screening step of the COPEC screening process, which was EU-specific, by media, using maximum detected concentrations and ESVs for protection of generic life.

Regarding EU-specific ESV screens, screening values for soil have been identified. The soil screening values are different than those presented in the Final SAP (SAIC 2000) because Ohio EPA provided a new set of screening values, which are now published in the Final Technical Memorandum (SAIC 2001). Ohio EPA's preferences (Ohio EPA 2001) are, in order of preference, Efroymson et al. (1997a) preliminary remediation goals; Efroymson et al. (1997b) plant soil screening values; Efroymson et al. (1997c) soil invertebrate and microorganism soil screening values; followed by the Ecological Data Quality Levels (EDQLs) values from EPA Region 5 (EPA 1998b). These can be found in Appendix S, Table S-1.

The sediment screening values are different than those presented in the Final SAP (SAIC 2000) because Ohio EPA provided a new set of screening values, which are now published in the Final Technical Memorandum (SAIC 2001). Ohio EPA's preferences are, in order of preference, MacDonald et al. (2000) and ecotox thresholds Region 5 (EPA 1998b). The preferred sediment ESVs are provided in Appendix S, Table S-2.

The surface water screening values are different than those presented in the Final SAP (SAIC 2000) because Ohio EPA provided a new set of values, which are now published in the Final Technical Memorandum (SAIC 2001). Ohio EPA's preferences are, in order of preference: State Water Quality Standards, as given in Chapters 3745-1 and 3745-2 of the Ohio Administrative Code (OAC) for the Lake Erie Basin (Ohio EPA 1999); EPA National Ambient Water Quality Criteria (NAWQC) (EPA 1999), or EPA Tier II values as compiled by Suter and Tsao (1996); and EDQLs from EPA Region 5 (EPA 1998b). An Ohio State Water Quality Standard is always the first choice value if one is published for a given analyte because it represents a codified standard. If an analyte does not have an Ohio Water Quality Standard published in Chapter 3745-1 of the OAC, the next preferred value to use as an ESV is an EPA NAWQC, etc., as described in the preceding hierarchy. The preferred surface water ESVs have been provided in Appendix S, Table S-3. Note that for some analytes the preferred ESV is actually from the Ohio Administrative Code.

Another criterion for identifying preliminary COPECs was whether the SRCs were considered persistent, bioaccumulative, and toxic (PBT) compounds. The PBT compounds were inorganic SRCs whose maximum bioaccumulation factor (BAF) was greater than 2, or organic SRCs whose log octanol-water partition coefficient (K_{ow}) was greater than 4.

The EU maximum concentrations were compared to the preferred ESVs, and constituents that exceeded ESVs, as well as those with no ESVs, were considered preliminary COPECs and were retained for further analysis on EU-by-EU and receptor-by-receptor bases to determine whether they qualified to be COPECs. In addition, PBT compounds were identified and considered preliminary COPECs, inorganic SRCs with bioaccumulation factors greater than 2, and organic SRCs with log K_{ow}. The results of EU-specific pre-screening against toxicity screening values are presented in Appendix S, Tables S-5 through S-10 for soil, S-11 through S-15 for sediment, and S-16 through S-18 for surface water. Constituents that were retained for further evaluation after the EU-specific toxicity pre-screens, along with the locations at which they occurred, are summarized in Tables 7-2 (soil), 7-3 (sediment), and 7-4 (surface water).

Analytes whose EU-specific maximum concentrations exceeded the Ohio EPA ESVs and/or had no ESVs were called "analytes exceeding the EU-specific ESV screening," or preliminary COPECs, and were retained for further analysis in the EU-specific screens with specific ecological receptors to identify the COPECs. This next or second screen was called the receptor-specific screen and is presented in Section 7.6. The receptor-specific screens used the EU-specific RMEs instead of EU-specific maxima, and they used receptor-specific TRVs instead of Ohio EPA ESVs. The TRVs are published NOAELs whenever available to ensure conservatism of the screening. For wildlife receptors, dietary exposure concentrations were calculated. Section 7.4 describes the details of the exposure models and assumptions. Section 7.5 describes the effects evaluations, and Section 7.6 describes the risk characterization to identify the COPECs for each medium and receptor.

7.3.5 Ecological Assessment and Measurement Endpoints

The exposed ecological receptors for the ERA were selected from animal species found in terrestrial/aquatic habitats. Three criteria, listed below, were used to select the ecological receptors:

- Ecological relevance means that the receptor has or represents a role in energy flow (e.g., plants), nutrient cycling (e.g., earthworms), or population regulation (e.g., owls).

- Susceptibility means that the receptor is known to be present, sensitive to constituents (e.g., robins), and through ingestion from food of preference is high (e.g., mink and great blue herons).

- Management goals include sustaining ecosystems and ecological processes while maintaining the central mission of LL 1, which is to train troops.

For LL 1, the ecological receptors include terrestrial plants, earthworms, deer mice, white-tailed deer, short-tailed shrews, American robins, red foxes, barn owls, sediment-dwelling organisms, aquatic organisms, mallard ducks (Outlet C channel and Ponds only), mink, and great blue herons. Risks were quantitatively estimated for each receptor. Figure 7-2 shows the terrestrial food chain for the terrestrial receptors. Figure 7-3 shows the aquatic food chain for the aquatic receptors.

Table 7-2. Summary of Analytes to be Carried Forward to the Receptor-Specific Screening for Identification of Soil COPECs

Site-Related Chemicals (SRCs)	Water Tower	CB-3 and CB-801	CB-4/4A and CA-6/6A	CB-13 and CB-10	CB-14, CB-17, and CA-15	Perimeter Area
Inorganics						
Aluminum	--	X	X	X	X	X
Antimony	--	X	--	X	--	--
Arsenic	--	X	X	X	X	X
Barium	--	X	X	X	X	--
Beryllium	--	--	--	--	--	--
Cadmium	X	X	X	X	X	X
Calcium	--	X	X	X	X	X
Chromium	X	X	X	X	X	X
Cobalt	--	X	X	X	X	X
Copper	--	--	X	X	X	--
Cyanide	--	--	X	--	X	X
Iron	X	X	X	X	X	X
Lead	X	X	X	X	X	X
Magnesium	--	X	X	X	X	X
Manganese	--	X	X	X	X	X
Mercury	X	X	X	X	X	X
Nickel	X	X	X	X	X	--
Potassium	X	X	X	X	X	X
Selenium	--	Y	X	X	--	X
Silver	--	--	--	--	--	
Sodium	--	X	X	X	X	--
Thallium	--	--	X	--	X	--
Vanadium	--	--	X	X	X	X
Zinc	X	X	X	X	X	X
Volatile Organic Compounds (VOCs)						
Acetone	--	--	X	X	--	--
1,2-Dichloroethene (total)	--	--	--	--	--	--
Methylene chloride	--	X	X	X	X	--
Phenol	--	--	--	--	--	--
Toluene	--	--	--	--	--	--
Semivolatile Organic Compounds (SVOCs)						
Acenaphthene	--	--	--	--	--	--
Anthracene	--	X	X	X	X	--
Benzo(a)anthracene	--	X	X	X	X	--
Benzo(a)pyrene	--	X	X	X	X	--
Benzo(b)fluoranthene	--	X	X	X	X	X
Benzo(g,h,i)perylene	--	X	X	X	X	--
Benzo(k)fluoranthene	--	X	X	X	X	--
bis(2-Ethylhexyl)phthalate	--	X	X	--	X	--
Butylbenzylphthalate	--	--	X	--	--	--

Table 7-2. Summary of Analytes to be Carried Forward to the Receptor-Specific Screening for Identification of Soil COPECs (continued)

Site-Related Chemicals (SRCs)	Water Tower	CB-3 and CB-801	CB-4/4A and CA-6/6A	CB-13 and CB-10	CB-14, CB-17, and CA-15	Perimeter Area
Carbazole	--	X	X	X	X	--
Chrysene	--	X	X	X	X	--
Dibenzo(a,h)anthracene	--	--	--	--	X	--
Dibenzofuran	--	X	X	--	X	--
Di-n-butylphthalate	--	X	--	--	X	--
Fluoranthene	--	X	X	X	X	X
Fluorene	--	X	X	X	X	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	--	--
2-Methylnaphthalene	--	--	--	--	--	--
Naphthalene	--	--	--	--	--	--
Pentachlorophenol	--	X	--	--	--	--
Phenanthrene	--	X	X	X	X	--
Pyrene	--	X	X	X	X	--
Trichloroethene	--	--	--	--	--	--
Pesticides/Polychlorinated Biphenyls						
Aroclor-1016	--	--	X	--	--	--
Arochlor-1254	--	X	X	X	X	--
Alpha-chlordane	--	--	X	--	X	--
Beta-BHC	--	X	X	--	--	--
4,4'-DDE	--	X	X	X	X	--
4,4'-DDT	--	X	X	X		--
Dieldrin	--	X	X	--	--	--
Endrin ketone	--	X	X	--	X	--
Endrin aldehyde	--	X	X	X	X	--
gamma-Chlordane	--	X	X	X	X	--
Heptachlor	--	--	X	X	--	--
Heptachlor Epoxide	--	--	X	--	--	--
Methoxychlor	--	X	X	--	X	--
Explosives						
4-Amino-2,6-dinitrotoluene	--	X	X	--	X	--
2-Amino-4,6-dinitrotoluene	--	X	X	--	--	--
1,3-Dinitrobenzene	--	--	X	--	--	--
2,4-Dinitrotoluene	--	--	--	X	--	--
2,6-Dinitrotoluene	--	--	X	X	--	--
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	--	--	X	X	X	--
Nitrobenzene	--	--	--	--	--	--
Nitrocellulose	--	X	X	X	X	--
Nitroglycerin	--	--	X	--	--	--
Nitroguanidine	--	--	X	--	--	--
3-Nitrotoluene	--	X	X	--	--	--
2-Nitrotoluene	--	X	X	--	--	--
4-Nitrotoluene	--	--	X	X	--	--

Table 7-2. Summary of Analytes to be Carried Forward to the Receptor-Specific Screening for Identification of Soil COPECs (continued)

Site-Related Chemicals (SRCs)	Water Tower	CB-3 and CB-801	CB-4/4A and CA-6/6A	CB-13 and CB-10	CB-14, CB-17, and CA-15	Perimeter Area
RDX (cyclonite or Hexahydro-1,3,5-trinitro-1,3,5-triazine)	--	X	X	X	X	--
1,3,5-Trinitrobenzene	--	--	X	--	--	--
2,4,6-Trinitrotoluene	--	X	X	X	X	--

COPEC = chemical of potential ecological concern.
X = analyte is carried forward to receptor-specific screen.
-- = analyte is not carried forward to receptor screen.

Table 7-3. Summary of Analytes to be Carried Forward to the Receptor-Specific Screening for Identification of Sediment COPECs

Site-Related Chemicals (SRCs)	Outlets A and B Channel	Outlet C Channel and Charlie's Pond	Outlets D, E, and F Channel and Criggy's Pond	North Area Channel	Off-AOC
Inorganics					
Aluminum	X	--	--	--	--
Antimony	X	X	X	--	--
Arsenic	X	X	X	--	X
Barium	X	X	X	X	--
Beryllium	X	X	X	X	X
Cadmium	X	X	X	X	X
Calcium	X	X	X	X	X
Chromium	X	--	X	--	--
Chromium, hexavalent	X	--	X	--	--
Cobalt	--	--	--	--	--
Copper	X	--	X	--	X
Iron	X	X	X	X	X
Lead	X	X	X	X	--
Magnesium	X	X	X	X	X
Manganese	--	X	X	--	--
Mercury	X	X	X	X	X
Nickel	X	X	X	X	X
Potassium	--	X	X	X	X
Selenium	X	X	X	--	X
Sodium	X	X	X	--	--
Thallium	X	--	--	--	--
Vanadium	X	--	X	--	X
Zinc	X	--	X	--	--
Organics					
Acenaphthene	X	--	--	--	--
Acetone	--	--	--	--	--
Anthracene	X	--	--	--	--
4-Amino-2,6-dinitrotoluene	X	X	--	--	X
2-Amino-4,6-dinitrotoluene	X	X	--	--	--
PCB-1254	X	X	--	--	--
Benzo(a)anthracene	X	X	--	--	--
Benzo(a)pyrene	X	X	--	--	--
Benzo(b)fluoranthene	X	X	--	--	--
Benzo(g,h,i)perylene	X	X	--	--	--
Benzo(k)fluoranthene	X	X	--	--	--
2-Butanone	--	--	--	--	--
Carbazole	X	--	--	--	--
Chrysene	X	X	--	--	--
Dibenzofuran	X	--	--	--	--
Dibenzo(a,h)anthracene	X	--	--	--	--
Di-n-butylphthalate	X	--	--	--	--
4,4'-DDE	--	X	--	--	--
1,2-Dichloroethene (total)	X	X	--	--	--
1,3-Dinitrobenzene	--	--	--	--	X
2,4-Dinitrotoluene	X	--	--	--	--

Table 7-3. Summary of Analytes to be Carried Forward to the Receptor-Specific Screening for Identification of Sediment COPECs (continued)

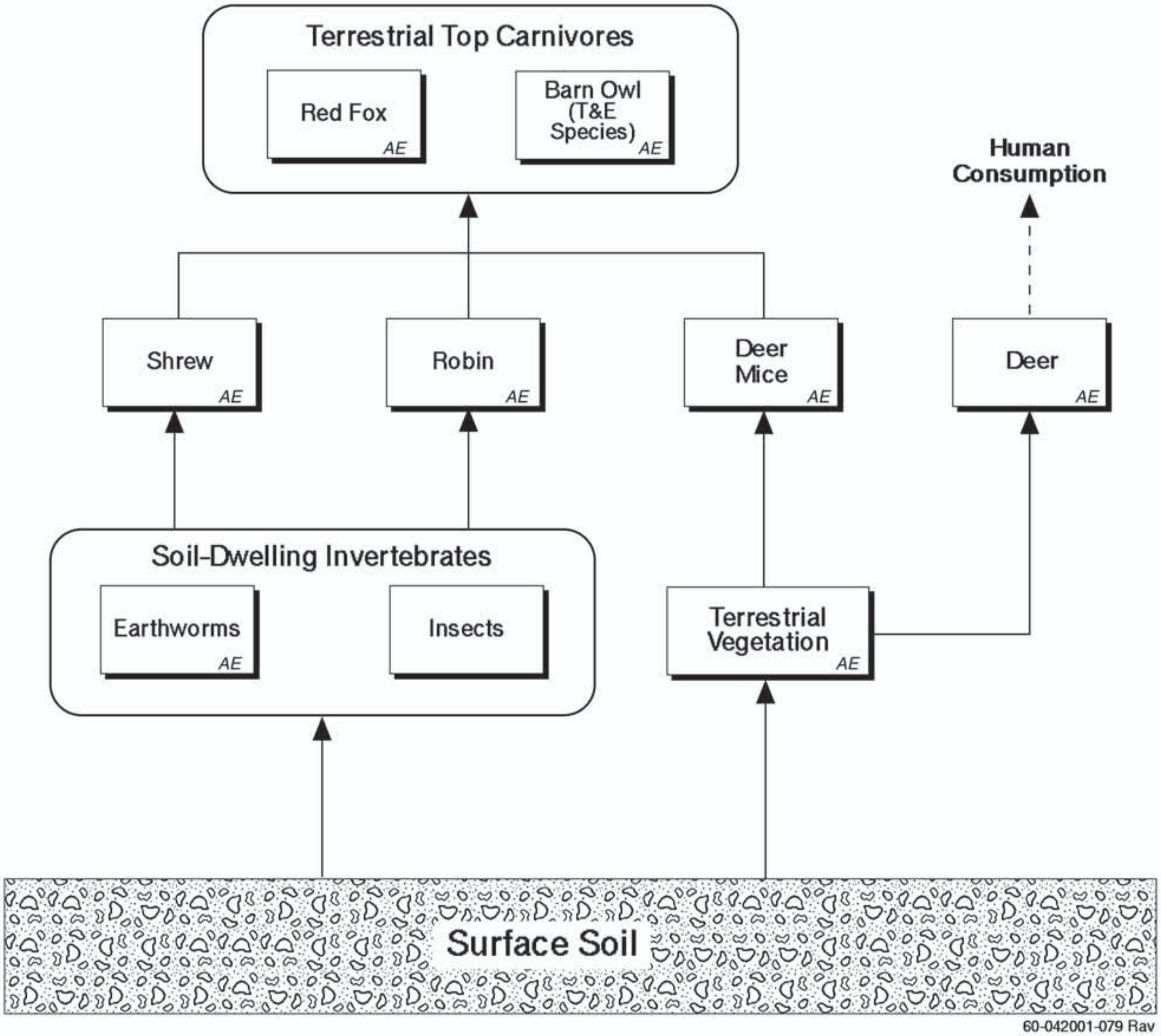
Site-Related Chemicals (SRCs)	Outlets A and B Channel	Outlet C Channel and Charlie's Pond	Outlets D, E, and F Channel and Criggy's Pond	North Area Channel	Off-AOC
2,6-Dinitrotoluene	X	X	--	--	--
Endrin	X	--	--	--	--
Fluoranthene	X	X	--	--	--
Fluorene	X	--	--	--	--
gamma-Chlordane	X	--	--	--	--
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	X	--	--	--	--
Indeno(1,2,3-cd)pyrene	X	--	--	--	--
Naphthalene	X	--	--	--	--
Nitrobenzene	--	--	--	--	--
Nitrocellulose	X	--	--	--	X
Nitroguanidine	--	--	--	--	X
2-Nitrotoluene	X	--	--	--	--
Phenanthrene	X	X	--	--	--
Pyrene	X	X	--	--	--
RDX (cyclonite or Hexahydro-1,3,5-trinitro-1,3,5-triazine)	--	--	--	--	X
Toluene	--	--	--	--	--
Trichloroethene	--	--	--	--	--
1,3,5-Trinitrobenzene	X	--	--	--	--
2,4,6-Trinitrotoluene	X	X	--	--	--

COPEC = chemical of potential ecological concern.
X = analyte is carried forward to receptor-specific screen.
-- = analyte is not carried forward to receptor screen.

Table 7-4. Summary of Analytes to be Carried Forward to the Receptor-Specific Screening for Identification of Surface Water COPECs

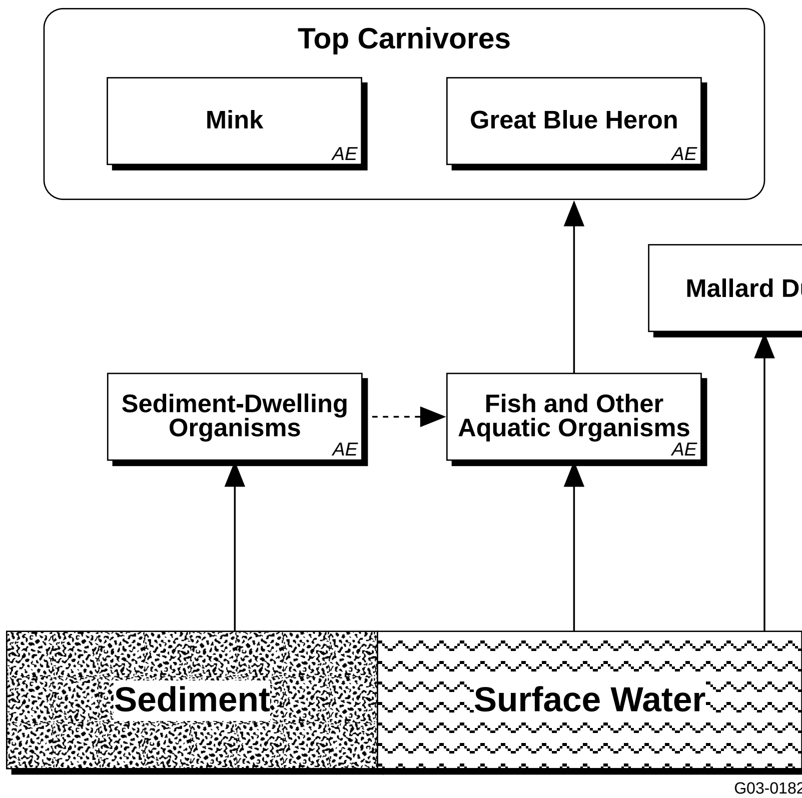
Site-Related Chemicals (SRCs)	Outlets D, E, and F Channel and Criggy's Pond	Outlet C Channel and Charlie's Pond	Off-AOC
Inorganics			
Arsenic	--	--	--
Barium	--	--	--
Cadmium	--	--	--
Calcium	X	X	X
Chromium	--	--	--
Chromium, hexavalent	--	--	--
Cobalt	--	--	--
Iron	--	X	X
Lead	--	X	X
Magnesium	X	X	X
Manganese	--	--	X
Mercury	--	--	--
Potassium	X	X	X
Nickel	--	--	--
Sodium	X	X	X
Vanadium	--	--	--
Zinc	--	--	X
Semivolatile Organic Compounds (SVOCs)			
Bis(2-ethylhexyl)phthalate	--	--	X
Explosives			
4-Amino-2,6-dinitrotoluene	--	--	X
2-Amino-4,6-dinitrotoluene	--	--	X
1,3-Dinitrobenzene	--	--	--
2,4-Dinitrotoluene	--	--	--
2,6-Dinitrotoluene	--	--	--
2-Nitrotoluene	--	--	X
3-Nitrotoluene	--	X	X
4-Nitrotoluene	--	--	X
RDX (cyclonite) Hexahydro-1,3,5-trinitro-1,3,5-triazine	--	--	X
Tetryl	--	--	X
1,3,5-Trinitrobenzene	--	--	--
2,4,6-Trinitrotoluene	--	--	X

COPEC = chemical of potential ecological concern.
X = analyte is carried forward to receptor-specific screen.
-- = analyte is not carried forward to receptor screen.



AE = assessment endpoint; organisms with no AE in box means they are intermediate in terms of transfers.

Figure 7-2. Terrestrial Food Web for Ecological Risk Assessment for Load Line 1



AE = assessment endpoint; organisms with no AE in box means they are intermediate in terms of transfers.

Figure 7-3. Aquatic Food Web for Ecological Risk Assessment for Load Line 1

The protection of ecological resources, such as the species of plants and animals and habitats described in Section 7.3.3, is mandated by a variety of legislation and government agency policies [e.g., CERCLA, RCRA, and the National Environmental Policy Act (NEPA)]. Through these laws, protection goals are established by legislation or agency policy. To determine whether a protection goal has been met, assessment and measurement endpoints were formulated.

An assessment endpoint is defined by the EPA (1992e) as "an explicit expression of the environmental value that is to be protected." A measurement endpoint is defined by the EPA (1993c) as a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint. Assessment endpoints are ecological resources that are expressed as ratios that, if they exceed 1 or unity, suggest the need for further examination. The ratios compare an exposure concentration (estimated from a measured concentration in a medium) and an effects concentration (e.g., the toxicity threshold below which there are no adverse effects). A measurement endpoint means the measurement or concentrations (of a constituent and a toxicity threshold) that are used to define and develop the ratio in the assessment endpoint.

Three policy goals were defined for the LL 1 SERA. Assessment and measurement endpoints are provided with each policy goal (Table 7-5). Policy goals are

- Policy Goal 1: The preservation and conservation of any threatened, endangered, and rare species and their environmentally sensitive or critical habitats.

- Policy Goal 2: The maintenance and protection of terrestrial populations and ecosystems.

- Policy Goal 3: The maintenance and protection of aquatic populations and ecosystems.

The decision rules associated with assessment endpoints for the SERA are stated quantitatively in terms of HQs. A HQ is the ratio of the measured or predicted concentration of an analyte to which receptors are exposed in an environmental medium and the measured concentration of an analyte that adversely affects an organism (benchmark or toxicity reference value) (Barnthouse et al. 1986). If the measured concentration exactly equals or is less than the concentration producing an adverse effect [i.e., the ratio of the two, or the HQ, is less than or equal to 1], the risk is considered acceptable (protective of the ecological receptor). Any HQ greater than 1, e.g., 1.1, indicates that the COPEC qualifies for further investigation of the actual likelihood of harm, i.e., a baseline risk assessment may be needed. The final ecological COCs are selected only after additional evaluation of the conservatism of exposure assumptions, toxicity thresholds, and uncertainties (e.g., background risk).

The next possible step for a BERA would be to use less conservative exposure, e.g., arithmetic mean, and less conservative effects, e.g., LOAELs, compared to SERAs (e.g., 95% UCL and NOAELs). The less conservative BERA would serve to drop the large HQs to smaller ones, but the HQ >1 threshold would prevail. A second part of the BERA is biological measurements. Here, the emphasis is on field-observed effects or ground-truthing of the mathematical predictions of ecological risk from the BERA. The scope of the present work is a SERA. The next step, as previously mentioned, will also be determined by new guidance from the Ohio EPA and an ongoing biological study at WBG (SAIC 2001).

In summary, the HQs >1 will help to focus on which media, which places, which constituents, and which receptors show ecological risk. The proposed direction is not to do more computations, but rather go to the field and look for manifested risk and also to extrapolate new data from WBG to LL 1. Extrapolation means the transfer of knowledge from one situation to another situation. The similarities at WBG and

Table 7-5. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules for Load Line 1

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
Policy Goal 1: The preservation and conservation of T&E species and their critical habitats.	**Assessment Endpoint 1:** Preservation of any state- or federally designated, threatened, or endangered species. Endpoint Species: barn owl.	**Measurement Endpoint 1:** Modeled contaminant concentrations in prey (shrews, robins, and rabbits) based on measured soil concentrations.	**Decision Rule for Assessment Endpoint 1:** If T&E species are not present, or RME concentrations in the media do not contribute to chronic NOAEL exceedance (i.e., HQs <1), then that contaminant alone is unlikely to cause adverse ecological effects, and therefore the T&E species should be preserved (this particular NOAEL will be adjusted by an intraspecies safety factor of 0.1 or 0.33 depending on the chemical as specified by Ohio EPA). If the HQ is >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
Policy Goal 2: The maintenance and protection of terrestrial populations and ecosystems.	**Assessment Endpoint 2:** Maintenance of plant community for erosion control and energy production. Endpoint Species: plants of various species.	**Measurement Endpoint 2:** Measured soil contaminant concentrations.	**Decision Rule for Assessment Endpoint 2:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore the plant populations and communities are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 3: Maintenance of soil-dwelling invertebrate community for nutrient and energy processing. Endpoint Species: earthworms.	**Measurement Endpoint 3:** Measured soil contaminant concentrations.	**Decision Rule for Assessment Endpoint 3:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore the soil invertebrate community is maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.

Table 7-5. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules for Load Line 1 (continued)

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
	Assessment Endpoint 4: Maintenance of populations of herbivorous animals. Endpoint Species: deer mouse and deer.	**Measurement Endpoint 4:** Modeled contaminant concentrations in food chain based on measured soil contaminant concentrations.	**Decision Rule for Assessment Endpoint 4:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore populations of the herbivores (e.g., voles, cottontail rabbits, and deer) are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 5: Maintenance of worm-eating and/or insectivorous animals. Endpoint Species: mammal – shrew; bird – robin.	**Measurement Endpoint 5:** Modeled contaminant concentrations in earthworms and other prey based on measured soil contaminant concentrations.	**Decision Rule for Assessment Endpoint 5:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore populations of worm-eating and/or insectivorous animals are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 6: Maintenance of terrestrial predators. Endpoint Species: mammal – red fox; bird – barn owl from Policy Goal 1 serves as avian predator.	**Measurement Endpoint 6:** Modeled contaminant concentrations in prey (shrews and robins) based on measured soil contaminant concentrations.	**Decision Rule for Assessment Endpoint 6:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore populations of terrestrial predators are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.

Table 7-5. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules for Load Line 1 (continued)

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
Policy Goal 3: The maintenance and protection of aquatic populations and ecosystems.	**Assessment Endpoint 7:** Maintenance of sediment-dwelling organisms. Endpoint Species: sediment-dwelling organisms.	**Measurement Endpoint 7:** Measured sediment contaminant concentrations.	**Decision Rule for Assessment Endpoint 7:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore populations of sediment-dwelling organisms are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 8: Maintenance of aquatic organisms, according to Ohio EPA chemical-specific criteria or, when appropriate, according to biological criteria as specified by Section 3745-1 of the Ohio Administrative Code. Endpoint Species: fish and other aquatic organisms.	**Measurement Endpoint 8:** Measured surface water contaminant concentrations.	**Decision Rule for Assessment Endpoint 8:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore populations of aquatic organisms are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 9: Maintenance of aquatic organism and fish-eating predator population for population regulation. Endpoint Species: mink and great blue heron.	**Measurement Endpoint 9:** Modeled contaminant concentrations in prey fish based on measured surface water concentrations.	**Decision Rule for Assessment Endpoint 9:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore populations of terrestrial predators are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 10: Maintenance of surface-feeding duck population for population regulation. Endpoint Species: mallard duck.	**Measurement Endpoint 10:** Modeled contaminant concentrations in ingested drinking water based on measured surface water concentrations.	**Decision Rule for Assessment Endpoint 10:** If the HQ is <1, then that contaminant alone is unlikely to cause adverse ecological effects, and therefore populations of surface-feeding ducks are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.

HQ = Hazard (risk) quotient.
NOAEL = No observed adverse effects level.
RME = Reasonable maximum exposure.
T&E = Threatened and endangered.

LL 1 and other AOCs at RVAAP increase the success of field-to-field extrapolations. The similarities to be considered include such environmental conditions as soil types, habitats, chemical-use history, and land-use. The USACE and the Ohio EPA are formulating the details for this.

Endpoints stated in terms of specific ecological receptors or exposure classes (groups of species exposed by similar pathways) often require data on the processes that increase or decrease the exposure concentration above or below the measured environmental concentration. Thus, some HQs in the assessment endpoints incorporate exposure factors (e.g., dietary soil fractions and bioaccumulation factors). Exposure factors for ecological receptors are discussed in Section 7.4.2.

Hazard quotients for assessment endpoints 1 through 6 (Table 7-5) were calculated for analytes remaining after the EU-specific ESV screens for soils. Assessment endpoints 7 and 8 deal with sediment and surface water assessment endpoints, respectively, and the HQs were calculated for analytes that remained after the EU-specific ESV screens. Assessment endpoint 9 deals with waterfowl (ducks) that feed on aquatic vegetation exposed to surface water. Assessment endpoint 10 deals with fish-eating terrestrial predators and their exposure to surface water. Assessment endpoint 6 deals with exposure to a raptor and another carnivore species, and assessment endpoint 1 deals with any threatened species.

7.3.6 Summary of Preliminary Constituents of Potential Ecological Concern

Preliminary COPECs are those substances detected in surface soil [from 0 to 0.6 m (0 to 2 ft below land surface], sediment, and surface water at the LL 1 that remain after the pre-screening step and have the potential to pose a hazard or risk to plants and animals. The process of identifying preliminary COPECs began with all constituents detected above background levels (SRCs). SRCs automatically are carried forward to the pre-screening step, which is an EU-specific screen by media with ESVs (which included OAC Water Quality Criteria for water). Analyte maximum concentrations that exceed the media ESV, or analytes without ESVs, or analytes that were PBT compounds are carried forward to the next or second screening step, which is an EU- and receptor-specific screening using EU-specific RMEs and receptor-specific TRVs. This second screening step occurs in the risk characterization (Section 7.6). Analytes whose HQs exceed 1 after the EU- and receptor-specific screens are considered COPECs.

7.4 EXPOSURE ASSESSMENT

Step 2 of EPA's four-step ERA process, as it applies to the SERA for LL 1, is discussed in this section. The exposure assessment describes the receptors, constituent sources, and exposure media. It also examines the route, magnitude, frequency, duration, and spatial pattern of exposure of each receptor population and habitat to a chemical or physical stressor.

7.4.1 Ecological Receptors and Their Exposure

The risk assessment evaluates the potential exposures of ecological receptors to constituents in surface soil, surface water, sediments, and plants and animals ingested by other receptors. The primary receptor categories are subcategorized by exposure classes. Exposure classes group together species with similar feeding habits and physiologies. Each exposure class for sites at LL 1 has one or more species of ecological receptor because of the preliminary nature of the work.

The terrestrial exposure classes and their ecological receptors for the LL 1 investigation are

- vegetation (variety of grasses, forbs, and trees),
- soil-dwelling invertebrates (earthworms),

- mammalian herbivores (deer mice, white-tailed deer),
- worm-eating and/or insectivorous mammals and birds (short-tailed shrews, American robins), and
- terrestrial top predators (red foxes, barn owls).

These receptors or their ecological equivalents are present or likely to be present at LL 1 and were selected in accordance with the EPA Framework (EPA 1992c, 1996c) as explained previously. Information on body weights, diets, and ingestion rates of the receptors has been provided by the EPA (EPA 1993b).

Exposure pathways were chosen to provide a range of potential exposures, including high exposures, to receptors under a variety of conditions. For example, earthworms and shrews constitute a pathway where exposure of small mammals to soil constituents would be maximized. Foxes and owls represent the top of the food web, where exposures from bioaccumulated materials can be maximal. By contrast, herbivores and plants constitute a pathway of lesser chemical exposure. The home ranges of the ecological receptors vary from very small (e.g., <1 m^2 for herbaceous vegetation to more than 590 hectares for the red fox). Receptors with small home ranges would likely receive their entire exposure to contaminants from a single EU, whereas wide-ranging receptors would likely receive exposure from a grouping or cluster of EUs. However, the conservative SERA assumes that receptors that are stationary or have small home ranges (e.g., plants, earthworms, deer mice, shrews, and robins) receive 100% of their exposure at the EUs. However, for receptors with large home ranges (e.g., deer and fox), the amount of exposure from each EU was adjusted to more accurately reflect that receptor's actual exposure based on its home range. This assures comparability of results for risk characterization.

7.4.1.1 Vegetation

Vegetation is composed of grasses, forbs, bushes, and trees of the type growing at LL 1. Vegetation converts sunlight to biomass in the form of roots, stems, leaves, and floral parts. In turn, the plant parts are eaten by herbivores. Vegetation also helps to control soil erosion. There is no parameter table for vegetation because exposure is direct.

7.4.1.2 Soil-dwelling invertebrates

Earthworms and other soil-dwelling invertebrates (lumbricids) are exposed to soil constituents in surface soil by ingestion and direct contact. It is assumed that earthworms ingest only soil and are exposed to the full-measured concentrations. Earthworms have ecological value because of their role in the decomposition of detritus, soil aeration, and soil fertility. Also, earthworms are ingested by worm-eating mammals and birds, and thus any decrease of earthworm populations would reduce the amount of food going to their predators and, in turn, could affect such predators. In addition, contaminated earthworms—both contaminated soil in their guts and contaminated tissue—can contaminate and affect their mammal and bird predators. There is no exposure table for soil-dwelling invertebrates because most exposure is direct.

7.4.1.3 Mammalian herbivores

Small- and large-sized herbivores [e.g., deer mice, *Peromyscus maniculatus* (Appendix S, Table S-19) and white-tailed deer, *Odocoileus virginianus* (Appendix S, Table S-20)] are exposed primarily to soil constituents that are in plant material. Exposure by direct contact with soil is assumed to be limited for deer mice and deer. The exposure for deer mice and deer is the sum of absorption from the ingested soil and ingestion of plants. The estimated exposure for this class does not include exposure by direct contact or inhalation. Few data are available for inhalation toxicity or toxicity by direct contact with contaminated soil (or the parameters required to model constituent absorption). Instead, conservative intake or exposure values for soil ingestion and dietary composition are used for these herbivores.

7.4.1.4 Worm-eating and/or insectivorous mammals and birds

Worm-eating and/or insectivorous mammals [e.g., short-tailed shrew, *Blarina brevicauda* (Appendix S, Table S-21), American robin, *Turdus migratorius* (Appendix S, Table S-22)] are primarily exposed by ingestion of potentially contaminated prey (e.g., earthworms, insect larvae, slugs) as well as by ingestion of soil. Worm-eating and/or insectivorous mammals and birds may also be exposed to soil constituents by direct contact and inhalation of VOCs and SVOCs and particulates. Dermal exposure is expected to be negligible, and skin-associated soil that is ingested is included in the estimated daily soil ingestion rate. The soil fraction of their diet includes soil from the intestinal tracts of their prey. For LL 1, the exposure for this class of receptors is the sum of materials absorbed from the soil and from ingested plants and animals. Exposure by direct contact and inhalation will not be evaluated. There are few data on inhalation toxicity or toxicity by direct contact with contaminated soil (or the parameters required to model constituent absorption). Instead, conservative values for soil ingestion and dietary composition will be used for shrews and robins.

7.4.1.5 Terrestrial top predators

Top predators are exposed primarily to analytes that have accumulated in their prey. Terrestrial top predators [e.g., red fox, *Vulpes vulpes* (Appendix S, Table S-23) and barn owl, *Tyto alba* (Appendix S, Table S-24)] feed primarily on terrestrial prey. Some terrestrial predators, such as foxes, also ingest vegetation and may incidentally consume soil; owls do not. Exposure by direct contact and inhalation will not be evaluated for terrestrial top predators because there are few data on inhalation toxicity or toxicity by direct contact with contaminated soil (or the parameters required to model constituent absorption). Instead, conservative values for soil ingestion and dietary composition were used for foxes and owls. The barn owl also represented a T&E species for the SERA.

In short, each receptor listed is directly linked to one of the assessment endpoints and provides an explicit expression of the environmental value to be protected. For example, soil-dwelling invertebrates are listed because the soil invertebrate community is ecologically important, is susceptible to constituents in soil, and is exposed at the site. The soil invertebrate community is essential for decomposition of detritus and for energy and nutrient cycling. Earthworms are probably the most important of the soil invertebrates in promoting soil fertility. They are highly exposed to soil, and toxicity information is available. Therefore, earthworms were chosen as the surrogate species to evaluate risks to the soil invertebrate community. Similarly, worm-eating and/or insectivorous mammals are ecologically important because they help to control the size of the terrestrial invertebrate population that might otherwise damage populations of primary producers, especially plants. They also are susceptible to soil constituents and are exposed at the site. Short-tailed shrews were chosen as surrogate species because they are highly exposed to constituents by their consumption of large quantities of terrestrial invertebrates that are present in the habitats at LL 1. They also ingest soil during feeding, including soil within the bodies of earthworms and other prey. Herbivores, such as deer mice and deer, feed directly on plants. Of course, plants are the basis for the food webs. Foxes and owls complete the food chain and represent predators, which eat small mammals and birds and which may bioaccumulate constituents.

7.4.1.6 Aquatic exposure classes and receptors

The aquatic exposure classes and their ecological receptors in the five sediment/surface water EUs on the LL 1 are

- sediment-dwelling organisms, which include worms, clams, and crayfish depending on the water body;
- fish and aquatic animals, which include such organisms as omnivores (caddisflies and may flies, minnows), predators (crayfish), mussels, and sediment-ingesting fish;

- surface-feeding ducks (mallard duck at Outlet C channel and Charlie's Pond, as well as Outlets D, E, and F channel and Criggy's Pond); and

- terrestrial top predators of aquatic organisms (mink and great blue herons).

Sediment-Dwelling Invertebrates. Sediment-dwelling invertebrates (e.g., crayfish) are assumed to be exposed to sediment and sediment pore water by multiple routes. The toxicity threshold concentrations for analytes in sediment for the LL 1 SERA are based on all exposure routes from sediment to sediment-dwelling invertebrates. Thus, the measured analyte concentrations in sediment are used as the estimated exposure concentrations for sediment-dwelling invertebrates.

Fish and Aquatic Animals. Fish and aquatic animals are exposed primarily to constituents in surface water and in the food they ingest. The exposure concentration for these animals is assumed to be equal to the measured environmental concentration because the aquatic toxicity thresholds used are expected to protect aquatic life from all exposure pathways, including ingestion of contaminated plants and animals. It is assumed that all aquatic animals (omnivores, predators, and sediment-ingesting fish) are exposed to the full concentration in surface water by direct contact and all other pathways. Although sediment-ingesting fish are exposed to constituents in both sediment and surface water, there are no known dietary toxicity data for such fish. Therefore, the exposure of sediment-ingesting fish is considered together with the other aquatic animals, and no exposure specific to sediment ingestion is calculated for these receptors.

Top Terrestrial Predators of Aquatic Organisms. Top terrestrial predators of aquatic organisms are primarily exposed by ingestion of potentially contaminated animal tissue (e.g., fish and other aquatic biota). Top terrestrial predators of aquatic organisms [e.g., mink, *Mustela vison* (Appendix S, Table S-25) and great blue herons, *Ardea herodias* (Appendix S Table S-26)] may also be exposed to surface water and sediment contaminants by direct contact and ingestion. For the three surface water EUs, the exposure for this class of receptors is the sum of materials absorbed from ingested water and animal tissues. Exposure by direct contact and ingestion of sediment was not evaluated. Exposure by direct contact with surface water and sediment is assumed to be negligible for the top terrestrial predators of aquatic organisms because their dense fur or feathers provide a protective barrier to the skin. There are few data on toxicity by direct contact with contaminated surface water (or the parameters required to model contaminant absorption). Instead, conservative values for dietary composition were used for the mink and great blue heron.

Surface-Feeding Ducks. Surface-feeding ducks are primarily exposed to constituents in surface water via aquatic plants and drinking water that they ingest. Surface-feeding ducks [e.g., mallard ducks, *Anas platyrhynchos* (Appendix S, Table S-27)] may also be exposed to surface water and sediment contaminants by direct contact and ingestion. The exposure for this class of receptors is the sum of materials absorbed from ingested water and plant tissues. Exposure by direct contact and ingestion of sediment was not evaluated because sediment only comprises <2% of the diet of mallards (EPA 1993a). This is discussed further in Section 7.7 (Uncertainties). Exposure by direct contact with surface water and sediment is assumed to be negligible for the surface-feeding ducks because their dense feathers provide a protective barrier to the skin. There are few data on toxicity by direct contact with contaminated surface water (or the parameters required to model contaminant absorption). Instead, conservative values for dietary composition were used for the mallards.

The exposures of these receptor classes to analytes are estimated from the measured concentrations in the soil, sediment, or water and quantified, as described below. Because the mink, heron, and mallard duck have large home ranges, their exposures to the EUs were not assumed to be 100%, but were adjusted to account for their home range relative to the EU size.

7.4.2 Quantification of Exposure

The exposure of an endpoint receptor to a constituent in surface soil at LL 1 was quantified as the average daily dose (ADD) using measured concentrations in the environment and exposure parameters that account for both the transfer of constituents from soil into food and the quantity of food and soil ingested daily. The concentration of a constituent to be used in the exposure calculation is termed the EPC. EPCs are provided in Chapter 4.0 for surface soil, sediment, and surface water. Where the sample size consists of a singular datum or small sample size, the maximum detected concentration was used as the EPC.

Exposure parameters used to derive the ADD for each endpoint receptor for LL 1 are provided in Appendix S, Tables S-19 through S-27 and Table S-33. The quantity of food ingested that is plant matter (I_P), animal matter (I_A), and soil (I_S) is calculated from the total daily rate of food ingestion (IR_F) and the fractions of the diet that are plant matter (PF), animal matter (AF), and soil (SF). Deer mice, deer, shrews, robins, foxes, mallards, and mink are assumed to ingest plant matter, but owls and great blue herons are assumed to have no plant matter in their diets. Robins and foxes are assumed to ingest fruits and berries, whereas deer mice, deer, shrews, duck, and mink ingest mainly vegetative parts of plants. The animal matter component of the diets of shrews and robins is assumed to consist of earthworms because earthworms are more directly exposed to soil constituents than most other animals and because soil-to-earthworm uptake factors are available. A fraction of the mass ingested while eating earthworms is soil inside the worm intestine; this amount is included in the amount of soil ingested daily (I_S).

Constituent-specific transfer factors are provided in Appendix S, Tables S-28 through S-30 of this ERA.

Some ecological receptors obtain only a portion of their diets from the LL 1 EU. Assuming that individuals are distributed randomly and/or forage randomly over their home or foraging ranges, they obtain only a fraction of their diet from an EU that is smaller than their range. The area use factor (AUF) is the ratio of the size of the home or foraging ranges to the size of the EU. AUFs are based on reported foraging or home ranges (Appendix S, Tables S-19 through S-27). As implied above, AUFs would vary from organism to organism. However, site-specific AUFs were only calculated for the wildlife receptors with large home ranges such as deer, fox, mink, and heron (Appendix S, Tables S-31 and S-32). The AUF was set to 1.0 for the other wildlife receptors, including the barn owl, regardless of their home range, because of the screening, i.e., conservative, nature of the work and the fact that those receptors could do all or nearly all of their feeding on one EU.

Exposure equations are presented below. The general equation is

$$\text{Exposure} = \text{Total average daily dose} = ADD_P + ADD_A + ADD_S$$

where

ADD_P = Average daily dose by ingestion of plant matter (mg/kg body wt/d),
ADD_A = Average daily dose by ingestion of animal matter (mg/kg body wt/d),
ADD_S = Average daily dose by ingestion of soil (mg/kg body wt/d).

For deer mice and deer,

$$ADD_P = EPC \times SP_r \times I_P \times AUF,$$

where

EPC = Exposure point concentration in soil (mg/kg soil),
SP_r = Soil-to-plant (fruiting parts) uptake factor (kg soil/kg plant),

I_P = Ingestion rate of plant matter (kg/kg body wt/d),
I_p = IRF × PF × TUF.

where

IR_F = Ingestion rate of food (kg/kg body wt/d),
PF = Fraction of plant matter in diet (unitless),
TUF = Temporal use factor (unitless),
AUF = Area use factor (unitless).

ADD_P for deer mice, deer, shrews, mallards, and mink is the same, except that the soil-to-plant uptake factor used is that for transfer from soil to vegetative parts, SP_v. The form of SP is not relevant for owls and great blue herons because the quantity of plant matter ingested is assumed to be zero.

Ingestion of constituents in animal matter by shrews and robins is given by the following equation:

$$ADD_A = EPC \times BAF_i \times I_A \times AUF$$

where

EPC = Exposure point concentration in soil (mg/kg soil),
BAF_i = Soil-to-soil-dwelling invertebrates uptake factor (kg soil/kg tissue),
I_A = Ingestion rate of animal matter (kg/kg body wt/d),
I_A = IR_F × AF × TUF.

where

IR_F = Ingestion rate of food (kg/kg body wt/d),
AF = Fraction of animal matter in diet (unitless),
TUF = Temporal use factor (unitless),
AUF = Area use factor (unitless).

Ingestion of constituents in prey by owls (proxy for other terrestrial predators) is a special case because uptake by prey from their diets must be accounted for. It is assumed that the diet of owls is entirely shrews because shrews are highly exposed to soil constituents. For owls,

$$ADD_A = (\text{Concentration in prey, Cs}) \times I_{A(owl)} \times AUF_{(owl)}$$

where

Cs = Prey ADD_{total} × BAF_v / IR_f ,
Prey ADD_{total} = Prey ADD_P + Prey ADD_A + Prey ADD_S,
Prey ADD_P = EPC × SP_v × $I_{P\text{-}s}$ × $AUF_{\text{-}s}$,
Prey ADD_A = EPC × BAF_i × $I_{A\text{-}s}$ × $AUF_{\text{-}s}$,
Prey ADD_S = EPC × $I_{S\text{-}s}$ × $AUF_{\text{-}s}$.

where

BAF_v = Food-to-tissue uptake factor in shrews (kg shrew's food/kg tissue),
IR_f = Shrew food ingestion rate (kg/kg body wt/d),
EPC = Exposure point concentration (mg/kg),
SP_v = Soil-to-plant (vegetative parts) uptake factor (kg soil/kg plant),

$I_{P\text{-}s}$ = Ingestion rate of plants by shrews (kg/kg body wt/d),
$AUF_{\text{-}s}$ = Shrew area use factor (unitless),
BAF_i = Soil-to-animal bioaccumulation factor for invertebrates,
$I_{A\text{-}s}$ = Ingestion rate of animal matter for shrews (kg/kg body wt/d),
$I_{S\text{-}s}$ = Ingestion rate of soil for shrews (kg/kg body wt/d),
$I_{A(owl)}$ = Ingestion rate of animal matter for owl,
$AUF_{(owl)}$ = Area use factor for owl (unitless).

The animal ingestion equation for foxes is the same as for owls.

Ingestion of constituents in soil by the terrestrial receptors is given by:

$$ADD_S = EPC \times I_S \times AUF$$

where

EPC = Exposure point concentration in soil (mg/kg soil),
I_S = Ingestion rate of soil (kg/kg body wt/d),
I_S = $IR_F \times SF \times TUF$,

where

IR_F = Ingestion rate of food (kg/kg body wt/d),
SF = Fraction of soil in diet (unitless),
TUF = Temporal use factor (unitless),
AUF = Area use factor (unitless).

The ingestion equation for mink and great blue herons is similar except that Cs is given by:

$$Cs = EPC \times BCF$$

where

EPC = Exposure point concentration in water (mg/L),
BCF = Bioconcentration factor from water into prey (L/kg).

Similarly, ingestion of surface water by mallards, mink, and great blue herons is given by:

$$ADDw = EPC \times I_w \times AUF$$

where

EPC = Exposure point concentration in water (mg/L surface water),
I_w = Ingestion rate of water (L/kg body wt/d),
AUF = Area use factor (unitless).

The fraction of the constituent in ingested soil and tissue that is absorbed is assumed to be 100%. Continuous year-round exposure, or a temporal use factor (TUF) of 1, is assumed for all receptors. Less conservative TUFs are possible when Ohio EPA agrees to them.

Exposure for sediment-dwelling organisms and aquatic organisms is expressed as the exposure point concentration (EPC) (mg/kg for sediment and mg/L for water).

The constituent-specific values for bioaccumulation for soil-to-plant uptake (SP_v and SP_r), soil-to-invertebrate uptake (BAF_i), and animal tissue-to-mammal tissue uptake (BAF_v) are detailed in Appendix S, Tables S-28 and S-29. The BAFs for soil-dwelling invertebrate prey ingested by shrews are those reported in *Risk Assessment Methodology for Loring Air Force Base* (HAZWRAP 1994). The BAFs for prey ingested by foxes and owls are those for small mammals (HAZWRAP 1994). Default BAFs for COPECs without published BAF values are 1 for metals and 1 for organics, based on the range of values reported for these two types of constituents (HAZWRAP 1994). Soil-to-plant bioaccumulation factors (SPs) are presented in Appendix S, Table S-28. Soil-to-biota BAFs are presented in Appendix S, Table S-29. Sediment-to-biota and water-to-biota bioconcentration factors (BCFs) are presented in Appendix S, Table S-30. Default BCFs for COPECs without published BCF values are 500 for metals and 100,000 for organics.

The exposure of endpoint receptors to COPECs in surface soil in each EU at LL 1 was estimated by multiplying exposure factors by the EPC concentration, a conservative estimate of the COPEC concentration. The EPC is a conservative estimate of the central tendency of the distribution of constituent concentrations in samples, especially in those cases where the maximum detected concentration is smaller than the 95% UCL. Individual organisms are potentially exposed to the maximum concentrations at an EU, which may be the maximum detected concentration. Constituent concentrations are those measured in soil at depths from 0 to 2 ft. Soil background concentrations also are given in Chapter 4.0.

The ingestion factors are summarized in Appendix S, Table S-33. The toxicity reference values are provided in Appendix S, Tables S-34 through S-38. The calculated exposure concentrations for wildlife receptors are provided in Appendix S, Tables S-39 through S-95.

It was assumed that there is no dilution of analytes for sediment-dwelling and aquatic receptors exposed directly to sediment and surface water. Therefore, exposure factors for these receptors are equal to 1.0. Concentrations are provided in Chapter 4.0 for sediment and for water with background concentrations in the same appendix table.

7.4.3 Summary of Exposure Assessment

The EPCs of analytes in media at EUs at LL 1 were multiplied by exposure factors to estimate exposure concentrations for each endpoint receptor. Exposure concentrations are the concentrations of analytes in soil and the prey to which the endpoint receptors are exposed. These average daily doses are an estimate of the exposure of receptors to analytes on a per-unit-constituent-concentration basis. These EPCs were compared to published toxicity threshold concentrations (Section 7.5) to characterize the risks to endpoint receptors from direct and indirect exposure to analytes in soil (and water for mink, herons, and ducks) at LL 1 (Section 7.6).

7.5 EFFECTS ASSESSMENT

The purpose of the effects assessment is to determine and evaluate the response to chemical stressors at LL 1 in terms of the selected assessment and measurement endpoints for the ecological receptors. Depending on the parameters of exposure, this effects assessment results in a profile of the response or toxicity reference value of receptor populations to stressors at concentrations or doses (or other units of stress) to which they are exposed.

7.5.1 Chemical Toxicity

Chemicals in the ecosystem may be directly toxic to plants and animals or indirectly harmful by reducing an organism's ability to survive and reproduce. These ranges of effects are characterized by different dose response relationships and may result from different exposure pathways. The toxicity thresholds used for animals in LL 1 are based on toxic effects observed in laboratory studies.

Chronic (long-term) toxicity resulting from inorganic, semivolatile, and pesticide constituents is the primary concern at LL 1. Most organisms do not ingest large amounts of soil and sediment, and assuming that the soil is not acutely toxic, these organisms are subject to chronic toxicity only.

Plants accumulate higher-than-background levels of some metals, resulting in chronic toxicity. Bioaccumulation is generally most significant in the roots of plants; however, several metals can be translocated to parts of the plants above the ground. Some metals (e.g., cadmium or mercury) accumulate in animal tissues and can have subtle deleterious effects on animals over long exposure times. Many organic constituents [e.g., pesticides and polychlorinated biphenyls (PCBs)] are extremely lipophilic (i.e., lipid- or fat-seeking) and can bioaccumulate in organisms. No investigation into chronic effects on local plants and animals as a result of exposure to soils and surface water has been conducted at LL 1. Therefore, reliance is placed on the scientific literature.

The toxicity of constituents varies, depending on the receptor species and on the attending physical and chemical factors, the presence of complexing agents, or the interaction with other constituents at the site. Plants can be adversely affected by constituents in numerous ways, including seed production, seed germination, growth rate, and plant biomass. Animals can be adversely affected in terms of behavioral and physiological changes including reproductive impairment and reduced survival. However, there is an investigation at nearby WBG where long-term exposure and effects to plants and small mammals has been conducted. The results of that investigation may be useful in interpreting potential adverse impacts at LL 1.

7.5.2 Toxicity Reference Values

Site-specific toxicological studies using LL 1 animal populations have not been conducted to determine whether the concentrations of analytes exceeding the EU-specific ESV screens at the site are truly toxic. Therefore, the effects assessment used toxicity data obtained from compiled databases [e.g., Sample et al. (1996), which utilize USFWS and other toxicity studies]. Information on test concentrations, modes of exposure, and effects on similar species from published toxicity studies was used to establish toxicity reference values or thresholds for risk calculations. Technically defensible values or benchmark concentrations of analytes obtained from published literature serve as toxicity reference values or thresholds (concentrations below which there are no unacceptable adverse effects).

Examples of the kinds of toxicological data that are used to assess effects of site constituents on ecological receptors are

- NOAEL – the highest concentration of a constituent in a study that causes no observable adverse effect on a test species, and

- LOAEL – the lowest concentration of a constituent in a study that causes an observable adverse effect on a test species.

The TRVs for plants are LOAEL-based published values but are meant to be screening values for ecological risk assessment (Efroymson et al. 1997c). The TRVs for soil invertebrates are LOAEL-based published values, also meant to be screening values for ecological risk assessment (Efroymson et al. 1997b).

NOAEL-based dietary limits are the EPA-preferred TRVs for wildlife receptors for the LL 1 SERA and were used in this screening ERA when available. Dietary TRVs for the wildlife receptors were obtained by adjusting test species dietary TRVs for uncertainties due to toxicity test durations and endpoint differences. For example, if the laboratory toxicity test duration for the effects study of a chemical was acute instead of chronic, the reported NOAEL was multiplied by an uncertainty factor of 0.1. Likewise, if the test species from the dietary study was different from the wildlife receptor, the test species NOAEL was multiplied by an uncertainty factor of 0.1. The TRVs for barn owls, which represent a surrogate species for T&E species assessment endpoint, were multiplied by an additional uncertainty factor of 0.1 for conservatism. These conservative adjustments to the test species' dietary TRVs were assumed to compensate for the uncertainty associated with the extrapolations from the test species to the wildlife species.

Ecological effects data are available for many analytes exceeding the EU-specific ESV pre-screening at LL 1. These data encompass effects arising from exposure to ingested matter, including soil and food for animals, and root uptake from soil by plants. Data are available for ecological receptors in all exposure classes for the EU. These data are used to identify inorganic and organic COPECs in the soil. Risks are calculated using the TRV for analytes from the soil.

Body weight is an integral part of the exposure equations. Because chronic toxicity is related to metabolic rate, which depends on body weight, toxicity benchmarks for mammals can be adjusted to the body weight of the receptor by applying a scaling factor. Body-weight conversions add more conservatism to the TRV when the mammal field receptor is larger than the laboratory test organism (i.e., white-tailed deer in field versus mouse in the laboratory). Conversely, body-weight conversions provide less conservative but more realistic TRVs for mammals smaller than the test animals. Body weight scaling was used to adjust the TRVs for mammals for the receptor-specific screens at LL 1. However, TRVs for birds were not adjusted for body weight.

TRV thresholds are provided in Appendix S, Tables S-34 (vegetation), S-35 (earthworms), S-36 and S-37 (mammals), S-38 (birds), S-2 (sediment-dwelling biota), and S-3 (aquatic biota). For sediment and surface water, the TRVs are the same as the preferred ESVs that were used in the EU-specific ESV screening, per latest Ohio EPA format. Thus, the first choice for surface water TRVs is the Codified Water Quality Standards in Chapter 3741-1 of the OQC.

7.6 RISK CHARACTERIZATION FOR ECOLOGICAL RECEPTORS

Risk characterization integrates exposure and stressor response on receptor organisms used in the assessment, summarizes risk or the likelihood of harm to animals, and interprets the ecological significance of these findings.

The ecological assessment endpoints depend on this comparison by using HQs to identify the COPECs. The HQs form the quantitative basis of this risk characterization (EPA 1989a). HQs compare the EPC or ADDs to TRVs. ADDs are derived from measured environmental concentrations expressed as EPCs, e.g., the smaller of the 95% UCL and maximum, by multiplying the measured concentration by exposure factors. The distribution of the data, log-normal or normal, was determined before computation of the summary statistics. This determines how the upper confidence limit of the mean is determined. If log-normal, then the land-statistics is used; otherwise the T-distribution is used. The effects information is expressed as the toxicity reference value or that constituent concentration that approximates the area of no response to a small response. This relationship is shown as:

$$HQ = \frac{EPC\ or\ Total\ Average\ Daily\ Dose}{Toxicity\ Reference\ Value}$$

When there was no TRV, the ratio of exposure point concentration and toxicity reference value could not be determined. Usually, there are a number of such situations where no HQ is possible because there is no TRV. Collectively, they were handled in the uncertainty section. The usual explanation in the uncertainty section is that ecological risk is slightly underestimated. One way to obtain a "proxy" TRV is the use of surrogate values. When Ohio EPA or other agencies issue such surrogates, the values will be used. Inspection of the screening value tables and TRV tables in Appendix S shows which constituents need surrogate values. For example, TRVs for thallium, vanadium, and benzo(b)fluoranthene are needed for sediments. Other uncertainties in the measured, estimated, and calculated concentrations on the final characterization of ecological risk at LL 1 are discussed qualitatively.

An HQ greater than unity (1.0) indicates that there is a potential for harmful ecological effects and that the COPEC qualifies for further investigation (possibly extrapolation from WBG findings of no biological field effects or other assessment) into its potential to pose a hazard. Moreover, the risk of potential hazardous effects is assumed to increase with the magnitude of the ratio. An HQ threshold of 1.0 assumes that the toxicity threshold and exposure concentrations are accurate. In reality, the range of values around 1.0 within which HQs may or may not indicate the existence of risk increases with the uncertainty of the estimated exposure and toxicity threshold concentrations.

As explained above, an HQ of 1 or greater focused on which chemicals, which receptors, and which EUs are likely associated with ecological risk. Then, in the next stage, e.g., BERA, the focus is for actual evidence of manifested risk, e.g., field-observed effects using field-metrics.

7.6.1 Current Preliminary Risk to Ecological Receptors

Risks to ecological receptors under current conditions were estimated by calculating HQs for all terrestrial and aquatic exposure classes, as represented by their ecological receptors, as well as summarizing the list of PBT compounds. HQs are summarized on a COPEC-by-COPEC basis for each EU for receptors in soil, sediment, and surface water in Tables 7-6 through 7-8, respectively. These tables also list the PBT compounds by EU.

The HQs are reported on an EU-by-EU and receptor-by-receptor bases, and the PBT compounds are summarized for each EU as follows:

Soil at Water Tower Area (Appendix S, Tables S-39 through S-45). The HQs for six inorganics (cadmium, chromium, iron, lead, nickel, and zinc) exceeded 1.0 for surface soil at the Water Tower area.

Plants. Iron had the largest HQ (4,560) and was the only one to exceed 1,000. Chromium had the next highest HQ (250) for plants. The HQs for lead (50) and zinc (12) for plants were between 10 and 99. The HQ (1.1) for nickel for plants was the only one between 1 and 9.

Earthworms. The HQ (626) for chromium was the largest, followed by lead (5) and zinc (3).

Deer Mice. The HQ (40) for lead was the only one that exceeded 1.

Deer. No HQs exceeded 1.

Table 7-6. Summary of Soil Chemicals of Potential Concern (PBT Compounds and/or HQs >1) – Receptor-Specific Screens, Load Line 1 RVAAP, Ravenna, Ohio

Exposure Unit	PBT Compounds	Range of RVAAP Load Line 1 HQs			
		1-9	10-99	100-999	> 1,000
Water Tower	Cadmium Lead Mercury Zinc	Cadmium (2) robin Lead (5) earthworm Nickel (1.1) plant Zinc (2) shrew Zinc (3) earthworm Zinc (2) robin	Chromium (37) robin Chromium (24) barn owl Lead (50) plant Lead (40) deer mouse Lead (80) barn owl Zinc (12) plant Zinc (75) robin	Chromium (250) plant Chromium (626) earthworm Lead (154) shrew Zinc (457) barn owl	Iron (4560) plant Lead (4080) robin
CB-3 and CB-801	Cadmium Lead Mercury Zinc Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Bis(2-ethylhexyl)phthalate Chrysene Di-n-butyl phthalate Dibenzofuran Fluoranthene Fluorene Pentachlorophenol Phenanthrene Pyrene 4,4'-DDT Dieldrin Methoxychlor Aroclor-1254 gamma-Chlordane	Aluminum (8) robin Aluminum (2) barn owl Arsenic (1.3) plant Arsenic (7) mouse Arsenic (7) shrew Barium (1.1) deer mouse Barium (1.1) shrew Cadmium (2) plant Cadmium (1.5) barn owl Chromium (6) robin Chromium (4) barn owl Lead (1.2) earthworm Manganese (3) plant Mercury (1.4) earthworm Mercury (2) barn owl Zinc (5) plant Zinc (1.3) earthworm Benzo(a)pyrene (1.2) mouse Benzo(a)pyrene (1.1) shrew 4,4'-DDT (7) robin Dieldrin (2) mouse Dieldrin (2) shrew Dieldrin (2) robin Dieldrin (8) barn owl	Aluminum (78) mouse Antimony (22) plant Antimony (81) mouse Antimony (76) shrew Cadmium (18) mouse Cadmium (17) shrew Cadmium (44) robin Chromium (44) plant Lead (12) plant Lead (40) mouse Lead (37) shrew Lead (19) barn owl Zinc (32) robin 4,4'-DDT (30) barn owl	Aluminum (241) plant Aluminum (592) shrew Chromium (110) earthworm Lead (985) robin Zinc (195) barn owl Aroclor-1254 (207) mouse Aroclor-1254 (194) shrew Aroclor-1254 (134) robin Aroclor-1254 (453) owl	Iron (3020) plant

Table 7-6. Summary of Soil Chemicals of Potential Concern (PBT Compounds and/or HQs >1) – Receptor-Specific Screens, Load Line 1 RVAAP, Ravenna, Ohio (continued)

Exposure Unit	PBT Compounds	Range of RVAAP Load Line 1 HQs			
		1-9	10-99	100-999	> 1,000
CB-4,4A and CB-6, 6A	Cadmium	Aluminum (6) robin	Aluminum (66) mouse	Aluminum (203) plant	Iron (22,50) plant
	Lead	Aluminum (2) barn owl	Cadmium (13) robin	Aluminum (498) shrew	Aroclor -1254 (53,000) mouse
	Mercury	Arsenic (1.1) plant	Chromium (25) plant	Lead (461) robin	Aroclor -1254 (49,700) shrew
	Zinc	Arsenic (6) mouse	Chromium (62) earthworm	Zinc (143) barn owl	Aroclor -1254 (34,300) robin
	Anthracene	Arsenic (6) shrew	Lead (19) mouse	Aroclor-1254 (859) fox	Aroclor -1254 (110,000) owl
	Benzo(a)anthracene	Cadmium (5) mouse	Lead (17) shrew		
	Benzo(a)pyrene	Cadmium (5) shrew	Thallium (20) mouse		
	Benzo(b)fluoranthene	Chromium (4) robin	Thallium (19) shrew		
	Benzo(g,h,i)perylene	Chromium (2) barn owl	Vanadium (10) plant		
	Benzo(k)fluoranthene	Copper (1.1) plant	Zinc (24) robin		
	Bis(2-ethylhexyl)phthalate	Copper (2) earthworm	4,4'-DDT (33) barn owl		
	Butylbenzyl phthalate	Lead (6) plant	Dieldrin (23) barn owl		
	Chrysene	Lead (9) barn owl	2,4,6-Trinitrotoluene (13) mouse		
	Dibenzofuran	Manganese (1.4) plant	2,4,6-Trinitrotoluene (12) shrew		
	Fluoranthene	Mercury (1.1) plant			
	Fluorene	Mercury (3) earthworm			
	Phenanthrene	Mercury (6) barn owl			
	Pyrene	Selenium (1.1) robin			
	4,4'-DDE	Selenium (1.2) barn owl			
	4,4'-DDT	Vanadium (7) mouse			
	Dieldrin	Vanadium (6) shrew			
	Heptachlor	Zinc (4) plant			
	Heptachlor epoxide	4,4'-DDT (8) robin			
	Methoxychlor	Dieldrin (7) mouse			
	Aroclor-1016	Dieldrin (6) shrew			
	Aroclor-1254	Dieldrin (6) robin			
	alpha-Chlordane	1,3-Dinitrobenzene (1.2) mouse			
	gamma-Chlordane	1,3-Dinitrobenzene (1.1) shrew			
CB-13 and CB-10	Cadmium	Aluminum (8) robin	Aluminum (84) mouse	Aluminum (260) plant	Iron (2260) plant
	Lead	Aluminum (2) barn owl	Cadmium (18) mouse	Aluminum (639) shrew	
	Mercury	Arsenic (1.1) plant	Cadmium (17) shrew	Lead (412) robin	

Table 7-6. Summary of Soil Chemicals of Potential Concern (PBT Compounds and/or HQs >1) – Receptor-Specific Screens, Load Line 1 RVAAP, Ravenna, Ohio (continued)

Exposure Unit	PBT Compounds	Range of RVAAP Load Line 1 HQs			
		1-9	10-99	100-999	> 1,000
	Zinc Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Chrysene Fluoranthene Fluorene Phenanthrene Pyrene Heptachlor Aroclor-1254 gamma-Chlordane	Arsenic (6) mouse Arsenic (6) shrew Cadmium (2) plant Cadmium (2) barn owl Chromium (5) robin Chromium (3) barn owl Copper (2) plant Copper (3) earthworm Lead (5) plant Lead (8) barn owl Manganese (3) plant Mercury (1.5) barn owl Selenium (1.2) robin Selenium (1.2) barn owl Vanadium (8) plant Vanadium (6) mouse Vanadium (6) shrew Zinc (9) plant Zinc (2) earthworm Zinc (1.4) mouse Zinc (1.3) shrew 2,4,6-Trinitrotoluene (1.1) mouse	Cadmium (45) robin Chromium (35) plant Chromium (88) earthworm Lead (17) mouse Lead (16) shrew Zinc (56) robin Aroclor -1254 (82) mouse Aroclor -1254 (77) shrew Aroclor -1254 (53) robin	Zinc (342) barn owl Aroclor -1254 (179) owl	
CB-14, CB-17, and CA-15	Cadmium Lead Mercury Zinc Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Bis(2-ethylhexyl)phthalate Chrysene Di-n-butyl phthalate	Aluminum (3) barn owl Arsenic (2) plant Cadmium (6) mouse Cadmium (6) shrew Chromium (4) robin Chromium (3) barn owl Lead (2) plant Lead (7) mouse Lead (7) shrew Lead (3) barn owl Manganese (2) plant Mercury (1.3) barn owl Nickel (1.1) plant	Aluminum (12) robin Arsenic (12) mouse Arsenic (11) shrew Cadmium (14) robin Chromium (28) plant Chromium (69) earthworm Thallium (34) mouse Thallium (32) shrew Vanadium (18) plant Vanadium (12) mouse Vanadium (12) shrew Zinc (27) robin	Aluminum (398) plant Aluminum (979) shrew Aluminum (129) mouse Lead (180) robin Zinc (164) barn owl Aroclor -1254 (226) mouse Aroclor -1254 (212) shrew Aroclor -1254 (147) robin Aroclor -1254 (495) owl	Iron (4020) plant

Table 7-6. Summary of Soil Chemicals of Potential Concern (PBT Compounds and/or HQs >1) – Receptor-Specific Screens, Load Line 1 RVAAP, Ravenna, Ohio (continued)

Exposure Unit	PBT Compounds	Range of RVAAP Load Line 1 HQs			
		1-9	10-99	100-999	> 1,000
	Dibenzo(a,h)anthracene Dibenzofuran Fluoranthene Fluorene Phenanthrene Pyrene Methoxychlor Aroclor-1254 alpha-Chlordane gamma-Chlordane	Zinc (4) plant Zinc (1.1) earthworm Aroclor -1254 (1.4) fox			
Perimeter Area	Cadmium Lead Mercury Zinc Benzo(b)fluoranthene Fluoranthene	Aluminum (9) robin Aluminum (2) barn owl Arsenic (1.3) plant Arsenic (7) mouse Arsenic (7) shrew Cadmium (2) robin Chromium (2) robin Chromium (2) barn owl Lead (1.4) mouse Lead (1.3) shrew Manganese (3) plant Selenium (1.1) robin Selenium (1.2) barn owl Vanadium (9) shrew Zinc (1.2) plant Zinc (8) robin	Aluminum (91) mouse Aluminum (30) deer Aluminum (22) fox Chromium (17) plant Chromium (42) earthworm Lead (34) robin Vanadium (14) plant Vanadium (10) mouse Zinc (46) barn owl	Aluminum (281) plant Aluminum (691) shrew	Iron (2400) plant

COPECs = Chemicals of potential ecological concern.
PBTs = Persistent, bioaccumulative, and toxic compounds.
HQ = Hazard quotient.
RVAAP = Ravenna Army Ammunition Plant.

Table 7-7. Summary of Sediment Chemicals of Potential Concern (PBTs and/or HQs >1) – Receptor-Specific Screens, Load Line 1 RVAAP, Ravenna, Ohio

Exposure Unit	PBT Compounds	Range of RVAAP Load Line 1 HQs			
		1-9	10-99	100-999	> 1,000
Outlets A and B Channel	Cadmium Lead Mercury Zinc PCB-1254 Endrin Anthracene Benzo(k)fluoranthene Benzo(g,h,i)perylene Di-n-butylphthalate Dibenzo(a,h)anthrancene Dibenzofuran Fluorene Phenanthrene gamma-Chlordane Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Chrysene Fluoranthene Pyrene	Arsenic (2) Copper (7) Chromium (1.4) Mercury (2) Nickel (2) Benzo(b)fluoranthene (1.2) Di-n-butylphthalate (6) Naphthalene (2) Zinc (8)	Cadmium (15) Lead (14) 2,4-Dinitrotoluene (27) gamma-Chlordane (10) Endrin (24) Anthracene (39) Benzo(a)anthracene (85) Benzo(a)pyrene (63) Benzo(g,h,i)perylene (32) Benzo(k)fluoranthene (23) Chrysene (57) Dibenzo(a,h)anthracene (52) Fluoranthene (59) Fluorene (14) Indeno(1,2,3-cd)pyrene (34) Phenanthrene (59) Pyrene (77)	Acenaphthene (104)	1,3,5-Trinitrobenzene (1410)
Outlet C Channel & Charlie's Pond	Cadmium Lead Mercury 4,4'-DDE PCB-1254 Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Chrysene Fluoranthene Phenanthrene Pyrene	Arsenic (3) Cadmium (1.1) Lead (1.1) 4,4'-DDE (7) 2,6-Dinitrotoluene (7)	None	None	None

Table 7-7. Summary of Sediment Chemicals of Potential Concern (PBTs and/or HQs >1) – Receptor-Specific Screens, Load Line 1 RVAAP, Ravenna, Ohio (continued)

Exposure Unit	PBT Compounds	Range of RVAAP Load Line 1 HQs			
		1-9	10-99	100-999	> 1,000
Outlets D, E, and F Channels and Criggy's Pond	Cadmium Lead Mercury Zinc	Arsenic (2) Cadmium (2) Chromium (3) Mercury (2) Nickel (2) Zinc (5)	Copper (32) Lead (34)	None	None
North Area Channel	Cadmium Lead Mercury	Nickel (1.1)	None	None	None
Off-AOC Channel	Cadmium Mercury	Arsenic (2) Copper (2)	1,3-Dinitrobenzene (55)	None	None

COPECs = Chemicals of potential ecological concern.
PBTs = Persistent, bioaccumulative, and toxic compounds.
HQ = Hazard quotient.
RVAAP = Ravenna Army Ammunition Plant.

Table 7-8. Summary of Surface Water Chemicals of Potential Concern (PBT Compounds and/or HQs >1) – Receptor-Specific Screens, Load Line 1 RVAAP, Ravenna, Ohio

Exposure Unit	PBT Compounds	Range of RVAAP Load Line 1 HQs			
		1-9	10-99	100-999	> 1,000
Outlets D, E, and F Channel and Criggy's Pond	None	None	None	None	None
Outlet C Channel and Charlie's Pond	Lead - aquatic biota Lead - mink Lead - heron Lead - mallard duck	None	Iron (10) aquatic biota	None	None
Off-AOC Channel	Lead - aquatic biota Lead - mink Lead - heron Zinc - aquatic biota Zinc - mink Zinc - heron Bis(2-ethylhexyl)phthalate - aquatic biota Bis(2-ethylhexyl)phthalate - mink Bis(2-ethylhexyl)phthalate - heron	Iron (4) aquatic biota Manganese (1.1) aquatic biota Manganese (2) mink	None	None	None

COPECs = Chemicals of potential ecological concern.
PBTs = Oersistent, bioaccumulative, and toxic compounds .
HQ = Hazard quotient.
RVAAP = Ravenna Army Ammunition Plant.

Shrews. The HQs for lead (154) and zinc (2) exceeded 1.

Robins. Four HQs exceeded 1 for robins, including those for lead (4,080), chromium (37), zinc (75), and cadmium (2).

Foxes. No HQs exceeded 1.

Barn Owls. Three HQs exceeded 1, including zinc (457), lead (80), and chromium (24),

Four inorganics (cadmium, lead, mercury, and zinc) were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that the numerous COPECs pose a potential risk of unacceptable toxicity to terrestrial receptors at the Water Tower.

Soil at Buildings CB-3 and CB-801 (Appendix S, Tables S-46 through S-52). The HQs for 12 inorganics (aluminum, antimony, arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, selenium, and zinc), 1 SVOC [benzo(a)pyrene], 1 PCB (aroclor-1254), and 3 pesticides (4,4'-DDE, dieldrin, and 4,4'-DDT) exceeded 1.0 for surface soil at Buildings CB-3 and CB-801.

Plants. Iron had the largest HQ (3,020) and was the only one to exceed 1,000. Aluminum had the next highest HQ (241) for plants. The HQs for chromium (44), antimony (22), and lead (12) for plants were between 10 and 99. Four HQs for plants ranged between 1 and 9, including zinc (5), manganese (3), cadmium (2), and arsenic (1.3).

Earthworms. Chromium had the largest HQ (110), whereas the HQs were 1 for lead, mercury, and zinc.

Deer Mice. The HQs for aroclor-1254 (207), antimony (81), aluminum (78), lead (40), and cadmium (18) were the largest, followed by arsenic (7), dieldrin (2), barium (1.1), and benzo(a)pyrene (1.2).

Deer. No HQs exceeded 1.

Shrews. The HQs for aluminum (592), aroclor-1254 (194), antimony (76), lead (37), cadmium (17), arsenic (7), dieldrin (2), barium (1.1), and benzo(a)pyrene (1.1) exceeded 1.

Robins. Eight HQs exceeded 1, including those for lead (985), aroclor-1254 (134), cadmium (44), zinc (32), aluminum (8), 4,4'-DDT (7), chromium (6), and dieldrin (2).

Foxes. No HQs exceeded 1.

Barn Owls. Ten HQs exceeded 1, including aroclor-1254 (453), zinc (195), 4,4'-DDT (30), lead (19), dieldrin (8), chromium (4), aluminum (2), mercury (2), and cadmium (1.5).

Four inorganics (cadmium, lead, mercury, and zinc), 15 SVOCs [anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, di-n-butylphthalate, dibenzofuran, fluoranthene, fluorene, pentachlorophenol, phenanthrene, and pyrene], and 5 pesticides/PCBs (aroclor-1254, 4,4'-DDT, dieldrin, methoxychlor, and gamma-chlordane) were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that the numerous COPECs pose a potential risk of unacceptable toxicity to terrestrial receptors at Buildings CB-3 and CB-801.

Soil at Buildings CB-4, -4A, and CA-6, -6A (Appendix S, Tables S-53 through S-59). The HQs for 14 inorganics (aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, thallium, vanadium, and zinc), 2 pesticides (4,4'-DDT and dieldrin), 1 PBC (aroclor-1254), and 2 explosives (1,3-dinitrobenzene and 2,4,6-trinitrotoluene) exceeded 1.0 for surface soil at Buildings CB-4, -4A and CA-6, -6A.

Plants. Iron had the largest HQ (2,250) and was the only one to exceed 1,000. Aluminum had the next highest HQ (203) for plants. The HQs for chromium (25) and vanadium (10) for plants were between 10 and 99. Six HQs for plants ranged between 1 and 9, including lead (6), zinc (4), arsenic (1.1), copper (1.1), manganese (1.4), and mercury (1.1).

Earthworms. Chromium had the largest HQ (62), followed by mercury (3) and copper (2).

Deer Mice. The HQs for aroclor-1254 (53,000), aluminum (66), thallium (20), lead (19), and 2,4,6-trinitrotoluene (13) were the largest, followed by vanadium (7), dieldrin (7), arsenic (6), cadmium (5), and 1,3-dinitrobenzene (1.2).

Deer. No HQs exceeded 1.

Shrews. The HQs for aroclor-1254 (49,200), aluminum (498), thallium (19), lead (17), 2,4,6-trinitrotoluene (12), arsenic (6), vanadium (6), dieldrin (6), cadmium (5), and 1,3-dinitrobenzene (1.1) exceeded 1.

Robins. Eight HQs exceeded 1, including those for aroclor-1254 (34,300), lead (461), zinc (24), cadmium (13), 4,4'-DDT (8), aluminum (6), chromium (4), and selenium (1.1).

Foxes. The HQ (859) for aroclor-1254 was the only one exceeding 1.

Barn Owls. Nine HQs exceeded 1, including aroclor-1254 (110,000), zinc (143), 4,4'-DDT (33), dieldrin (23), lead (9), mercury (6), aluminum (2), chromium (2), and selenium (1.2). Please see Section 7.7.2 (Uncertainties in Exposure) about overestimates of exposure to the barn owl.

Four inorganics (cadmium, lead, mercury, and zinc), 14 SVOCs [anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, buthylbenzylphthalate, chrysene, dibenzofuran, fluoranthene, fluorene, phenanthrene, and pyrene], and 10 pesticides/PCBs (aroclor-1016, aroclor-1254, 4,4'-DDE, 4,4'-DDT, dieldrin, heptachlor, heptachlor epoxide, methoxychlor, alpha-chlordane, and gamma-chlordane), were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that the numerous COPECs pose a potential risk of unacceptable toxicity to terrestrial receptors at Buildings CB-4, 4A and CA-6, 6A.

Soil at Buildings CB-13 and CB-10 (Appendix S, Tables S-60 through S-66). The HQs for 13 inorganics (aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, vanadium, and zinc), 1 PCB (aroclor-1254), and one explosive (2,4,6-trinitrotoluene) exceeded 1.0 for surface soil at Buildings CB-13 and CB-10.

Plants. Iron had the largest HQ (2,260), followed by aluminum (260) and mercury (170). The HQ for chromium (35) for plants was between 10 and 99. Seven HQs for plants ranged between 1 and 9, including zinc (9), vanadium (8), lead (5), manganese (3), cadmium (2), copper (2), and arsenic (1.1).

Earthworms. Chromium had the largest HQ (88), followed by copper (3) and zinc (2).

Deer Mice. The HQs for aluminum (84), aroclor-1254 (82), cadmium (18), and lead (17) were the largest, followed by vanadium (6), arsenic (6), barium (1), zinc (1), and 2,4,6-trinitrotoluene (1).

Deer. No HQs exceeded 1.

Shrews. The HQs for aluminum (639), aroclor-1254 (77), cadmium (17), lead (16), arsenic (6), vanadium (6), and zinc (1.3) exceeded 1.

Robins. Eight HQs exceeded 1, including those for lead (412), zinc (56), aroclor-1254 (53), cadmium (45), aluminum (8), chromium (5), and selenium (1.2).

Foxes. No HQs exceeded 1.

Barn Owls. Eight HQs exceeded 1, including zinc (342), aroclor-1254 (179), lead (8), chromium (3), aluminum (2), cadmium (2), mercury (1.5), and selenium (1.2).

Four inorganics (cadmium, lead, mercury, and zinc), 11 SVOCs [anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene], and 3 pesticides/PCBs (aroclor-1254, heptachlor, and gamma-chlordane) were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that the numerous COPECs pose a potential risk of unacceptable toxicity to terrestrial receptors at Buildings CB-13 and CB-10.

Soil at Buildings CB-14, CB-17, and CA-15 (Appendix S, Tables S-67 through S-73). The HQs for 12 inorganics (aluminum, arsenic, cadmium, chromium, iron, lead, manganese, mercury, nickel, thallium, vanadium, and zinc) and 1 PCB (aroclor-1254) exceeded 1.0 for surface soil at Buildings CB-14, CB-17, and CA-15.

Plants. Iron had the largest HQ (4,020), followed by aluminum (398), chromium (28), and vanadium (18). Five HQs for plants ranged between 1 and 9, including zinc (4), arsenic (2), lead (2), manganese (2), and nickel (1.1).

Earthworms. Chromium had the largest HQ (69), followed by zinc (1.1).

Deer Mice. The HQs for aroclor-1254 (226), aluminum (129), thallium (34), arsenic (12), and vanadium (12) were the largest, followed by lead (7) and cadmium (6).

Deer. No HQs exceeded 1.

Shrews. The HQs for aluminum (974), aroclor-1254 (212), thallium (32), vanadium (12), arsenic (11), lead (7), and cadmium (6) exceeded 1.

Robins. Six HQs exceeded 1, including those for lead (180), aroclor-1254 (149), zinc (27), cadmium (14), aluminum (12), and chromium (4).

Foxes. The HQ (1.4) for aroclor-1254 was the only HQ that exceeded 1.

Barn Owls. Five HQs exceeded 1, including aroclor-1254 (495), zinc (164), aluminum (3), chromium (3), lead (3), and mercury (1.3).

Four inorganics (cadmium, lead, mercury, and zinc), 15 SVOCs [anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, di-n-butylphthalate, dibenzo(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, phenanthrene, and pyrene], and 4 pesticides/PCBs (aroclor-1254, methoxychlor, alpha-chlordane, and gamma-chlordane) were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that the numerous COPECs pose a potential risk of unacceptable toxicity to terrestrial receptors at Buildings CB-14, CB17, and CA-15.

Soil at Perimeter Area (Appendix S, Tables S-74 through S-80). The HQs for 10 inorganics (aluminum, arsenic, cadmium, chromium, iron, lead, manganese, selenium, vanadium, and zinc) exceeded 1.0 for surface soil at the Perimeter Area.

Plants. Iron had the largest HQ (2,400), followed by aluminum (281), chromium (17), and vanadium (14). Three HQs for plants ranged between 1 and 9, including manganese (3), arsenic (1.3), and zinc (1.2).

Earthworms. Chromium had the only HQ (42) over 1.

Deer Mice. The HQs for aluminum (91) and vanadium (10) were the largest, followed by arsenic (7) and lead (1.4).

Deer. No HQs exceeded 1.

Shrews. The HQs for aluminum (691), vanadium (9), arsenic (7), and lead (1.3) exceeded 1.

Robins. Six HQs exceeded 1, including those for lead (34), aluminum (9), zinc (8), cadmium (2), chromium (2), and selenium (1.1).

Foxes. The HQ (22) for aluminum was the only one that exceeded 1.

Barn Owls. Four HQs exceeded 1, including zinc (46), aluminum (2), chromium (2), and selenium (1.2).

Four inorganics (cadmium, lead, mercury, and zinc) and two SVOCs [benzo(b)fluoranthene and fluoranthene] were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that the numerous COPECs pose a potential risk of unacceptable toxicity to terrestrial receptors at the Perimeter Area.

Sediment at Outlets A and B Channel (Appendix S, Table S-81). The HQs for eight inorganics (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc), two pesticides (endrin and gamma-chlordane), 16 SVOCs [acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, di-n-butylphthalate, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene], and two explosives (1,3,5-trinitrobenzene and 2,4-dinitrotoluene) exceeded 1.0 for sediment at the Outlets A and B Channel. The highest HQ (1,410) of all the COPECs was for 1,3,5-trinitrobenzene, and it was the only HQ to exceed 1,000. Acenaphthene (HQ=104) was the only COPEC whose HQ was between 100-999. Eighteen COPECs had HQs ranging between 10-99, including two inorganics, two pesticides, 12 SVOCs, and one explosive. The HQs between 10-99 ranged from HQ=10 for gamma-chlordane to HQ=85 for benzo(a)anthracene. Eight COPECs had HQs ranging between 1-9, with the highest value (HQ=8) for zinc, followed by HQ=7 for copper.

Four inorganics (cadmium, lead, mercury, and zinc), 14 SVOCs, and 2 pesticides were PBT compounds but also had HQs that exceeded 1. PCB-1254 was an additional COPEC by virtue of being a PBT compound.

These findings indicate that numerous COPECs pose a potential risk of unacceptable toxicity to sediment-dwelling biota at this EU.

Sediment at Outlet C Channel and Charlie's Pond (Appendix S, Table S-82). The HQs for four inorganics (arsenic, cadmium, lead, and nickel), one pesticide (4,4'-DDE), and one explosive (2,6-dinitrotoluene) exceeded 1.0 for sediment at the Outlet C Channel and Charlie's Pond. Two COPECs—4,4'-DDE, and 2,6-dinitrotoluene—had the highest HQs (7) of all the COPECs at this EU. Four other COPECs had HQs that ranged between 1 and 10, including arsenic (3), cadmium (1.1), and lead (1.1).

Three inorganics (cadmium, lead, and mercury), two pesticides/PCBs (aroclor-1254 and 4,4'-DDE), and nine PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene] were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that numerous COPECs pose a potential risk of unacceptable toxicity to sediment-dwelling biota at this EU.

Sediment at Outlets D, E, and F Channels and Criggy's Pond (Appendix S, Table S-83). The HQs for eight inorganics (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) exceeded 1.0 for sediment at the Outlets D, E, and F Channel and Criggy's Pond. Lead had the highest HQ (34) of all the COPECs at this EU. Copper was the only other COPEC whose HQ (32) ranged between 10 and 99. Six HQs ranged from 1 to 9, including arsenic (2), cadmium (2), chromium (3), mercury (2), nickel (2), and zinc (5).

The four inorganic PBT compounds (cadmium, lead, mercury, and zinc) at this EU already had HQs greater than 1, but they are also COPECs by virtue of their PBT compound status. These findings indicate that numerous COPECs pose a potential risk of unacceptable toxicity to sediment-dwelling biota at this EU.

Sediment at North Area Channel (Appendix S, Table S-84). The HQ (1) for one inorganic (nickel) equaled 1.1 at the North Area channel. This was the only analyte whose HQ exceeded 1 for this EU.

Three inorganics (cadmium, lead, and mercury) were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that several COPECs pose a potential risk of unacceptable toxicity to sediment-dwelling biota at this EU.

Sediment at Off-AOC Channel (Appendix S, Table S-85). The HQs for two inorganics (arsenic and copper) and one explosive (1,3-dinitrobenzene) exceeded 1 at the off-AOC channel. The highest HQ (55) of all the COPECs was for 1,3-dinitrobenzene and was the only one to exceed 10. The HQs for arsenic (2) and copper (2) ranged between 1 and 9.

Two inorganics (cadmium and mercury) were PBT compounds at this EU. Thus, these analytes are considered COPECs based on the fact that they are PBT compounds. These findings indicate that several COPECs pose a potential risk of unacceptable toxicity to sediment-dwelling biota at this EU.

Surface water at Outlet C Channel and Charlie's Pond (Appendix S, Tables S-86 through S-89). The HQ (10) for iron for aquatic biota exceeded 1 in surface water at this EU. No other HQs exceeded 1 for aquatic biota, herons, or mallard ducks at this EU.

One inorganic (lead) was a PBT compound at this EU. Thus, this analyte is considered a COPEC for aquatic biota, mink, herons, and mallard ducks at this EU based on the fact that it is a PBT compound. These findings indicate that two COPECs in surface water pose a potential risk of unacceptable toxicity to ecological receptors at this EU.

Surface water at Outlets D, E, and F Channel and Criggy's Pond (Appendix S, Tables S-90 through S-93). No HQs exceeded 1 for aquatic biota, mink, herons, or mallard ducks exposed to surface water at this EU. In addition, there were no PBT compounds at this EU. Thus, there are no COPECs for surface water at this EU.

Surface Water at Off-AOC Channel (Appendix S, Tables S-94 through S-96). The HQs for two inorganics (iron and manganese) exceeded 1 for surface water at the off-AOC channel. The largest HQ (4) was for iron for aquatic biota. For aquatic biota, the only other HQ greater than or equal to 1 was for manganese (1.1). For mink, only one HQ was between 1 and 9, namely manganese (2). No HQs exceeded 1 for herons. Two inorganics (lead and zinc) and one SVOC [bis(2-ethylhexyl)phthalate] were PBT compounds at this EU. Thus, these analytes are considered COPECs for aquatic biota, mink, and herons at this EU based on the fact that they are PBT compounds. These findings indicate that several COPECs in surface water pose a potential risk of unacceptable toxicity to ecological receptors at this EU.

7.6.2 HMX and RDX Considerations

During the review of the draft RI, more information was requested about the possible ecological risk from RDX and HMX to mammals. See the following text about this.

EPA cites in the IRIS database a dietary NOAEL of 0.3 mg/kg/d for RDX in chronically (i.e., 2 years) exposed rats, but the test endpoint is inflammation of the prostrate gland. Similarly, the IRIS database contains a dietary NOAEL of 50 mg/kg/d for HMX in subchronically (14 days) exposed rats, but the test endpoint is hepatic lesions. The test endpoints have uncertainty regarding their ecological significance or consequences, compared to endpoints such as survival, growth, and reproduction success. Thus, the dietary NOAELs for RDX and HMX that are presented in IRIS have questionable technical validity as screening benchmarks for mammals.

Although the dietary NOAELs for RDX and HMX in IRIS have much uncertainty regarding their ecological significance for use in screening wildlife ecological receptors, these NOAELs were utilized to estimate risks to shrews, deer mice, deer, and red foxes. The risks were estimated by calculating HQs, using the same exposure equations and parameters as for all the other SRCs. The dietary NOAELs in IRIS for the test species (rats) were adjusted to the body weights of the ecological receptors by assuming the test species weight of 0.35 kg. The summary of risk results for RDX and HMX to the four mammal receptors is presented here for informational purposes only.

RDX was an SRC at four EUs, including: CB-3 and CB-801; CB-4/4A and CA-6/6A; CB-13 and CB-10; and CB-14, CB-17, and CA-15. The HQs for RDX exceeded 1 for shrews and deer mice at 3 EUs; CB-4/4A and CA-6/6A; CB-13 and CB-10; and CB-14, CB-17, and CA-15. The HQs for RDX for shrews at the EUs were as follows: CB-4/4A and CA-6/6A (HQ=99); CB-13 and CB-10 (HQ=4); and CB-14, CB-17, and CA-15 (HQ=28). The HQs for RDX for deer mice at the EUs were as follows: CB-4/4A and CA-6/6A (HQ=106); Cb-13 and CB-10 (HQ=4); and CB-14, CB-17, and CA-15 (HQ=30). The only other HQ for RDX that exceeded 1 for the mammals was for deer (HQ=2).

HMX was a SRC at three EUs, including: CB-4/4A and CA-6/6A; CB-13 and CB-10; and CB-14, CB-17, and CA-15. No HQs for HMX exceeded 1 for any of the four mammals receptors at any of the three EUs. The HQ for HMX (0.99) for deer mice at EU CB-4/4A and CA-6/6A rounded up to 1.0.

7.6.3 Future Preliminary Risk to Ecological Receptors

The HQs for the terrestrial animals at LL 1 are considered to be the same or similar in the future because soil contaminant concentrations are not expected to change much over time. Vegetation would be expected to continue to colonize all terrestrial EU areas if the natural invasional/successional process is allowed to proceed and if the HQs are expected to be the same or similar. The lack of toxicity thresholds for a few of the organic COPECs will contribute to the uncertainty of any assessment of the risk to future animals at the EUs. Some organic COPECs would be expected to decrease in concentration through natural degradation processes, although their number and concentration of breakdown products could increase. Regardless, risks in the future are assumed to be the same as risks in the current condition at LL 1.

In the aquatic habitats, the ecological environment is expected to change from year to year because of new inputs of sediments. Thus, the HQs for sediment and surface water may vary accordingly.

7.6.4 Use of Characterization Results

Analytes that exceed background concentrations, the EU-specific ESV screens, and the HQs greater than 1 from the receptor-specific screens are considered COPECs that potentially could pose a risk of unacceptable toxicity to ecological receptors. In addition, analytes that are PBT compounds are considered COPECs. Analytes that do not have toxicity screening values were further evaluated in the receptor-specific screening. If the analytes did not have a TRV for the receptor-specific screen, they were dropped from further consideration and handled as uncertainties. The COPECs may require additional investigation to evaluate more thoroughly whether or not they pose risks to ecological receptors. Less conservative (and more realistic) exposure and toxicity characterizations could be performed, along with a weight-of-evidence analysis including extrapolations from the WBG biological field studies.

7.7 UNCERTAINTIES

Uncertainties in the LL 1 SERA are discussed in this section by the four interrelated steps of the EPA approach to ERA: problem formulation, exposure assessment, effects assessment, and risk characterization. The uncertainty section also contains specific evaluations of the COPECs.

7.7.1 Uncertainties in Problem Formulation

Environmental concentrations of analytes in the soil, sediment, and surface water at LL 1 were based on a limited number of samples. A degree of uncertainty exists about the actual spatial distribution of constituents. Exposure concentrations could be overestimated or underestimated, depending on how the actual data distribution differs from the measured data distribution. Because the estimated 95% UCL of the mean concentrations or maximum detected concentration was used as the EPC concentration to calculate HQs, the estimates of risk from COPECs are conservative (i.e., protective). Using 95% UCL or maximum concentrations decreases the likelihood of underestimating the risk posed by each COPEC and increases the likelihood of overestimating the risk.

The full distribution and abundance of organisms comprising the ecological receptors at LL 1 has not been quantified by field studies. The lack of quantitative data introduces uncertainties concerning whether, and to what extent, the risk characterization based on the selected receptor species underestimates or overestimates the risk to organisms that were not used in the risk computations but that occur at LL 1. On-site reconnaissance has established the nature and quality of habitat and has confirmed the presence of vegetation types and of active, visible animal species. Observations made during this reconnaissance justify assumptions about the presence of unobserved organisms that are essential to normal ecosystem functioning, such as soil-dwelling worms and arthropods and herbivorous insects. This area falls within the acceptable range of each species. Note that the extrapolations of no ecological effects at WBG may moderate this type of uncertainty and show HQs at LL 1 to be an overestimate of risk.

It is possible that one (or more) unobserved species at LL 1 is more sensitive than the ecological receptors for which toxicity data are available for use in the ERA. It does not necessarily follow that these unevaluated, more sensitive species are at significantly greater risk than the species estimated in this SERA because exposure concentrations for ecological receptors in this SERA could be greater than those for more sensitive receptors due to different dietary regimes.

7.7.2 Uncertainties in Exposure Assessment

The actual movement of analytes from the LL 1 constituent source media to ecological receptors has not been measured for this ERA. This introduces uncertainties about the actual modes and pathways of exposure, bioavailability of constituents, and the actual exposure concentrations of these analytes to the ecological receptors. Actual exposure concentrations can differ from the measured environmental concentrations as a result of physical and chemical processes during transport from source to receptor and as a result of biomagnification through the food web. Actual exposure concentrations in physical media are sometimes less than the total measured concentrations because a portion of the total constituent is not bioavailable to the receptors. These processes have not been evaluated quantitatively in this ERA. Thus, the exposures could be overestimated based on the total measured concentration. In contrast, although bioaccumulation was estimated for those receptors ingesting food for which toxicity thresholds are available, it is possible that exposure to top predators was underestimated because biomagnification of certain constituents in certain prey could have been underestimated.

The modes and pathways used to characterize the exposure to ecological receptors are the most important ones for the relatively large and active species in terrestrial habitats. Soil-dwelling terrestrial animals may be exposed to constituents in soil by way of inhalation following volatilization, but gaseous concentrations in soil interstices, cavities, and burrows were not available for LL 1. Therefore, the exposure to burrowing organisms at the site from contaminated soil and soil interstitial water may be underestimated if gas concentrations are larger than soil concentrations, which is unlikely. Risk also will be underestimated if toxicity thresholds are lower for inhalation than they are for ingestion. Conservative exposure estimates were used for absorption of COPECs from soil (1.0) and absorption from tissue (1.0). Overestimating exposure by using conservative exposure concentrations is thought to counterbalance the underestimation of exposure that results from neglecting certain exposure modes and pathways of lesser importance, such as inhalation. Additional uncertainties are inherent in ingestion rates and dietary fractions of plants and animals.

Uptake factors from soil to earthworms (BAF_i) are not available for many elements, including thallium and several organics. Instead, default values were used. It is not known whether this substitution overestimates or underestimates exposure. However, the default values are thought to be conservative, so it is likely that exposures will not be underestimated.

Estimates of the contaminant concentrations in aquatic biota (i.e., fish) were calculated using published BCFs. BCFs account for the pathway of direct uptake of contaminants from surface water into fish. Uptake of contaminants into aquatic biota from their ingestion of sediment and food was not accounted for by the BCFs, thereby potentially underestimating their body burden of contaminants and the subsequent dose and risk to the fish-eating terrestrial predators. The BCF was assumed to be an appropriate tool for estimating contaminant uptake for the SERA because fish have direct and constant contact with surface water via their gills, and the gills offer a large surface area of very permeable tissue to facilitate uptake from water. If further investigation is deemed necessary after completion of this SERA, additional, more detailed exposure pathways for aquatic biota and fish-eating terrestrial predators could be examined to evaluate exposure from dietary intake of sediment and contaminated food. For example, the following pathways could be examined:

- sediment to biota, using the biota to sediment accumulation factor (BSAF) per EPA (1994); or
- sediment-to-pore water-to-food-to-fish-to fish-eating terrestrial predators.

The BSAF is defined as the ratio of the contaminant concentration in fish lipids to the organic carbon normalized contaminant concentration in sediment, and it accounts for uptake by all mechanisms such as ingestion of sediment and food. The methodology for the BSAF was developed for estimating concentrations of dioxin-like contaminants in fish for use in human health risk assessment. The sediment-to-pore water-to-food-to-fish-to-fish-eating terrestrial predators pathway would use equilibrium partitioning or Kds to estimate pore water concentrations of contaminants from the sediment concentrations, then use published BCFs to estimate body burdens of the sediment biota (food for the fish). In the BERA, the fish body burdens would then be estimated using published BAFs and ingestion rates to derive their contaminant body burdens from ingestion of food.

Literature-derived factors to describe dietary intake and bioaccumulation of elements may not reflect actual diets and bioaccumulation at the site. However, the literature values are assumed to be sufficiently similar to site-specific values that exposures neither will be underestimated nor overestimated.

Exposure concentrations are likely to be overestimated because of conservative exposure factors. Exposure factors include published bioaccumulation factors, irrespective of species and environmental conditions. In particular, it should be noted that, while the largest bioaccumulation factors may overestimate bioaccumulation at LL 1 by at least one order of magnitude for some COPECs, very high bioaccumulation, as well as biomagnification, are well-documented for other constituents, although not necessarily all those likely detected.

Conservative AUFs and TUFs of 1.0 are rather routine for the screening ERA, but they represent another uncertainty. A conservative AUF of 1.0 for small home-range receptors and the barn owl as a T&E species surrogate is simply a mathematical ratio that states that the EU is larger than the ecological receptor's home range. Even though the receptor's home range can be smaller than the area of the EU, there is no assurance that the receptor does all of its feeding on the EU because the habitat on the EU might not provide all the receptor's needs. Thus, the AUF might overestimate the exposure. Another situation involves the wide-ranging predators like the fox whose home range may include several EUs and, therefore, overestimate or underestimate risk. Similarly, the conservative TUF of 1.0 is a mathematical ratio that states that the time spent by the receptor on the EU is 100% of its time. The TUF might also overestimate actual exposure for the same reasons described for AUFs or if the receptor migrates off the EU part of the year.

Regarding exposure to the mallard duck, the emphasis was placed on exposure to chemicals in surface water and not in sediment. The lack of modeled exposure to sediments means that exposure and risks are likely underestimated for mallard ducks. However, the magnitude of underestimated risks to the mallard is likely small due to the small AUF (0.007) for the EU and to the small amount of dietary sediment ingested (<2%) by mallards.

Regarding exposure to the T&E barn owl, there were conservative adjustments to exposure as well as to effects. For example, a conservative AUF was set at 1, even though the site-specific AUFs would have ranged between 0.001 and 0.03 on the smaller EUs and 0.7 for the Perimeter Area. Thus, exposure was maximized by factors up to 1,000-fold, resulting in large overestimates of actual exposure.

Finally, the exposure of plants and animals to constituents below detection limits was not considered in the ERA. In addition, the exposure of ecological receptors to tentatively identified compounds is not considered, which could result in an underestimation of exposure.

7.7.3 Uncertainties in Effects Assessment

Toxicity thresholds for all receptors except earthworms were based on concentrations reported to have no or little effect on the test organism or were estimated conservatively from published toxicity data as provided in Appendix S. The TRVs for earthworms are based on LOAELs. TRUs for vegetation were derived with methods similar to how earthworm TRUs were developed and, therefore, plant TRUs are more like LOAELs than NOAELs. Dietary limits for the terrestrial wildlife receptors that were used as threshold levels for soils were derived from NOAELs or LOAELs using multiplier factors of 1 or 10 (Sample et al. 1996), with 10 being the most conventional one. These thresholds would underestimate the risks only to organisms at LL 1 that are considerably more sensitive than the study organisms. They are more likely to overestimate the risk to organisms that are equally or less sensitive than the study organisms. The possibility remains that some thresholds were set at levels at or above which some harm would occur to organisms at LL 1.

The calculated risks to the ecological receptors at LL 1 are the risks of individual analytes. The risks from exposure to multiple analytes depend on their interactions; effects could be greater or lesser than those from the individual analytes. This ERA provides findings for COPEC-specific risk estimates. An evaluation of risk from COPEC mixtures cannot be conducted without additional data and evaluation of alternative models of COPEC interaction. Although hazard indices (sum of individual HQs) are computed and provided in the Appendix HQ tables, such values are not discussed. Regardless, the HIs have uncertainties associated with grouping all the HQs together as if there were one single mode of action when there are actually several modes of action (e.g., neurotoxics, hepatic).

There are no available TRVs for some analytes, especially organics, for all ecological receptors considered. This contributes to uncertainty associated with likely underestimates of risk. This lack of data makes an analyte a COPEC of uncertain risk until it undergoes the HQ analysis in the EU- and receptor-specific screen. Then, if an analyte did not have a TRV and a HQ could not be calculated, it was dropped and handled here in the Uncertainty section, because only constituents with HQs greater than 1 were considered COPECs.

Additional uncertainty exists as to the pertinence of individual organism toxicity for characterizing the risk to populations and ecosystems. It is possible that populations may compensate for the loss of large numbers of juveniles or adults with increased survival or birthrates, and habitats or ecosystems may possess functionally redundant species that are less sensitive to constituents. Although LL 1 habitats surely possess these buffering mechanisms, a conservative approach is still justified to risk assessment based on organismal toxicity thresholds (i.e., NOAELs). Note that some of these uncertainties may be tempered when the extrapolations of no ecological effects are applied from WBG to LL 1.

7.7.4 Uncertainties in Risk Characterization

The uncertainties described above ultimately produce uncertainty in the quantification of current and future risks to terrestrial and aquatic animals at LL 1. Four additional areas of uncertainty in the risk characterization exist: off-site risk, cumulative risk, future risk, and background risk.

7.7.4.1 Off-site risk

The risks to off-site receptors could be characterized with the benefit of clearly identified body burden data from on-site receptors, pathways (especially any surface water pathways), as well as any constituent tracer studies and off-site plant, animal, and habitat surveys. Off-site receptors can be exposed to constituents via physical and organismal transport processes, but evaluating the magnitude of this exposure would require additional studies. It is unlikely that off-site receptors would have lower toxicity thresholds for constituents than the thresholds used for on-site receptors. In addition, there is little reason to expect that constituents migrating off-site would be concentrated above measured concentrations at LL 1 unless a constituent bioconcentrates in organisms that migrate on and off the site. In general, the risk to most off-site receptors is likely to be overestimated, rather than underestimated, by the risk estimate for on-site receptors.

7.7.4.2 Cumulative risk

The ERA estimates the risk to populations of ecological receptors from individual constituents. Yet, in nature, receptors are exposed simultaneously to mixtures of constituents. Generally, the methods used are sufficiently conservative, resulting in individual risks that are overestimated. Nevertheless, cumulative risk is possible when several living plants and animals are affected simultaneously, as inferred in Section 7.7.3 about uncertainties in effects. Harmful effects in ecosystems (including effects on individual organisms) may cascade throughout the system and have indirect effects on the ability of a population to persist in the area even though individual organisms are not sensitive to the given constituents in isolation. Therefore, the ecological risk characterization for LL 1 may underestimate actual risks to plants and animals from cumulative risks. The use of the HI addresses parts of this concern. This may be modified, given the nature of the WBG biological studies in which the effects of on-site chemicals and cumulative risk were documented.

7.7.4.3 Future risk

A third area of uncertainty in the ecological risk characterization is the future risk to plants and animals from contamination at LL 1. The ERA characterizes the current risk based on chronic exposure to measured concentrations of toxicants with the potential to persist in the environment for extended periods of time. HQs for animals estimate the risk to animal species that would be natural parts of future successional stages at these areas. Nevertheless, possible mechanisms exist that could significantly increase (e.g., erosion, leaching to surface water or groundwater) or decrease (e.g., enhanced microbial degradation) the risk to future plants and animals at the sites.

7.7.4.4 Background risk

Another source of uncertainty is ecological risk relative to background conditions. Although only inorganics with concentrations above background were examined in the COPEC screening, some COPECs are above background only by statistically small amounts. The conservative approach to comparing site concentrations to background likely overestimates the risk from COPECs compared to background.

7.7.5 Summary of Uncertainties

The most important uncertainties in the LL 1 SERA are those surrounding the estimates of the constituent concentrations to which ecological receptors are actually exposed (exposure concentrations) and the concentrations that present an acceptable level of risk of harmful effects (toxicity reference values or thresholds). These uncertainties arise from multiple sources, but especially from the lack of site-specific data on constituent transport and transformation processes, bioavailability of contaminants, organism toxicity, animal behavior and diet, population dynamics, and the response of plant and animal populations to stressors in their environments. Despite these uncertainties, the available site-concentration data and published exposure and effects information should allow COPECs (HQs >1 and HIs >1) to be identified for specific EUs, specific media, and specific receptors. Thus, the purpose of the SERA is fulfilled.

7.8 SUMMARY OF THE SCREENING ECOLOGICAL RISK ASSESSMENT

A screening ERA was performed in accordance with written guidance from the EPA and Ohio's water quality standards (Ohio EPA 1999). This guidance recognizes step-by-step procedures. The Ohio water quality standards are applicable or relevant and appropriate requirements and the first benchmarks to be utilized when evaluating surface water conditions. Following this comparison, surface water, sediment, and soil concentrations are compared to ecological screening levels. The present SERA adheres to an ERA process that includes problem formulation, followed by exposure assessment and effects assessment, and culminating in risk characterization with attention to uncertainties and summarization. The ERA is of the screening type (SERA).

The site contains sufficient terrestrial and aquatic (surface water and sediment) habitat to support various classes of ecological receptors. For example, terrestrial habitats at LL 1 include old fields, woodlots, and grassy areas. Various classes of receptors, such as vegetation, small and large mammals, and birds, have been observed at the site. Thus, the presence of suitable habitat and observed receptors at the site warrants a screening ecological risk assessment.

An initial step compared the maximum concentrations at each EU location on LL 1 to the EU-specific background concentrations. Analytes whose concentrations exceeded the background concentrations were considered SRCs and entered the pre-screening step in which the EU-specific RMEs were compared to Ohio EPA's ambient water quality criteria or, in their absence, to preferred toxicity screening values. Analytes whose EU-specific concentrations exceeded the Ohio EPA's water quality criteria or preferred toxicity screening values, or that lacked ESVs or were considered PBT compounds, were called "analytes that exceeded the ESV and PBT screens," or preliminary COPECs.

The preliminary COPECs were retained for further evaluation in a second screen, an EU- and receptor-specific screening for each of the ecological receptors for the medium, using the EU-specific RMEs and receptor-specific NOAEL TRVs (whenever available). Analytes with an HQ greater than 1 after the EU- and receptor-specific screen were considered COPECs.

In the second screen, the current and future risks to ecological receptors from COPECs at LL 1 and nearby aquatic EUs were characterized by evaluating HQs according to ecological assessment endpoints. HQs were calculated for several different receptors for every analyte that exceeded background concentrations, the ESVs in the EU-specific ESV screen, and for which a TRV was available from published information. Each HQ compared two concentrations: the analyte EPC in soil or other media or dietary dose from soil or other media to which a given receptor is exposed, and the toxicity reference value for the analyte and receptor. The TRV is the dietary limit or other threshold concentration expected to cause no harm to the receptor, minimal harm with no ecological significance, or minimal harm to a community of organisms (i.e., assemblage of species) exposed to the COPEC in that medium. Thus, the TRV is meant to be a safe or protective concentration.

Of the many observed plant and animal taxa, five terrestrial classes (vegetation, soil-dwelling invertebrates, worm-eating and/or insectivorous mammals, mammalian herbivores, and terrestrial top predators) were selected for terrestrial receptors. For aquatic classes, sediment-dwelling organisms, aquatic organisms, and terrestrial top predators of aquatic organisms were selected.

From the regulatory viewpoint, an HQ >1 has negative connotations for ecological receptors in the environment. From a technical viewpoint, a range of HQs strongly implies a range of risk. For example, a HQ >1,000 means more concern or ecological risk than a HQ >1 or >10 or >100. The basis for these categories is professional judgment based on numerous ecological risk assessments. The use of such a simple method to organize HQs is designed to help risk management, not to supplant this responsibility that is related but different from risk assessment. However, full acknowledgement was given to any analyte with a HQ of 1 or higher based on the EU- and receptor-specific screening by deeming the analyte a COPEC.

The regulatory exit strategy is the baseline risk assessment for screening risk assessments that show HQ >1. There are three options to the baseline ERA (1) re-calculation of site risks based on more precise exposure parameters, (2) use of RVAAP-specific biological measurements, e.g., ground-truthing, as previously mentioned in the text, and (3) evaluation of actual remedial options in the feasibility study. Usually, activity 1 precedes activity 2. Ground-truthing by skilled biologists would emphasize field-observed effects and manifest risk, rather than mathematical manipulations, to reach recommendations about protection of the environment while remedial action in the Feasibility Study would be an additional exit strategy.

7.8.1 Soil Ecological Chemicals of Potential Ecological Concern (Persistent, Bioaccumulative, and Toxic Compounds and/or Hazard Quotients >1)

Ecological COPECs in soil were

- **Water Tower:**

PBT Compounds
- cadmium
- lead
- mercury
- zinc

HQs ≥ 1
- cadmium
- chromium
- iron
- lead
- nickel
- zinc

- **CB-3 and CB-801:**

PBT Compounds
- cadmium
- lead
- mercury
- zinc
- anthracene
- benzo(a)anthracene
- benzo(a)pyrene
- benzo(b)fluoranthrene
- benzo(g,h,i)perylene
- benzo(k)fluoranthene
- bis(2-ethylhexyl)phthalate
- chrysene
- di-n-butylphthalate
- dibenzofuran
- fluoranthrene
- fluorene
- pentachlorophenol
- phenanthrene
- pyrene
- 4,4'-DDT
- dieldrin
- methoxychlor
- Aroclor-1254
- gamma-chlordane

HQs ≥ 1
- aluminum
- antimony
- arsenic
- barium
- cadmium
- chromium
- iron
- lead
- manganese
- mercury
- zinc
- benzo(a)pyrene
- 4,4'-DDT
- dieldrin
- Aroclor-1254

- **CB-4/4A and CA-6/6A:**

PBT Compounds	HQs ≥ 1
- cadmium	- aluminum
- lead	- arsenic
- mercury	- cadmium
- zinc	- chromium
- anthracene	- copper
- benzo(a)anthracene	- iron
- benzo(a)pyrene	- lead
- benzo(b)fluoranthrene	- manganese
- benzo(g,h,i)perylene	- mercury
- benzo(k)fluoranthene	- selenium
- bis(2-ethylhexyl)phthalate	- thallium
- butylbenzylphthalate	- vanadium
- chrysene	- zinc
- dibenzofuran	- 4,4'-DDT
- fluoranthrene	- dieldrin
- fluorene	- 1,3-dinitrobenzene
- phananthrene	- 2,4,6-trinitrotoluene
- pyrene	- RDX
- 4,4'-DDE	
- 4,4'-DDT	
- dieldrin	
- heptachlor	
- heptachlor epoxide	
- methoxychlor	
- Aroclor-1016	
- Aroclor-1254	
- alpha-chlordane	
- gamma-chlordane	

- **CB-13 and CB-10:**

PBT Compounds	HQs ≥ 1
- cadmium	- aluminum
- lead	- arsenic
- mercury	- cadmium
- zinc	- chromium
- anthracene	- copper
- benzo(a)anthracene	- iron
- benzo(a)pyrene	- lead
- benzo(b)fluoranthrene	- manganese
- benzo(g,h,i)perylene	- mercury
- benzo(k)fluoranthene	- selenium
- chrysene	- vanadium
- fluoranthrene	- zinc
- fluorene	- Aroclor-1254
- phenanthrene	- 2,4,6-trinitrotoluene
- pyrene	- RDX
- fluorene	
- phananthrene	
- pyrene	

- heptachlor
- Aroclor-1254
- gamma-chlordane

- **CB-14, CB-17, and CA-15:**

PBT Compounds	HQs ≥ 1
- cadmium	- aluminum
- lead	- arsenic
- mercury	- cadmium
- zinc	- chromium
- anthracene	- iron
- benzo(a)anthracene	- lead
- benzo(a)pyrene	- manganese
- benzo(b)fluoranthrene	- mercury
- benzo(g,h,i)perylene	- nickel
- benzo(k)fluoranthene	- thallium
- bis(2-ethylhexyl)phthalate	- zinc
- chrysene	- Aroclor-1254
- di-n-butylphthalate	- RDX
- dibenzo(a,h)anthracene	
- dibenzofuran	
- fluoranthrene	
- fluorene	
- phananthrene	
- pyrene	
- Aroclor-1254	
- alpha-chlordane	
- gamma-chlordane	
- methoxychlor	

- **Perimeter Area:**

PBT Compounds	HQs ≥ 1
- cadmium	- aluminum
- lead	- arsenic
- mercury	- cadmium
- zinc	- chromium
- benzo(b)fluoratnthrene	- iron
- fluoranthrene	- lead
-	manganese
-	mercury
-	selenium
-	vanadium
-	zinc

7.8.2 Sediment Ecological Chemicals of Potential Ecological Concern (Persistent, Bioaccumulative, and Toxic Compounds and/or Hazard Quotients >1)

Ecological COPECs in sediment are as follows:

- **Outlets A and B Channel:**

PBT Compounds	HQs ≥ 1
- cadmium	- arsenic
- lead	- cadmium
- mercury	- chromium
- zinc	- copper
- Aroclor-1254	- lead
- endrin	- mercury
- gamma-chlordane	- nicklel
- anthracene	- zinc
- benzo(k)fluoranthene	- 2,4,-dinitrotoluene
- benzo(g,h,i)perylene	- gamma-chlordane
- dibenzo(a,h)anthracene	- fluoranthene
- di-n-butylphthalate	- endrin
- dibenzofuran	- acenaphthene
- fluorene	- anthracene
- phenanthrene	- benzo(a)anthracene
- benzo(a)anthracene	- benzo(a)pyrene
- benzo(a)pyrene	- benzo(b)fluoranthene
- benzo(b)fluoranthene	- benzo(g,h,i)perylene
- chrysene	- benzo(k)fluoranthene
- fluoranthene	- chrysene
- pyrene	- dibenzo(a,h)anthracene
-	di-n-butylphthalate
-	fluorene
-	indeno(1,2,3-cd)pyrene
-	naphthalene
-	phenanthrene
-	pyrene
-	1,3,5-trinitrobenzene

- **Outlet C Channel and Charlie's Pond:**

PBT Compounds	HQs ≥ 1
- cadmium	- arsenic
- lead	- cadmium
- mercury	- lead
- Aroclor-1254	- 4,4'-DDE
- benzo(a)anthracene	- 2,6-dinitrotoluene
- benzo(a)pyrene	
- benzo(b)fluoranthene	
- benzo(g,h,i)perylene	
- benzo(k)fluoranthene	
- chrysene	
- fluoranthrene	
- phenanthrene	
- pyrene	

- **Outlets D, E, and F Channel and Criggy's Pond:**

PBT Compounds	HQs ≥ 1
- cadmium	- arsenic
- lead	- cadmium
- mercury	- chromium
- zinc	- copper
-	lead
-	mercury
-	nickel
-	zinc

- **North Area Channel:**

PBT Compounds	HQs ≥ 1
- cadmium	- nickel
- lead	
- mercury	

- **Off-AOC:**

PBT Compounds	HQs ≥ 1
- cadmium	- arsenic
- mercury	- copper
-	1,3-dinitrobenzene

7.8.3 Surface Water Chemicals of Potential Ecological Concern (Persistent, Bioaccumulative, and Toxic Compounds and/or Hazard Quotients >1)

Ecological COPECs in surface water are as follows:

- **Outlet C Channel and Charlie's Pond:**

PBT Compounds	HQs ≥ 1
- lead	- iron

- **Outlets D, E, and F Channel and Criggy's Pond:**

PBT Compounds	HQs ≥ 1
- none	- none

- **Off-AOC:**

PBT Compounds	HQs ≥ 1
- lead	- iron
- bis(2-ethylhexyl)phthalate	- manganese

In summary, there are COPECs (PBT compounds and/or HQs >1) for soil at all the terrestrial EUs, for sediment at all five EUs, and for surface water at two of the three EUs. The soil COPECs included many by virtue of HQs greater than 1 (highest was five orders of magnitude greater than 1, with several others at three or four orders higher than 1), as well as many PBT compounds. The soil COPECs included numerous inorganics, many SVOCs and pesticides, a couple of PCBs, and several explosives. For soils, the HQs for Aroclor-1254 for owls, shrews, mice, and robins (110,000, 49,100, 53,000, and 34,300, respectively) at EU CB-4, 4A and CA-6, 6A were the highest observed in the SERA. The HQs for iron for plants were the next highest (exceeding 2,000 at all six EUs). Several inorganics (cadmium, chromium, iron, lead, and zinc) had HQs that exceeded 1 at all six EUs. Explosives were COPECs by virtue of HQs greater than 1 at three soil EUs: CB-4, -4A and CA-6, -6A; CB-14, CB-17, and CA-15; and CB-13 and CB-10. The CB-4, -4A and CA-6, -6A EU had the highest number of soil COPECs (14 inorganic, 2 pesticides, and 3 explosives with HQs greater than 1, and 14 SVOCs, 8 pesticides, and 2 PCBs that were PBT compounds). The large number of COPECs at most of the terrestrial EUs, coupled with the large number of HQs between 100 and 999 and the many PBT compounds, suggests that terrestrial ecological receptors are at risk from COPECs in surface soil.

Of the five sediment EUs, Outlets A and B channel and Outlet C channel and Charlie's Pond contained the most COPECs. For example, Outlets A and B channel had eight inorganic, two pesticides, 17 SVOCs, and two explosive COPECs by virtue of their HQs greater than 1. In addition, this EU had one PCB COPEC by virtue of being a PBT compound. Thus, Outlets A and B channel had 30 COPECs. At EU Outlet C Channel and Charlie's Pond, there were three inorganic, one pesticide, and one explosive COPECs by virtue of HQs greater than 1, with one inorganic, nine SVOCs, and one PBC COPECs by virtue of being PBT compounds. Thus, this EU also had a total of 17 COPECs. The highest HQ (55) was for the explosive 1,3-dinitrobenzene at the off-AOC channel. Lead had the next highest HQs (34 and 32 at Outlets D, E, and F channels and Criggy's Pond and at Outlets A and B channel, respectively). The Outlets D, E, and F channel had eight inorganic COPECs with HQs greater than 1, four of which were also PBT compounds. The North Area channel only had four COPECs, all inorganic, including nickel (HQ = 1.1), and cadmium, lead, and mercury were PBT compounds. The off-AOC channel had five COPECs, including 1,3-dinitrobenzene (HQ = 55), arsenic (HQ=2), and copper (HQ=2), cadmium, and mercury were COPECs by virtue of being PBT compounds.

For surface water, iron was a COPEC in Outlet C channel and Charlie's Pond and in the off-AOC channel for aquatic biota, with HQs of 10 and 4, respectively. At the off-AOC channel EU, manganese was a COPEC for aquatic biota and mink, with HQs of 1.1 and 2, respectively. Lead was a COPEC for all aquatic receptors at the Outlet C channel and Charlie's Pond, as well as the off-AOC channel EUs by virtue of being a PBT compound. A PBT compound that was a COPEC for all the aquatic receptors was bis(2-ethylhexyl)phthalate at the off-AOC channel. Outlets A and B channel had no surface water.

Ecological risk has also been summarized in illustration form. Figures 7-4 through 7-7 show that ecological risk for explosives, PAHs, PCBs, pesticides, and selected metals associated with vegetation, earthworms, deer mice, and shrews. Figure 7-8 summarizes ecological risk for sediment-dwelling organisms based on the highest HQs. Note that the highest ecological risk is associated with deer mice and shrews at CB-4/4A and CB-6/6A because of PCBs.

In summary, one other surface soil from the six terrestrial EUs had the most COPECs and the highest HQs for the most receptors among the three media that were evaluated for this SERA. Thus, soils represent the medium with the highest potential risk to ecological (terrestrial) receptors at LL 1. Sediments at the five sediment EUs had fewer COPECs than the soil EUs, but potential risks to sediment-dwelling biota were also indicated. The surface water at the three surface water EUs had few or no COPECs, but they presented a few HQs greater than 1 as well as two PBT compounds. Thus, of the three media studied for this SERA, surface water appears to present the least amount of risk to ecological receptors.

There is an intent to extrapolate the results from the WBG findings to LL 1 and other AOCs at Ravenna that have similar environmental conditions such as soil types, habitats, chemical-use history, and intended land-use. Extrapolation means the transfer of knowledge from one situation to another situation. Extrapolation depends on the constancy of laws and principles that prevail in the natural world. Field-to-field extrapolations are superior to laboratory-to-field extrapolations and the details of this are being formulated by the USACE and the Ohio EPA.

VEGETATION RISK

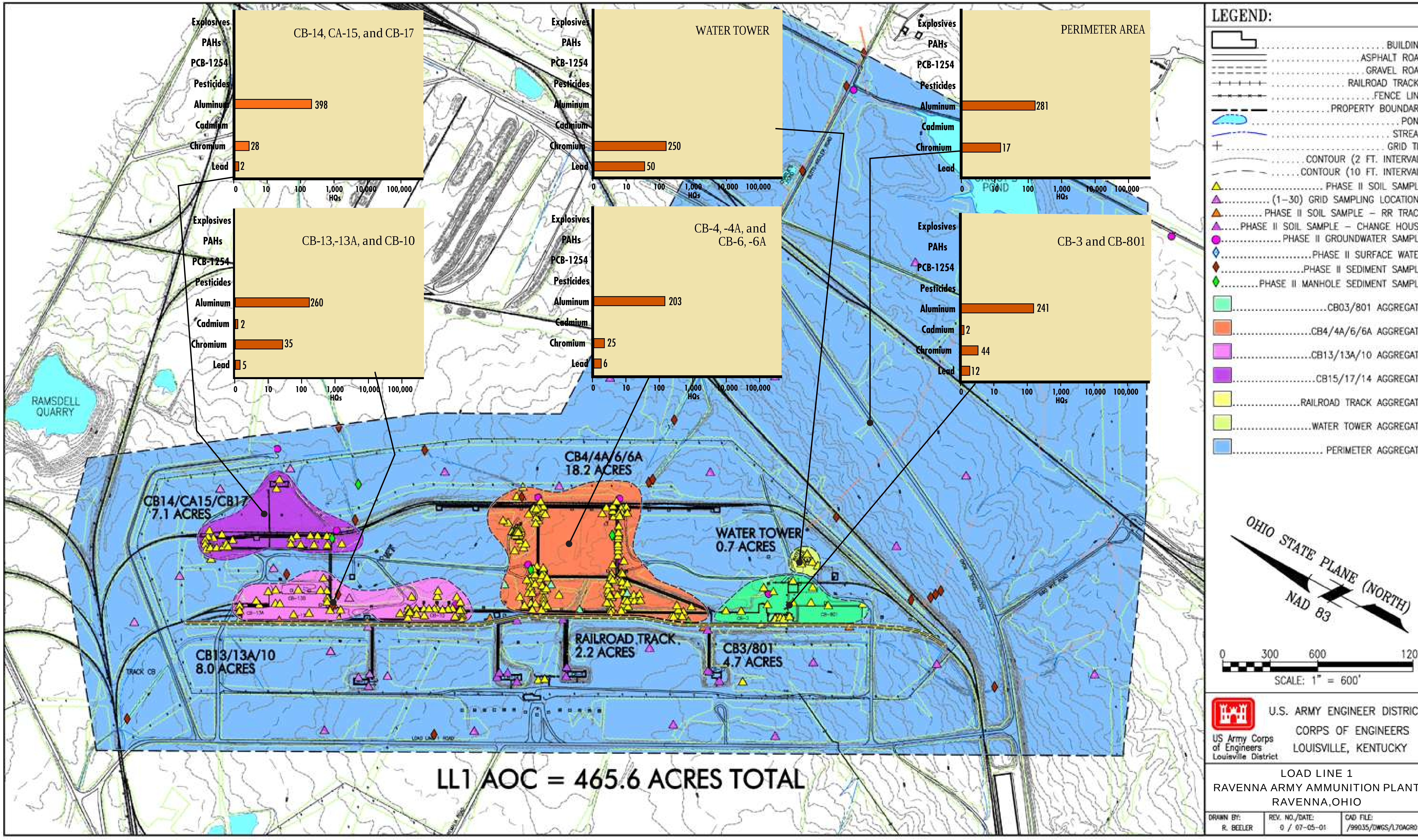


Figure 7-4. Summary of Ecological Risk to Vegetation in Soil Aggregates at Load Line I Phase II RI

EARTHWORMS RISK

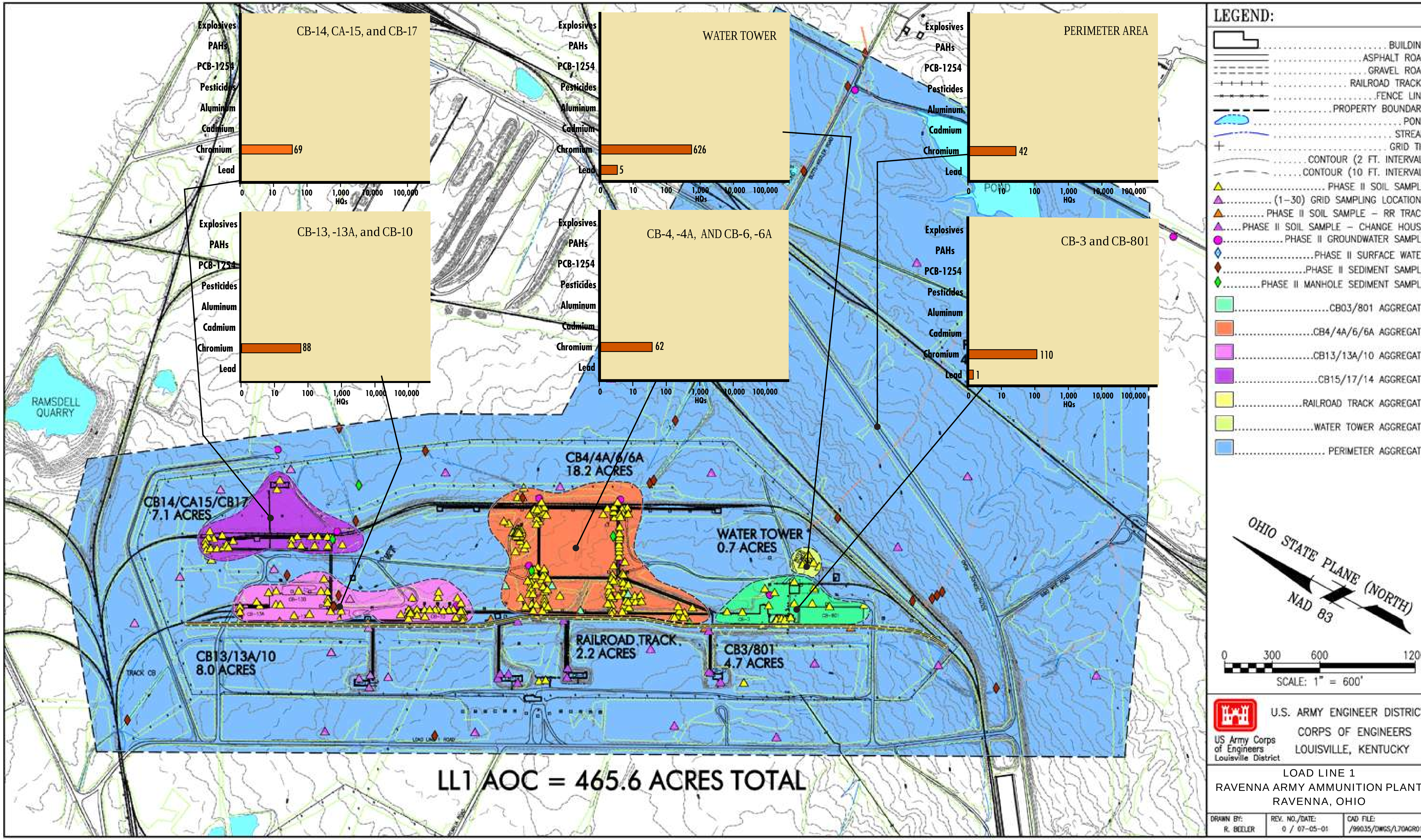


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Figure 7-5. Summary of Ecological Risk to Earthworms in Soil Aggregates at Load Line 1 Phase II RI

DEER MICE RISK

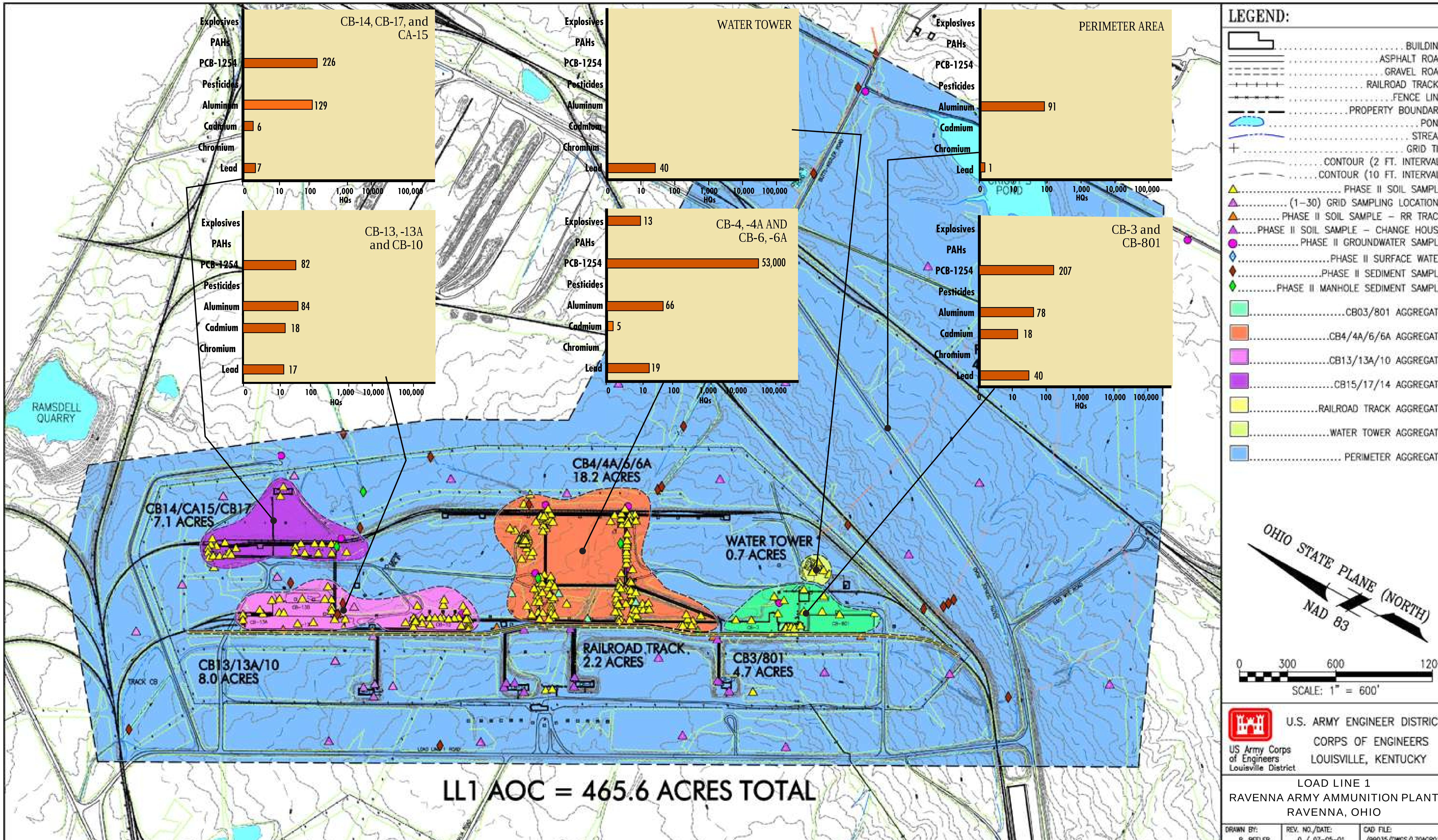

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Figure 7-6. Summary of Ecological Risk to Deer Mice in Soil Aggregates at Load Line I Phase II RI

SHREWS RISK

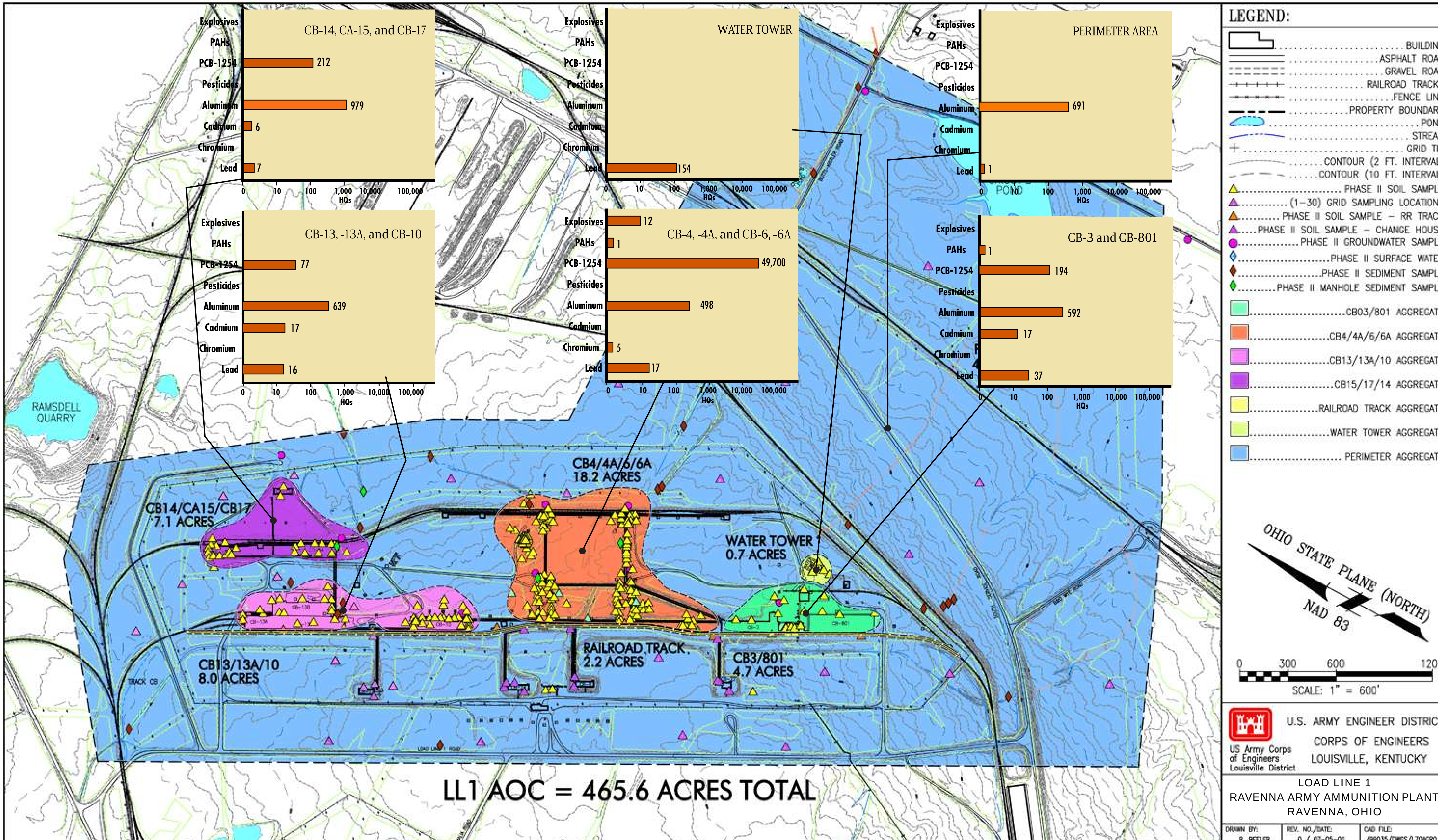

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Figure 7-7. Summary of Ecological Risk to Shrews in Soil Aggregates at Load Line I Phase II RI

SEDIMENT-DWELLING ORGANISMS

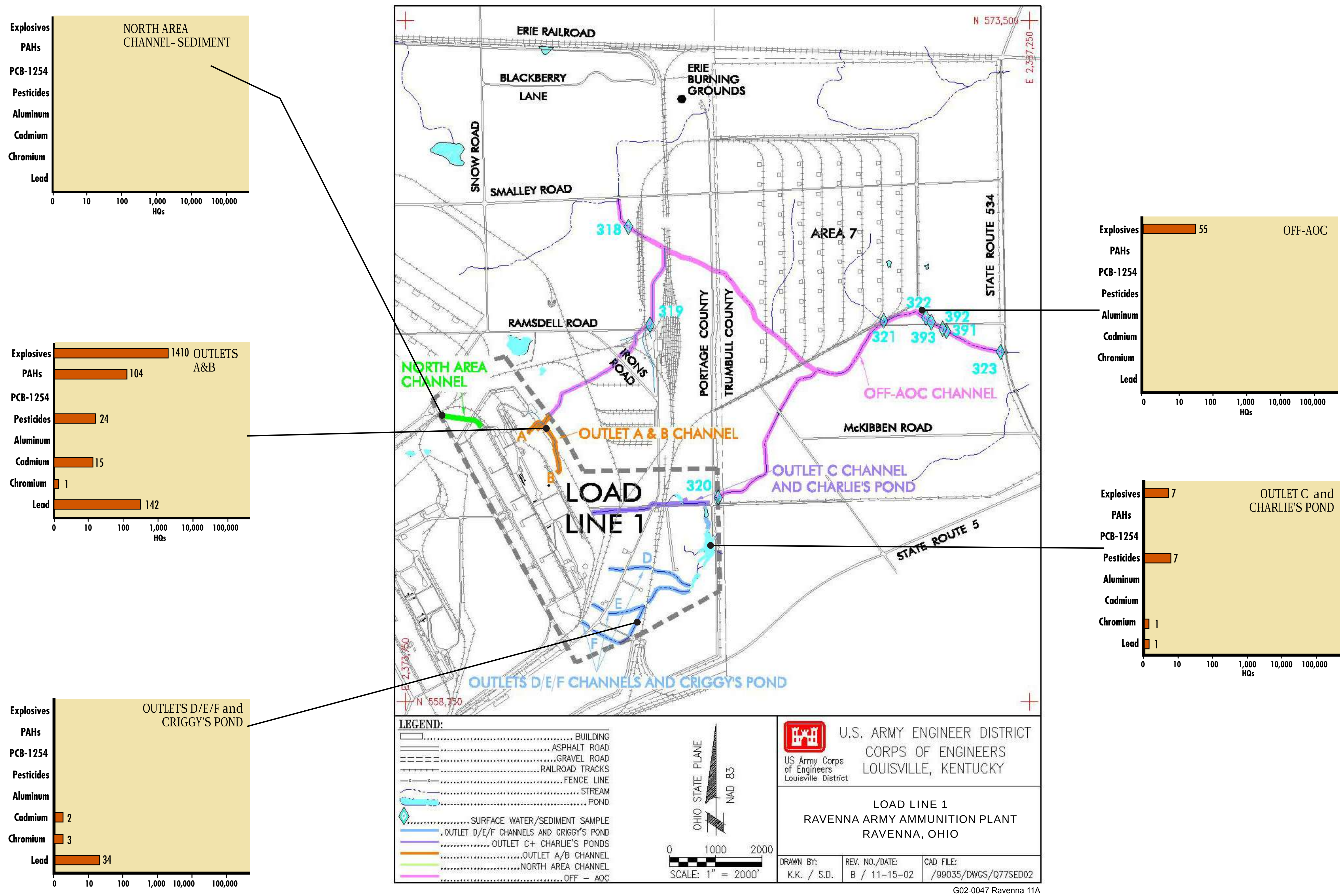

Figure 7-8. Summary of Ecological Risk for Sediment-Dwelling Organisms at Load Line I Aggregates by Drainage Area

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