7.0 SCREENING ECOLOGICAL RISK ASSESSMENT

An 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 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, or equivalent, is needed to evaluate the possible risk to plants and wildlife from current and future exposure to contamination at the Load Line 4. A BERA will follow completion of the SERA.

The initial regulatory guidance for an ERA is contained in EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume II, Environmental Evaluation Manual* (EPA 1989b) and in subsequent documents (EPA 1991b, 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 1989c). 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 1997c, 1998b) supersedes *RAGS, Volume II* (EPA 1989b). This latter guidance makes the distinction between the interrelated roles of screening and BERAs. Briefly, SERAs utilize conservative assumptions for exposures and effects, while a BERA means increasingly unit-specific, more realistic (and generally less conservative) exposures and effects. Newly published EPA guidance (EPA 1997c) was used because it provided the clearest information on preliminary or SERAs. The Army has a protocol for site-wide ERA at RVAAP. One of the cardinal points in this document is the value of extrapolation from one AOC to another. For example, extrapolation of findings at Load Line 1 to Load Line 4 is an important time-and cost-saving activity. Additionally, the Ohio EPA has guidance, and that too is being used, especially for the hierarchy for ecological screening values (ESVs) and toxicity reference values (TRVs) (Ohio EPA 2003). Emphasis was placed on Level I, Level II (SERA), and Level III (BERA).

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 RVAAP, USACE, Ohio EPA, and SAIC.

The following sections present the scope and objectives for SERA activities (Section 7.1); the procedural framework (Section 7.2); and the four steps necessary to complete the screening and extrapolation work, hereafter referred to as the SERA, with emphasis on problem formulation (Section 7.3). The results are presented in Section 7.4. Finally, there is an Uncertainties section (Section 7.5) and a Summary (Section 7.6) that comprise the final two sections of the SERA.

For the BERA or Tier III, the following sections present the scope and objectives (Section 7.7); the procedural framework (Section 7.8); and the problem formulation (Section 7.9). The results are presented in Section 7.10. There is an uncertainties section (Section 7.11) and a master summary of both SERA and BERA results (Section 7.12).

7.1 SCOPE AND OBJECTIVES FOR THE SCREENING ECOLOGICAL RISK ASSESSMENT

The scope of the SERA is to characterize, in a preliminary way, the risk to plant and animal populations at Load Line 4, 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 human health risk assessment, which focuses on individuals, the SERA focuses on populations or groups of interbreeding individuals. In the SERA process, individuals are addressed only if they are protected under the Endangered Species Act.

The SERA used site-specific analyte concentration data for surface soil, sediment, and surface water from various geographical parts of Load Line 4. Groundwater is not a medium of concern for ecological receptors. However, groundwater is expected to flow into the drainage ditches and ponds on Load Line 4. Groundwater is treated as surface water once it surfaces and mixes with existing surface water. Risks to ecological receptors that could be exposed to the media were evaluated by performing a multi-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 Army conducted ground-truthing investigations of plants and animals at WBG near Load Line 4 (SAIC 2002) and completed a draft final SERA for Load Line 1. These documents provided some of the framework for this SERA for Load Line 4. However, the screening process for surface soil at Load Line 4 is different from the process that was utilized for Load Line 1, per scope changes advanced by the Army, and as described below in Section 7.3.4.

7.2 PROCEDURAL FRAMEWORK

According to the *Framework for Ecological Risk Assessment* (EPA 1992c), the SERA 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 Load Line 4, these three phases were partially completed by performing four interrelated steps. Each has the following parts.

- **Problem Formulation:** Problem formulation establishes the goals, breadth, and focus of the SERA 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 can also include 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 7.4).

- **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 Load Line 4, in contrast to background (naturally occurring) risk, and to assess the potential for population and ecosystem recovery based on Load Line 1 findings (Section 7.4).

The SERA is organized by the four interrelated steps of the EPA framework. Sections 7.3 and 7.4 detail the technical issues and data evaluation procedures associated with each step. Section 7.5 evaluates the degree of reliability or uncertainty of these methodological steps and the data used. Finally, Section 7.6 provides the summary.

7.3 PROBLEM FORMULATION FOR THE SCREENING ECOLOGICAL RISK ASSESSMENT

The first step of EPA's approach to the SERA 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 CSM of Load Line 4 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); and
- identification of preliminary COPECs (Sections 7.3.4 and 7.3.5).

7.3.1 Ecological Conceptual Site Model

The ecological CSM of Load Line 4 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 CSM. Each part is briefly explained below.

- **Constituent Source and Source Media.** Constituent sources at Load Line 4 were defined in the introductory sections of this 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.

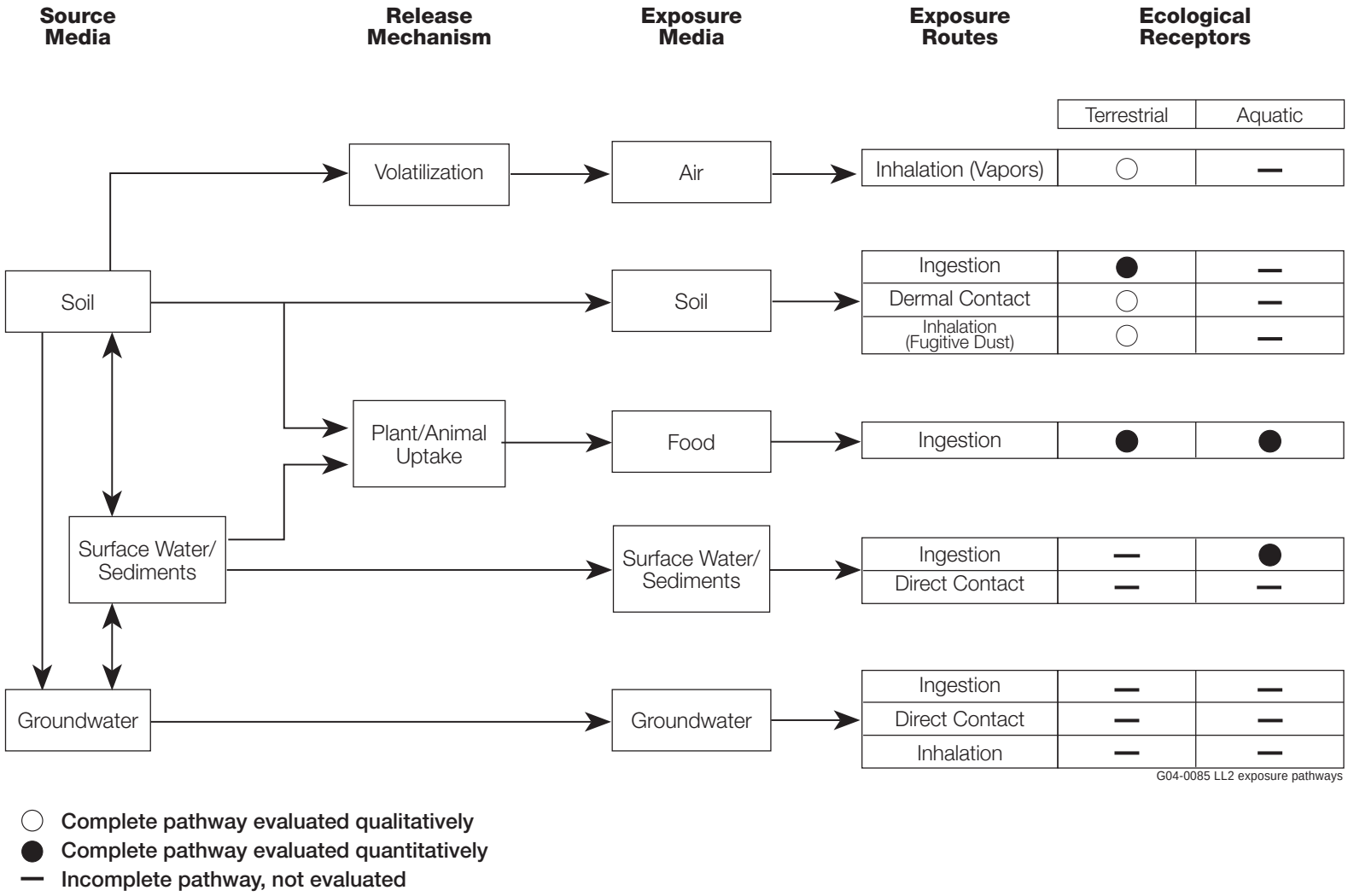


Figure 7-1. Exposure Pathways for Terrestrial and Aquatic Receptors

Sediment and surface water are also present in the creeks, drainage ditches, and small pond at Load Line 4. 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 where a complete pathway is possible. 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 complete 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 (Sample et al. 1996). By contrast, direct exposure to constituents in surface soil, sediment, and surface water are complete pathways for plants and earthworms, sediment-dwelling organisms, and fish, respectively. A complete exposure route is contact of biota with soils at Load Line 4. 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 CSM (Figure 7-1).

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 historical use of various processes: receiving, handling, and shipping. 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 (Figure 4-1). These proposed EUs for Load Line 4 are as follows:

Terrestrial EUs:

- Explosive Handling Areas Aggregate,
- Preparation and Receiving Areas Aggregate,
- Packaging and Shipping Areas Aggregate,
- Perimeter Area Aggregate, and
- Melt-Pour Area Drainage Ditches Aggregate.

Sediment EUs:

- Main Stream Segment Upstream Perimeter Road,
- Main Stream Segment and Settling Pond, and
- Exit Drainage.

Surface Water EUs:

- Main Stream Segment Upstream Perimeter Road,
- Main Stream Segment and Settling Pond, and
- Exit Drainage.

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 Description of Habitats and Populations

This section provides a description of the ecological resources at Load Line 4. Habitats and communities 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. All of this information shows that Level I in the Ohio EPA Guidance is met. There are ecological resources present in the form of vegetation and animal life in both terrestrial and aquatic ecosystems. Thus, Level II was justified.

7.3.3.1 Terrestrial habitats and plant communities

The Load Line 4 AOC occupies a total area of about 136 acres (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 Ravenna. Information on plant communities at Load Line 4 was gleaned from the *Plant Community Survey For The Ravenna Army Ammunition Plant* (SAIC 1999). The RVAAP plant community survey was based on a combination of color infrared and black-and-white aerial photogrammetry available from the mid-1990s and field surveys conducted in 1998 and 1999.

Table 7-1. Plant Communities and Other Habitat Recorded at Load Line 4

Plant Community Type	Acres	Area (%)
Forest Formations		
Fagus grandifolia - *Acer saccharum* - (*Liriodendron tulipifera*) Forest Alliance	5.72	4.2
Acer rubrum Successional Forest	44.28	32.4
Fraxinus pennsylvanica - *Ulmus americana* - *Celtis* (*occidentalis, laevigata*) Temporarily Flooded, Forest Alliance	3.31	2.4
Quercus palustris - (*Quercus bicolor*) Seasonally Flooded Forest Alliance	22.29	16.3
Shrubland Formations		
Dry, Mid-successional, Temperate, Cold-deciduous Shrubland	49.10	35.9
Herbaceous Formations		
Maintained Grassland	1.81	1.3
Typha spp.-(*Scirpus* spp.) Semipermanently Flooded Herbaceous Alliance	1.81	1.3
Open Water	3.64	2.7
Buildings	4.66	3.4
Total	136.62	100.0

7.3.3.1.1 Forest formations

Forest formations at RVAAP correspond to plant communities with closed tree canopies. Forest formations occupy approximately 13,330 acres at RVAAP. Note that some areas at RVAAP contain plant

communities dominated by tree species, but intermixed with patches of shrubs as a result of past disturbance. The following types of forest formations occur at the Load Line 4 AOC.

Lowland or submontane, cold-deciduous forests

***Fagus grandifolia – Acer saccharum – (Liriodendron tulipifera)* Forest alliance**

This forest alliance describes a diverse community common to mesic, gently sloping sites throughout the east-central United States and southern Canada. At RVAAP, many of the most mature upland stands correspond to this alliance. American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) dominate the canopy. Other common trees include yellow poplar (*Liriodendron tulipifera*), northern red oak (*Quercus rubra*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), American basswood (*Tilia americana*), various hickories (*Carya* spp.), and, occasionally, white oak (*Quercus alba*). Shrub and herbaceous species are generally sparse, probably as a result of heavy browsing by deer. Spicebush (*Lindera benzoin*), American hornbeam (*Carpinus caroliniana*), and eastern hop-hornbeam (*Ostrya virginiana*) were frequently observed in the understory. Mayapple (*Podophyllum peltatum*) and New York fern (*Thelypteris noveboracensis*) were frequently observed in the herbaceous layer. This community is located along the northwestern side of Load Line 4. This forest type makes up about 6 acres or 4.2% of the Load Line 4 AOC (Table 7-1).

***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 they are never 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 is located throughout the north-central and western sides of the Load Line 4 AOC; it makes up about 44 acres or 32.4% of the Load Line 4 AOC (Table 7-1).

Seasonally flooded, cold-deciduous forest

***Fraxinus pennsylvanica – Ulmus americana – Celtis* (*occidentalis, laevigata*) Temporarily flooded, forest alliance**

This forest alliance is associated with floodplains near streams and rivers and other temporarily flooded areas. Some of these areas may qualify as jurisdictional wetlands. Characteristic tree species include green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), hackberry (*Celtis occidentalis*), and red maple (*Acer rubrum*). Black walnut (*Juglans nigra*), white ash (*Fraxinus americana*), swamp white oak (*Quercus bicolor*), cottonwood (*Populus deltoides*), and black willow (*Salix nigra*) also are present. Sycamore (*Platanus occidentalis*) and silver maple (*Acer saccharinum*), two species often associated with floodplain forests, generally are not abundant at RVAAP. The understory and shrub layers are dense and include species such as American elm, northern arrowwood (*Viburnum recognitum*), silky dogwood (*Cornus amomum*), elderberry (*Sambucus canadensis*) and willows (*Salix* spp.). Herbaceous species include wingstem (*Verbesina alternifolia*), jewelweed (*Impatiens biflora* and *I. pallida*), false nettle (*Boehmeria cylindrica*), jack-in-the-pulpit (*Arisaema triphyllum*), smartweeds (*Polygonum* spp.), sedges (*Carex* spp.), and many others. Examples of this community occur in the southeastern, western, and northern sections of the AOC. This forest type makes up about 3 acres or 2.4% of the Load Line 4 AOC (Table 7-1).

***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. A large example of the alliance occurs in the southwestern and southeastern corners of the AOC. This forest formation makes up about 22 acres or 16.3% of the Load Line 4 AOC (Table 7-1).

7.3.3.1.2 Shrubland formations

Shrubland formations at RVAAP correspond to plant communities where the dominant life form is shrub. The term shrub corresponds to both true shrub species and young tree species (seedlings and saplings). For example, successional areas at RVAAP that contain young trees or young trees mixed with shrubs were classified as shrubland if the majority of the vegetation did not exceed 20 ft in height. Note that many areas at RVAAP that were classified as shrubland are successional areas comprised mostly of young trees mixed with shrubs (i.e., mature old fields). Without disturbance, many of these areas will probably develop into young forest communities within approximately 5 to 15 years. The following type of shrubland formations occur at the Load Line 4 AOC.

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. It is characterized by shrub species covering more than 50% of the area with relatively few large trees (~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 represents an advanced stage of an "Old Field Community." This community is present in the center of the Load Line 4 AOC. This shrubland formation makes up about 49 acres or 35.9% of the Load Line 4 AOC (Table 7-1).

7.3.3.1.3 Herbaceous vegetation formations

Herbaceous formations at RVAAP correspond to plant communities where the dominant life form is herbaceous (non-woody). Herbaceous formations occupy approximately 3,400 acres at RVAAP. The following types of herbaceous vegetation formations occur at the Load Line 4 AOC.

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. There are two areas of maintained grassland along the southern boundary of the Load Line 4 AOC. This grassland formation makes up about 2 acres or 1.3% of the Load Line 4 AOC (Table 7-1).

***Typha* spp.– (*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 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. A large example of this alliance is the marsh area adjacent to boundary fence in the north-central section of the AOC. This herbaceous formation makes up about 2 acres or 1.3% of the Load Line 4 AOC (Table 7-1).

Buildings

There are several buildings still standing within the Load Line 4 AOC. These areas occupy a total of 5 acres or 3.4% of the Load Line 4 AOC (Table 7-1).

7.3.3.2 Forestry resources, management, and unique habitats

Load Line 4 is within Forest Management Compartment 7 of the 10 compartments designated within the RVAAP and Compartment 7 has a total area of 2,860 acres. While each compartment is further subdivided into cutting units, the cutting unit boundaries reflect topographic features (e.g., creeks and roads) rather than forest types. Of Compartment 7's total area, 2,046 acres are in sawtimber (994 acres), poletimber (681 acres), and timber stands considered to be of adequate regeneration (371 acres). No specific timber stand improvement prescriptions are currently in place for Forest Management Compartment 7, although limited harvesting is scheduled as sawtimber clearing for powerline right-of-way maintenance. The timber harvest schedule for RVAAP forests shows Forest Management Compartment 7 being harvested during 2008 with an expected allowable harvest of over 600,000-board ft (Doyle Rule) (OHARNG 2001, Morgan 2003a).

Sensitive habitats and special interest areas

The Ohio Department of Natural Resources (ODNR) and the U. S. Fish and Wildlife Service did not identify any sensitive habitats on or near Load Line 4 during their natural heritage data searches (ODNR 1997). No Special Interest Areas have been designated within Load Line 4 (OHARNG 2001, Morgan 2003a). Special Interest Areas include communities that host state-listed species, are representative of historic ecosystems, or are otherwise noteworthy (OHARNG 2001).

Jurisdictional wetlands

There have been two jurisdictional delineations performed in recent years at RVAAP to support National Environmental Protection Agency requirements of specific project proposals. All of these maps and delineations are on file in the Ravenna Army Ammunition Plant (RTLS) Environmental Office (OHARNG 2001). No wetland delineations have been performed on the AOCs (Morgan 2003b). However, it is probable that jurisdictional wetlands would be found within Load Line 4 if a jurisdictional delineation were to be performed (Morgan 2003b).

7.3.3.3 Animal populations

The plant communities at RVAAP and Load Line 4 provide habitat that supports many species of animals. For RVAAP, results of 1992-1993 ODNR surveys included 27 mammals, 154 birds, 12 reptiles, 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, such as deer, are managed through hunts scheduled during the fall months (ODNR 1997).

For Load Line 4, about 40% is shrubland and about 40% is successional forest. The plant communities within the Load Line 4 AOC provide habitats that support many species of animals of the types listed above. About 40% of Load Line 4 is open shrubland habitat, about one-third is in red maple successional forest, and about one-fifth is in seasonally flooded forest. Common bird species that use the mid-stage successional habitat include the song sparrow (*Melospiza melodia*), field sparrow (*Spizella pusilla*), common yellowthroat (*Geothylpis trichas*), gray catbird (*Dumetella carolinensis*), rufous-sided towhee (*Pipilo erythrophthalmus*), American goldfinch (*Carduelis tristis*), and blue-winged warbler (*Vermivora pinus*). Common large mammals include white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and woodchuck (*Marmota monax*), while eastern cottontail (*Sylvilagus floridanus*), white-footed mouse (*Peromyscus leucopus*), short-tailed shrew (*Blarina brevicauda*), and meadow vole (*Microtus pennsylvanicus*) are common small mammals (ODNR 1997).

Woodland bird species, such as the wood thrush (*Hylocichla mustlina*), may be found within the red maple and pin oak stands found along the north side of the AOC. These woodlots and their edges may also provide habitat for species such as the red-eyed vireo (*Vireo olivaceous*), yellow-throated vireo (*Vireo flavifrons*), eastern wood-pewee (*Contopus virens*) and Acadian flycatcher (*Empidonax virescens*) in addition to permanent residents typified by the tufted titmouse (*Parus bicolor*), black-capped chickadee (*Parus atricapillus*), American crow (*Corvus brachyrhynchos*), bluejay (*Cyanocitta cristata*), and red-bellied (*Melanerpes carolinus*) and downy (*Picoides pubescens*) woodpeckers (ODNR 1997).

The pond and associated riparian habitat along the main stream drainage ditch channel support several animal species. Common wetland birds found are red-winged blackbirds (Agelaius phoeniceus), great blue herons (*Ardea herodias*), tree swallows (*Tachycineta bicolor*), wood ducks (*Aix sponsa*), and mallards (*Anas platyrhynchos*). Muskrat (*Ondatra zibethicus*) are likely inhabitants of most ponds (ODNR 1997).

7.3.3.4 Aquatic habitats

Aquatic EUs consist of perennial streams and a settling pond. There are other water bodies, especially ditches, but they are not full-fledged EUs because they are ephemeral. One major drainage occurs within Load Line 4, flowing onto the site from the west and emptying into the Load Line 4 Settling Pond. There is an outlet to the pond.

Streams and ditches

The Main Stream Segment Upstream of Perimeter Road Bridge Aggregate flows from Wilcox-Wayland Road Bridge for about 1,800 ft before flowing under the Perimeter Road Bridge. From this point, the Main Stream Segment and Settling Pond Aggregate continues another 2,000 ft and totals roughly 5 acres. The Settling Pond is drained by a stream (Exit Flow) flowing south across the site boundary. The Exit Flow Drainage Aggregate flows for about 1,200 ft from the settling pond to PF-8. These drainage aggregates 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.

Ponds

From the perimeter road bridge, the Main Stream Segment and Settling Pond Aggregate totals roughly 5 acres. This surface water body is wholly within the Load Line 4 boundary.

Currently, no specific information exists about the fish communities of the Load Line 4 settling pond. In general, there are 13 fish species associated with the ponds at the RVAAP and include bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosus*) and warmouth (*Lepomis gulosus*) sunfish, largemouth bass (*Micropterus salmoides*), grass pickerel (*Esox americanus vermicula*), mudminnow (*Umbra limi*) and golden shiner (*Notemigonus crysoleucas*) (ODNR 1997). Most ponds support between three and five species (ODNR 1997). The fish communities within the ponds appear to be the result of intentional and accidental introductions and account for species such as channel catfish (*Ictalurus punctatus*) and fathead minnows (*Pimephales promelas*) (ODNR 1997).

The planned end use for all RVAAP ponds is an unrestricted, recreational fishery (Morgan 2003b). The Load Line 4 Settling Pond normally is a catch-and-release fishery with no wading permitted, but the Load Line 4 area is currently off-limits (Morgan 2003b). The no-wading restriction was put in place to keep potentially contaminated pond sediments from being stirred up and re-suspended (Morgan 2003b).

7.3.3.5 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. None of these are known to exist within the Load Line 4 AOC (OHARNG 2001, Morgan 2003a).

Federal

No known federally listed T&E species have been documented on RVAAP (OHARNG 2001, Morgan 2003a). Although the federal endangered Indiana bat (*Myotis sodalis*) has been documented nearby (Morgan 1996), the Indiana bat was not identified during any surveys and is not known to occur on RVAAP (OHARNG 2001).

There are no federal-listed plants or animals currently known to occur at RVAAP. A site-wide bat survey was performed in 1999. Bat species captured included little brown bats, big brown bats, northern long-eared bats, red bats, and hoary bats. The Indiana bat (*Myotis sodalis*) was not identified in any of the surveys and does not occur on RVAAP (OHARNG 2001).

Several species listed as under Federal Observation (formerly Federal Candidate Species, Category 2) occur on RVAAP. These species include the Cerulean Warbler (*Dendroica cerulea*), Henslow's Sparrow (*Ammodramus henslowii*), and the butternut tree (*Juglans cinerea*) (ODNR 1997). None of these species have been documented at Load Line 4 (Morgan 2003a).

State

State-listed endangered species include three birds [Northern Harrier (*Circus cyaneus*), Common Barn Owl (*Tyto alba*), and Yellow-bellied Sapsucker (*Sphyrapicus varius*)], a lamprey [Mountain Brook Lamprey

(*Ichthyomyzon greeleyi*)], and a butterfly [Graceful Underwing (*Catocala gracilis*)] (ODNR 1997). None of these species have been documented at Load Line 4 (Morgan 2003a).

Portage County has more rare species, especially plants, than any other county in Ohio. This is reflected in the number of species occurring on RVAAP that are listed as State Potentially Threatened. These species include two trees [the gray birch (*Betula populifolia*) and the butternut (*Juglans cinerea*)], four woody species [Northern rose azalea *(Rhododendron nudiflorum* var. *roseum*), large cranberry (*Vaccinium macrocarpon*), hobblebush (*Viburnum alnifolium*), and fox grape (*Vitus labrusca*)], and four herbaceous species [round-leaved sundew (*Drosera rotundifolia*), closed gentian (*Gentiana clausa*), blunt mountain-mint (*Pychanthemum muticum*), and woodland horsetail (*Equisetum sylvaticum*)]. Two additional plant species that are suspected to occur on RVAAP are the long beech fern (*Phegopteris connectilis*) and eel-grass (*Vallisneria americana*) (ODNR 1997). None of these species have been documented at Load Line 4 (Morgan 2003a).

Species that are state-listed as of Special Concern [listed either by the Ohio Department of Wildlife (ODOW) or the Heritage Program (Heritage)] include the woodland jumping mouse (*Napaeozapus insignis*) (ODOW); four birds [the Solitary Vireo (*Vireo solitarius*) (Heritage), Sharp-shinned Hawk (*Accipiter striatus*) (ODOW), Sora (*Porzana carolina*) (ODOW), and Virginia Rail (*Rallus limicola*) (ODOW)]; and two herpetiles [the four-toed salamander (*Hemidactylium scutatum*) (ODOW) and the smooth green snake (*Opheodrys vernalis*) (Heritage)] (ODNR 1997). None of these species have been documented at Load Line 4 (Morgan 2003a).

7.3.4 Overview of Identification of Preliminary Chemicals of Potential Ecological Concern

The identification of preliminary COPECs was done through a systematic process involving both (1) standard SERA activities and (2) Load Line 1 extrapolations to Load Line 4. For soil, both activities were used, and the exact methods are shown in Figure 7-2 and presented in the text below. For sediment and surface water, only standard SERA activities were performed. Because Load Line 1 information was key to the Load Line 4 work, the methods for Load Line 1 are explained (Section 7.3.4.1) separately from Load Line 4 methods (Section 7.3.4.2).

7.3.4.1 Load Line 1: Identification of preliminary COPECs

For Load Line 1, the identification of preliminary COPECs began with the SRCs that were identified using the background and frequency of detection/WOE screens described in Chapter 4.0 of that RI for Load Line 1 (SAIC 2002). This pre-screening entailed comparing the EU-specific maximum concentrations against ESVs specified by Ohio EPA for protection of generic life. The pre-screening step is described in more detail below.

For Load Line 1, 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 MDLs) were dropped in Chapter 4.0. More specifically, analytes other than explosives and propellants must have been detected at a frequency of 5% or greater to be considered SRCs and be carried forward to the risk assessment (see Section 4.1). Additionally, a background screen was conducted, as explained in Chapter 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, methylene chloride, 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 Load Line 1, along with an indication of whether they were retained for further evaluation. Detected analytes

from the background and frequency of detection/WOE screens (Chapter 4.0) were identified as SRCs. The soil SRCs were carried forward to a multi-step, EU-specific pre-screening process for identifying the COPECs. The sediment and surface water SRCs were carried forward to a pre-screening process, which was EU-specific, by media, using MDCs and ESVs for protection of generic life.

Regarding EU-specific ESV screens for soil, Ohio EPA's preferences (Ohio EPA 2001) are, in order of preference, Efroymson et al. (1997a) PRGs; 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 1998a). These can be found in Appendix R, Table R-1.

Regarding the EU-specific ESV screens for sediment, Ohio EPA's preferences are, in order of preference, consensus-based sediment quality guidelines (MacDonald et al. 2000) and EPA Region 5 EDQLs (EPA 1998a). The preferred sediment ESVs are provided in Appendix R, Table R-2.

Regarding the EU-specific ESV screens for surface water, Ohio EPA's preferences are, in order of preference: State Water Quality Standards (WQSs), as given in Chapters 3745-1 and 3745-2 of the Ohio Administrative Code (OAC) for the Ohio River Basin (Ohio EPA 2002); EPA National Ambient Water Quality Criteria (NAWQC) (EPA 2002), or EPA Tier II values as compiled by Suter and Tsao (1996); and EDQLs from EPA Region 5 (EPA 1998a). An Ohio State WQS 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 WQS published in Chapter 3745-1 of the OAC, the next preferred value to use as an ESV is an EPA NAWQC, followed by an EPA Tier II value, or a Region 5 EPA EDQL, as described in the preceding hierarchy. The preferred surface water ESVs have been provided in Appendix R, Table R-3. Note that for some analytes the preferred ESV is from the OAC.

Another criterion for identifying preliminary COPECs was whether the analytes were considered persistent, bioaccumulative, and toxic (PBT) compounds. The PBT compounds were identified as any inorganic SRCs whose maximum bioaccumulation factor (BAF) was ≥ 2, or any analytes whose log octanol-water partition coefficient (K_{ow}) was ≥ 4. BAFs and log K_{ow} values are presented in Appendix R, Table R-4. Any analyte that was identified as a PBT compound was automatically considered at preliminary COPEC, even if the analyte's maximum concentration was less than the preferred ESV.

7.3.4.2 Load Line 4: Identification of preliminary COPECs

The methods that were used to identify preliminary COPECs in sediment and surface water at Load Line 1 were also used to identify preliminary COPCs at Load Line 4. For soil, a different methodology was used at Load Line 4 than the one described above for Load Line 1. The process for identifying preliminary COPECs in soil at Load Line 4 is described below.

The site-wide SERA protocol (Army Corps of Engineers 2003) specifies comparison of ecological risk already performed at Load Line 1 to other load lines, including Load Line 4. Comparisons were made between one EU at Load Line 4 and its equivalent EU at Load Line 1. Thus, the following Load Line 4 and Load Line 1 soil EUs were compared:

- Load Line 4 Explosives Handling Area Aggregate to Load Line 1 Explosives Handling Area Aggregate,

- Load Line 4 Preparation and Receiving Areas Aggregate to Load Line 1 Preparation and Receiving Areas Aggregate,

- Load Line 4 Packaging and Shipping Areas Aggregate to Load Line 1 Packaging and Shipping Areas Aggregate,
- Load Line 4 Perimeter Area Aggregate to Load Line 1 Perimeter Area Aggregate, and
- Load Line 4 Melt-Pour Area Drainage Ditches Aggregate to Load Line 1 Perimeter Area Aggregate.

The ecological screening process for surface soil at Load Line 4 consisted of a sequential series of steps that evaluated and often compared parameters associated with Load Line 4 and Load Line 1. The ecological screening process for soil is depicted as a flowchart on Figure 7-2. As shown in the flowchart, the ecological screening process for surface soil consists of three major subprocesses, which are shown as portions A, B, and C of the flowchart. Each of these subprocesses is briefly described below. Each subprocess contains two to six steps. Most of the steps in each of the three portions of the flowchart are decision points that lead to one of two actions or conclusions based on the outcome of the activity associated with the step. For any detected constituent in surface soil at Load Line 4, the ecological screening process always began with the steps depicted in portion A of the flowchart and continued to any subsequent portions, until a decision was made for either NFA or further analysis deferred to a separate scope of work. Whether the screening process utilized portions B or C of the flowchart for a given constituent depended on the outcomes of the steps in portion A, as discussed below.

The ecological screening for analytes in soil began with the steps depicted in portion A of the soil screening process flowchart (Figure 7-2). Portion A of the flowchart consists of six steps (A1 through A6). One of the six steps (A6) can end with a decision of NFA for the constituent, whereas two of the steps (A4 and A6) can lead to additional evaluation of the constituent, as depicted in other portions of the flowchart before the decision of NFA or risk management analysis is made. If the constituent from Load Line 4 was not present in soil at Load Line 1 (Step A1), a screening HQ will be calculated as part of a deferred, separate scope of work that is not addressed in this SERA. If the soil constituents at Load Line 4 were also present in soil at Load Line 1 (Step A1), the mean concentrations from the Load Line 4 EU samples were compared to the exposure concentrations [sometimes this could be the lower of the UCL_{95} and the maximum to create the exposure concentration] from corresponding EUs from Load Line 1 (Step A3). The exposure concentrations were the lower of the maximum detect or, the UCL_{95} of the mean, and represent the numerical values used to calculate the screening HQs for Load Line 1. The exposure concentrations for most Load Line 4 analytes were the UCL_{95}. Constituents at Load Line 4 whose mean concentrations exceeded the exposure concentrations from corresponding EUs at Load Line 1 were further evaluated via steps presented in portion C of the flowchart. Portion C of the flowchart is described below. Constituents whose mean soil concentrations in EUs from Load Line 4 were $\leq$ the exposure concentrations in soil from corresponding Load Line 1 EUs were further evaluated by utilizing the Load Line 1 SERA maximum HQs for those constituents (Step A5). If the Load Line 1 maximum screening HQs exceeded 1, the constituents were further evaluated per the steps presented in portion B of the flowchart; otherwise, the conclusion was NFA for that constituent (Step A6). Portion B of the flowchart is described below.

Portion B of the flowchart that depicts the soil ecological screening process for Load Line 4 shows the steps for evaluating constituents that remain after step A6 (i.e., constituents in Load Line 4 soil EUs whose means were $\leq$ the exposure concentrations of that constituent in soil at Load Line 1 and whose screening HQs at Load Line 1 were ≥ 1). Portion B of the flowchart contains three steps (B1, B2, and B3).

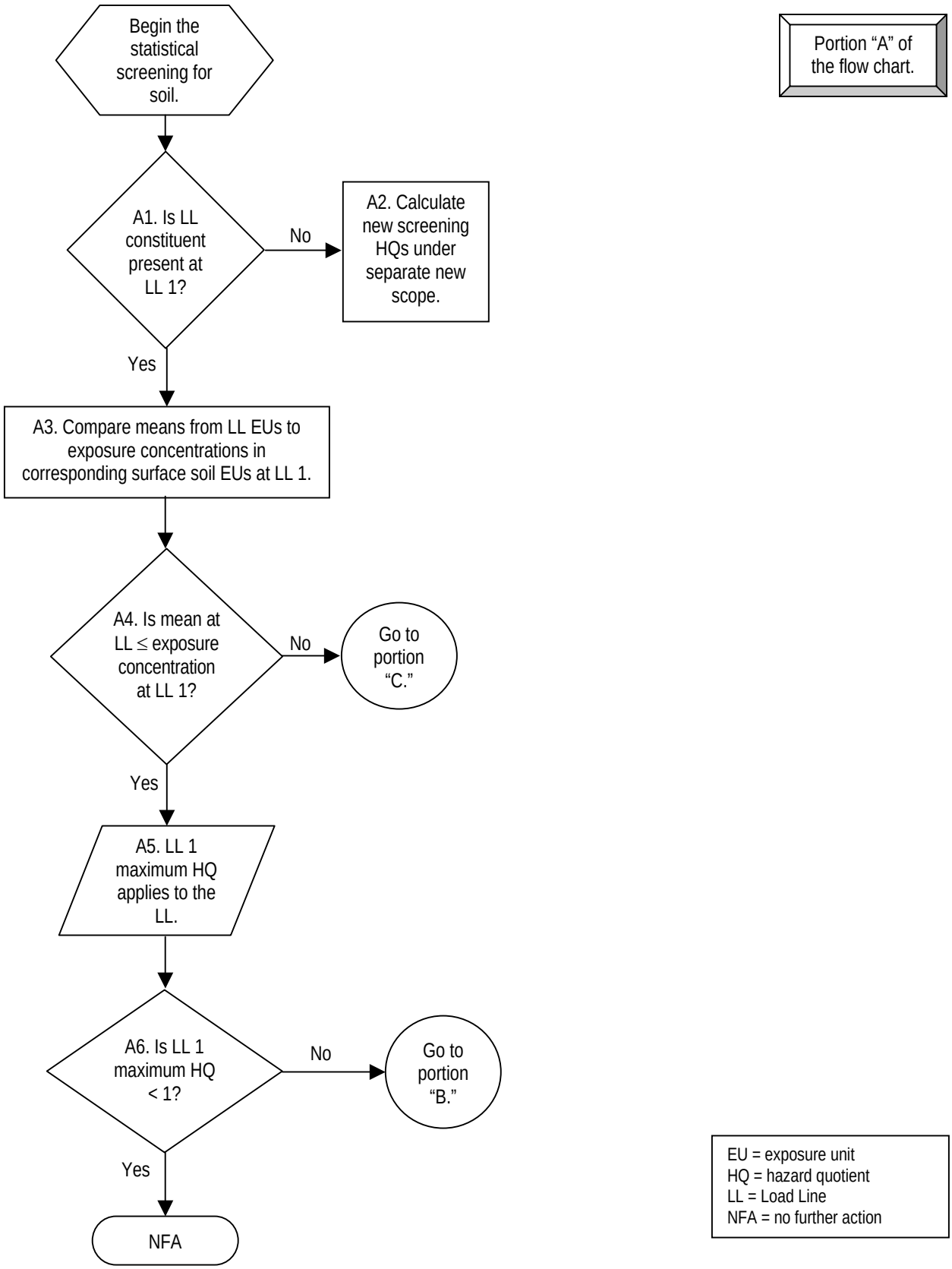
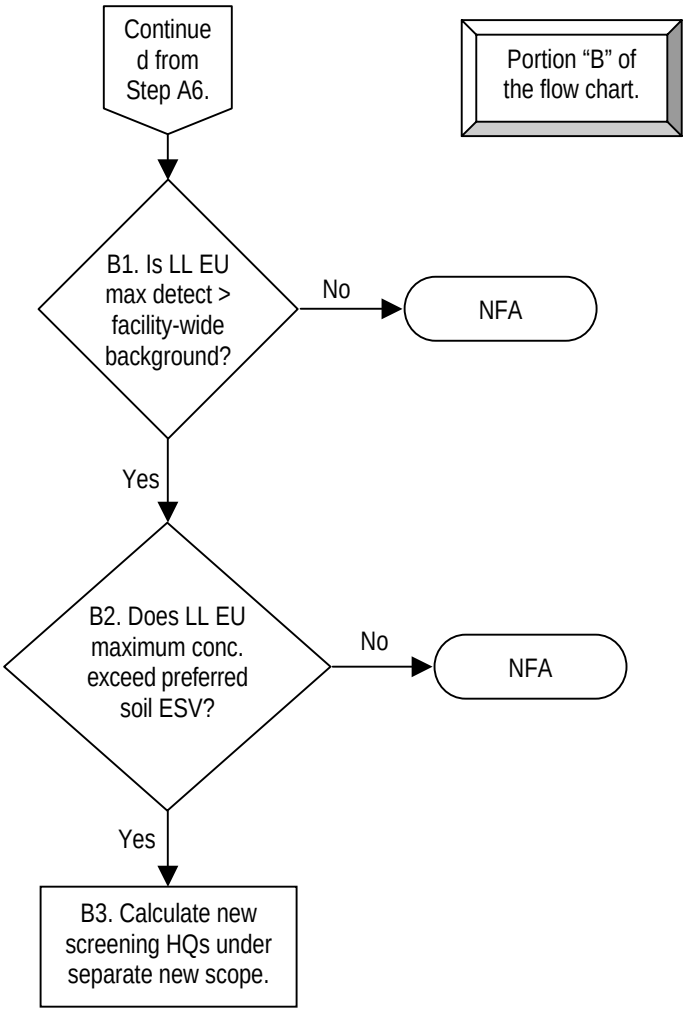
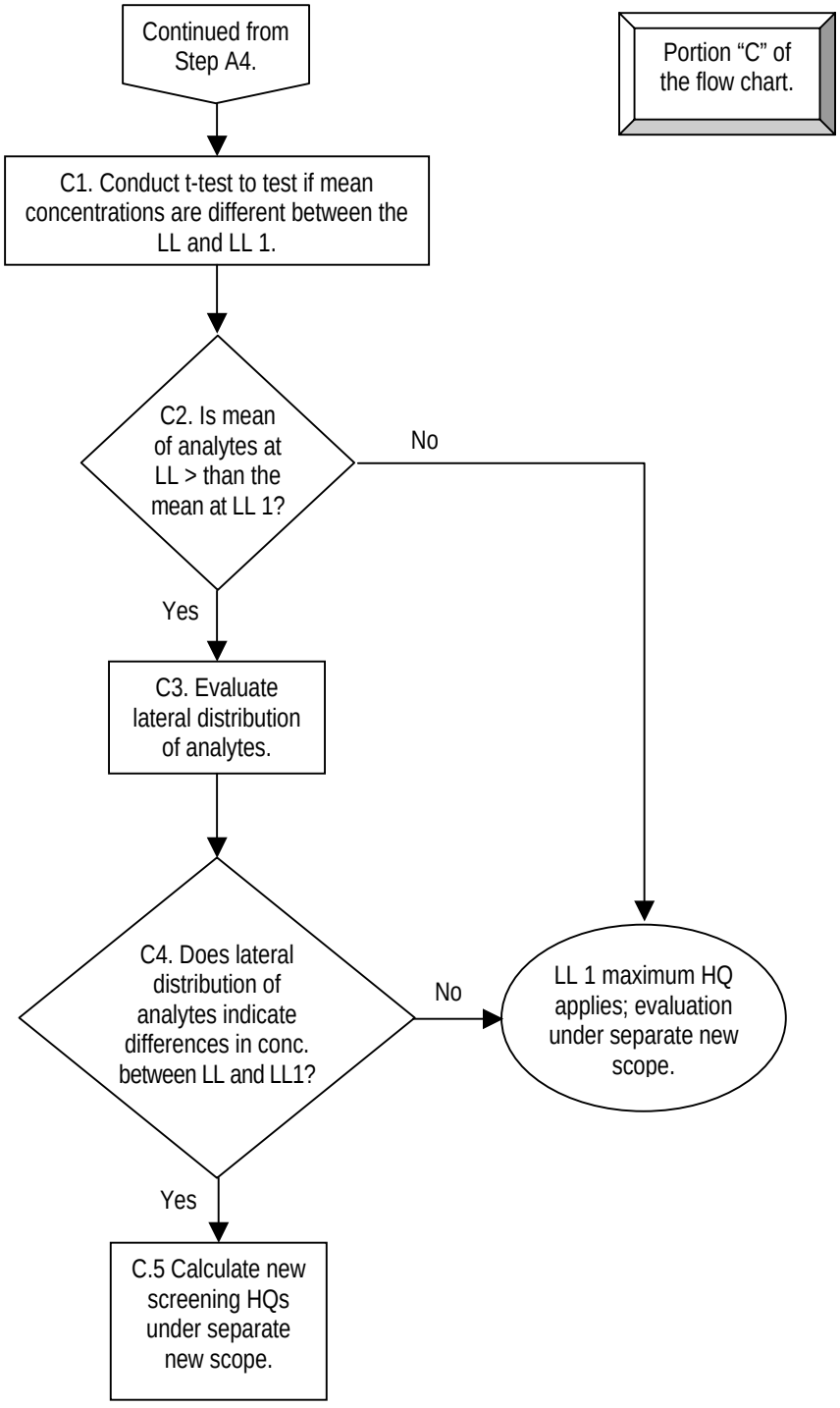


Figure 7-2. Flow Chart Depicting the Statistical and Ecological Screening Process for Surface Soil at Ravenna Load Lines



LL = Load Line
HQ = hazard quotient
EU = exposure unit
NFA = no further action
conc. = concentration
max. = maximum
Note: Step B2 includes a PBT screen, where a PBT compound is an inorganic analyte whose BAF >= to 2, or an organic analyte whose log Kow >= to 4. If the analyte is a PBT compound, it automatically carries forward to Step B3; otherwise, Step B2 governs as indicated.
PBT = persistent, bioaccumulative, and toxic
BAF = bioaccumulation factor
Kow = octanol-water partition coefficient

Figure 7-2. Flow Chart Depicting the Statistical and Ecological Screening Process for Surface Soil at Ravenna Load Lines (continued)



LL = Load Line
conc. = concentration
HQs = hazard quotients

Figure 7-2. Flow Chart Depicting the Statistical and Ecological Screening Process for Surface Soil at Ravenna Load Lines (continued)

If the MDC of the constituent at the Load Line 4 EU did not exceed the facility-wide background concentration (Step B1), the conclusion was NFA for that constituent. Otherwise, the evaluation of the constituent continued by comparing the MDC in the Load Line 4 EU against the hierarchy of soil ESVs (Step B2). The ESVs include plant protection levels developed at WBG (SAIC 2002) and intended to be extrapolated to the other AOCs at RVAAP. The ESVs include plant protection levels developed at WBG (SAIC 2002) and intended to be extrapolated to other AOCs at RVAAP. If the MDC of the constituent did not exceed the soil ESV and the constituent was not a PBT compound, a conclusion of NFA was appropriate for that constituent; otherwise, the constituent was deemed in need of a screening HQ to be calculated as part of a deferred, separate scope of work that is not addressed in this SERA (Step B3).

Portion C of the flowchart begins with the constituents from Step A4 (i.e., constituents that are present in soil at Load Line 4 EUs and Load Line 1 corresponding EUs but whose means at Load Line 4 exceeded the exposure concentrations at Load Line 1). A t-test was performed to evaluate if the concentrations were different between Load Line 1 and Load Line 4 (Step C1). If the t-test indicated that the concentrations were not significantly different (Step C2), then the maximum HQ from the corresponding soil EU at Load Line 1 applied to the Load Line 4 EU. However, if the t-test (Step C1) indicated that the mean soil concentrations at Load Line 4 EUs were greater than the mean soil concentrations at Load Line 1 corresponding EUs (Step C2), then the evaluation continued by assessing the lateral distribution of the constituents (Step C3). If the lateral distribution of constituents at Load Line 4 indicated that there are real differences in concentrations between Load Line 4 and Load Line 1, then the constituent was deemed in need of a screening HQ to be calculated as part of a deferred, separate scope of work that is not addressed in this SERA (Step C5). Lateral proximity of 50 ft or less was assumed to mean a difference. If the lateral distribution of constituents indicated no real differences between the means at comparable EUs from Load Line 4 and Load Line 1, then the maximum HQ from the corresponding soil EU at Load Line 1 was applied to the Load Line 4 EU.

7.4 RESULTS OF PRELIMINARY CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

7.4.1 Load Line 4 Soil Preliminary Chemicals of Potential Ecological Concern

Regarding the first question in the statistical and ecological screening process, as depicted in "portion A" of Figure 7-2 (i.e., Step A1 – is the Load Line 4 constituent present at Load Line 1?), all of the detected constituents at Load Line 4 had also been detected at Load Line 1. Thus, there were no "new" constituents at Load Line 4 that needed HQ calculations per Step A2 in Figure 7-2. Table 7-2 summarizes the Load Line 4 analytes that are justified for NFA according to the four criteria defined in Figure 7-2. The four criteria for NFA included maximum Load Line 1 HQ < 1 (Step A6), maximum Load Line 4 detection greater than facility-wide background (Step B1), analyte was eliminated during the Load Line 1 ESV pre-screening, or analyte had no Load Line 1 HQ due to the absence of a TRV. Tables that contain the detailed information and comparisons for identifying the Load Line 4 analytes that qualify for NFA are presented in Appendix R, as follows.

- Appendix R, Table R-5: detected soil analytes at Load Line 4, by EU, along with their concentrations and the concentrations in corresponding EUs at Load Line 1; also, any new constituent is identified by the presence of a blank row.

- Appendix R, Table R-6: comparisons between mean concentrations of analytes from Load Line 4 against the exposure concentrations from Load Line 1, and listing the maximum HQs from Load Line 1, and the comparison of MDCs of analytes from Load Line 4 versus background concentration.

Table 7-2. Summary of Soil Load Line 4 Analytes Whose Means Do Not Exceed the Load Line 1 Exposure Concentration and are Justified for No Further Action

Analyte	CAS Number	Rationales for NFA			
		NFA Because Load Line 1 Max. HQ < 1	NFA Because Load Line 4 Max. Det. < Bkg.	NFA Because the Analyte was Eliminated During the Load Line 1 ESV Pre-screening	NFA Because the Analyte had no Load Line 1 HQ due to the Absence of a TRV
Explosives Handling Areas Aggregate					
Metals					
Antimony	7440-36-0			X	
Cobalt	7440-48-4	X			
Cyanide	57-12-5	X			
Nickel	7440-02-0	X			
Potassium	7440-09-7				X
Vanadium	7440-62-2		X		
Organics-Pesticide/PCB					
alpha-Chlordane	5103-71-9	X			
4,4'-DDD	72-54-8			X	
Endosulfan II	33213-65-9			X	
Endrin	72-20-8			X	
Endrin Aldehyde	7421-93-4				X
Endrin Ketone	53494-70-5				X
gamma-Chlordane	5103-74-2				X
Heptaclor	76-44-8				X
Heptaclor Epoxide	1024-57-3				X
PBC-1254	11096-82-5	X		X	
Organics-Volatiles					
Chloroform	67-66-3			X	
Toluene	108-88-3			X	
Organics-Semivolatiles					
Acenaphthylene	208-96-8			X	
Anthracene	120-12-7				X
Benzo(*a*)anthracene	56-55-3				X
Benzo(*a*)pyrene	50-32-8	X			
Carbazole	86-74-8				X
Di-n-butylphthalate	84-74-2			X	
Fluoranthene	206-44-0				X
Fluorene	86-73-7	X			
Phenanthrene	85-01-8				X
Pyrene	129-00-0	X			
Preparation and Receiving Areas Aggregate					
Metals					
Aluminum	7429-90-5		X		
Beryllium	7440-41-7			X	
Calcium					X
Cobalt	7440-48-4			X	
Copper	7440-50-8	X			
Cyanide	57-12-5			X	
Magnesium	7439-95-4				X
Manganese	7439-96-5	X			

Table 7-2. Summary of Soil Load Line 4 Analytes Whose Means Do Not Exceed the Load Line 1 Exposure Concentration and are Justified for No Further Action (continued)

Analyte	CAS Number	Rationales for NFA			
		NFA Because Load Line 1 Max. HQ < 1	NFA Because Load Line 4 Max. Det. < Bkg.	NFA Because the Analyte was Eliminated During the Load Line 1 ESV Pre-screening	NFA Because the Analyte had no Load Line 1 HQ due to the Absence of a TRV
Potassium	7440-09-7				X
Sodium	7440-23-5				X
Thallium	6533-73-9			X	
Vanadium	7440-62-2			X	
Organics-Semivolatiles					
Bis(2-ethylhexyl)phthalate	117-81-7	X			
Fluoranthene	206-44-0				X
Phenanthrene	85-01-8				X
Pyrene	129-00-0	X			
Organics-Volatiles					
Toluene	108-88-3			X	
Packaging and Shipping Areas Aggregate					
Metals					
Aluminum	7429-90-5		X		
Antimony	7440-36-0	X			
Arsenic	7440-38-2		X		
Beryllium	7440-41-7			X	
Calcium	7440-70-2				X
Cobalt	7440-48-4	X			
Magnesium	7439-95-4				X
Nickel	7440-02-0	X			
Potassium	7440-09-7				X
Sodium	7440-23-5				X
Thallium	6533-73-9			X	
Vanadium	7440-62-2		X		
Organics-Explosives					
Nitrocellulose	9004-70-0				X
Organics-Pesticides/PCBs					
4,4'-DDE	72-55-9			X	
gamma-Chlordane	5103-74-2				X
PCB-1260	11096-82-5			X	
Organics-Semivolatiles					
Benzo(*a*)anthracene	56-55-3				X
Benzo(*a*)pyrene	50-32-8	X			
Benzo(*b*)fluoranthene	205-99-2				X
Benzo(*g,h,i*)perylene	191-24-2				X
Bis(2-ethylhexyl)phthalate	117-81-7			X	
Chrysene	218-01-9				X
Fluoranthene	206-44-0				X
Phenanthrene	85-01-8				X
Pyrene	129-00-0	X			
Organics-Volatiles					
Toluene	108-88-3			X	

Table 7-2. Summary of Soil Load Line 4 Analytes Whose Means Do Not Exceed the Load Line 1 Exposure Concentration and are Justified for No Further Action (continued)

Analyte	CAS Number	Rationales for NFA			
		NFA Because Load Line 1 Max. HQ < 1	NFA Because Load Line 4 Max. Det. < Bkg.	NFA Because the Analyte was Eliminated During the Load Line 1 ESV Pre-screening	NFA Because the Analyte had no Load Line 1 HQ due to the Absence of a TRV
Perimeter Area Aggregate					
Metals					
Aluminum	7429-90-5		X		
Arsenic	7440-38-2		X		
Barium	7440-39-3			X	
Beryllium	7440-41-7			X	
Cobalt	7440-48-4	X			
Copper	7440-50-8		X		
Mercury	7487-94-6	X			
Nickel	7440-02-0		X		
Potassium	7440-09-7			X	
Selenium	7782-49-2		X		
Sodium	7440-23-5			X	
Thallium	6533-73-9			X	
Vanadium	7440-62-2		X		
Organics-Semivolatiles					
Benzo(*a*)anthracene	56-55-3			X	
Benzo(*g,h,i*)perylene	191-24-2			X	
Benzo(*k*)fluoranthene	207-08-9			X	
Bis(2-ethylhexyl)phthalate	117-81-7			X	
Chrysene	218-01-9			X	
Pyrene	129-00-0			X	
Organics-Volatiles					
Toluene	108-88-3			X	
Melt-Pour Area Drainage Ditches Aggregate					
Metals					
Aluminum	7429-90-5		X		
Barium	7440-39-3			X	
Beryllium	7440-41-7		X		
Cobalt	7440-48-4	X			
Cyanide	57-12-5	X			
Manganese	7439-96-5	X			
Mercury	7487-94-6	X			
Nickel	7440-02-0		X		
Potassium	7440-09-7		X		
Selenium	7782-49-2		X		
Sodium	7440-23-5			X	
Thallium	6533-73-9			X	
Vanadium	7440-62-2		X		
Organics-Volatiles					
Acetone	67-64-1			X	

CAS = Chemical Abstract Service.
Det. = Detected.
ESV = Ecological screening value.
HQ = Hazard quotient.
Max. = Maximum.
NFA = No further action.
PCB = Polychlorinated biphenyl.
TRV = Toxicity reference value.
X = The analyte is justified NFA because of this condition.

- Appendix R, Table R-7: Load Line 4 analytes whose mean concentrations did not exceed the Load Line 1 exposure concentrations and were deemed justified for NFA because their maximum HQ from Load Line 1 was less than 1, or, their MDC at Load Line 4 EU was less than background.

- Appendix R, Table R-8: Load Line 4 analytes whose mean concentrations did not exceed the Load Line 1 exposure concentrations and were deemed justified for NFA because they did not have corresponding HQs at Load Line 1 due to being eliminated during the Load Line 1 ESV and PBT screen.

- Appendix R, Table R-9: Load Line 4 analytes whose mean concentrations did not exceed the Load Line 1 exposure concentrations and were deemed justified for NFA because they did not have corresponding HQs at Load Line 1 due to the absence of published TRVs for the SERA.

Regarding portions A and B (Step B2) of the methods flowchart, Table 7-3 summarizes the Load Line 4 analytes, by EU, that were retained after the ESV and PBT screen. Twelve metals, two pesticides, and one PCB were retained at one or more EUs following the ESV and PBT screen. The Explosives Handling Area Aggregate had the most retained analytes (10 metals, 2 pesticides, and 1 PCB). The Perimeter Area Aggregate, as well as the Melt-Pour Area Drainage Ditches Aggregate, had fewer retained analytes (four and five, respectively) than the Explosives Handling Area Aggregate, but all of the analytes that entered the ESV and PBT screens were retained for these three EUs. All Load Line 4 soil analytes that were retained after the ESV and PBT screen will need a screening HQ to be calculated as part of a deferred, separate scope of work. The tables that contain the detailed information and comparisons for identifying the Load Line 4 soil analytes that qualify for ESV and PBT screening, and the tables showing the soil ESV and PBT screens for the five EUs are presented in Appendix R, as follows.

- Appendix R, Table R-10: Load Line 4 analytes whose means did not exceed the Load Line 1 exposure concentrations but needed the ESV and PBT screening because the maximum HQs for these analytes at corresponding EUs at Load Line 1 exceeded 1 and the Load Line 4 maximum concentrations exceeded background.

- Appendix R, Tables R-11 through R-15: soil ESV and PBT screens for the five EUs at Load Line 4.

Regarding portion C of the method, Table 7-4 summarizes the Load Line 4 analytes whose means were not different from the means at Load Line1 per the t-test, so the Load Line 1 maximum HQ that is listed applies. This list of analytes included one metal in each EU, except for the Melt-Pour Area Drainage Ditches Aggregate, which had no analytes in this classification. Bis(2-ethylhexyl)phthalate was the only organic analyte in this classification, and it was only present at the Explosive Handling Areas Aggregate. The tables that contain the detailed information and comparisons for identifying the Load Line 4 analytes whose means did not differ from those at Load Line 1 are presented in Appendix R as follows.

- Appendix R, Table R-16: Load Line 4 analytes, by EU, whose means exceeded the Load Line 1 exposure concentrations and had t-tests for differences between means at Load Line 4 and Load Line 1.

- Appendix R, Table R-17: Load Line 4 analytes whose means exceeded the Load Line 1 exposure concentrations, but whose means did not exceed the means at Load Line 1, per the t-tests.

Regarding portion C (Steps C3 and C4) of the methods, Table 7-5 summarizes the Load Line 4 analytes whose means are truly different, as verified by the t-tests and supported by spatial distribution evaluation. Nine metals comprised this classification of analytes. These analytes listed in Table 7-5 will need a screening HQ to be calculated as part of a deferred, separate scope of work that is not addressed in this

Table 7-3. Summary of Soil Load Line 4 Analytes that Remained After the Exposure Unit-Specific ESV and PBT Screen

Analytes that are SRCs	CAS Registry Number	Explosives Handling Area Aggregate	Preparation and Receiving Areas Aggregate	Packaging and Shipping Areas Aggregate	Perimeter Area Aggregate	Melt-Pour Area Drainage Ditches Aggregate
Metals						
Aluminum	7429-90-5	X	NA	NA	NA	NA
Arsenic	7440-38-2	X	X	NA	NA	X
Barium	7440-39-3	X	—	—	NA	NA
Cadmium	7440-43-9	X	X	X	X	X
Chromium	7440-47-3	X	X	X	NA	X
Copper	7440-50-8	X	NA	X	NA	NA
Iron	7439-89-6	X	X	X	X	X
Lead	7439-92-1	X	X	X	NA	X
Manganese	7439-96-5	NA	NA	X	X	NA
Mercury	7487-94-6	X	NA	X	NA	NA
Nickel	7440-02-0	NA	X	NA	NA	NA
Zinc	7440-66-6	X	X	X	X	NA
Organics-Pesticides/PCBs						
4,4'-DDT	50-29-3	X	NA	NA	NA	NA
Dieldrin	60-57-1	X	NA	NA	NA	NA
PCB-1254	11097-69-1	X	X	X	NA	NA

— = SRC did not remain after the exposure unit-specific ESV and PBT screen.
CAS = Chemical Abstract Service.
DDT = Dichlorodiphenyltrichloroethane.
ESV = Ecological screening value.
NA = Not applicable because the SRC was inillegible for ESV screening at this exposure unit.
PBT = Persistent, bioaccumulative, and toxic.
PCB = Polychlorinated biphenyl.
SRC = Site-related chemical.
X = SRC remains after the exposure unit-specific ESV and PBT screen.

Table 7-4. Summary of Soil Load Line 4 Analytes Whose Means Were Not Different From Those at Load Line 1 per T-Test and Whose Load Line 1 HQ Applies

Analysis Type	Load Line 4 Analytes	CAS Registry Number	Load Line 1 Max. HQ
Explosives Handling Areas Aggregate			
Metals	Manganese	7439-96-5	1.40E+00
Organics-Semivolatiles	Bis(2-ethylhexyl)phthalate	117-81-7	5.44E-04
Preparation and Receiving Areas Aggregate			
Metals	Mercury	7487-94-6	1.40E+00
Packaging and Shipping Areas Aggregate			
Metals	Selenium	7782-49-2	1.23E+00
Perimeter Area Aggregate			
Metals	Chromium	7440-47-3	4.20E+01

CAS = Chemical Abstract Service.
HQ = Hazard quotient.
Max. = Maximum.

Table 7-5. Summary of Soil Load Line 4 Analytes Whose Concentrations are Truly Greater Than Those Same Analyte's Concentrations at Load Line 1 and, thus, Require Subsequent HQ Calculation

Load Line 4 Analyte	CAS Registry Number	Explosives Handling Areas Aggregate	Preparation and Receiving Areas Aggregate	Packaging and Shipping Areas Aggregate	Perimeter Area Aggregate	Melt-Pour Area Drainage Ditches Aggregate
Beryllium	7440-41-7	X				
Calcium	7440-70-2	X				
Copper	7440-50-8					X
Lead	7439-92-1				X	
Magnesium	7439-95-4	X				X
Selenium	7782-49-2	X				
Sodium	7440-23-5	X				
Thallium	6533-73-9	X				
Zinc	7440-66-6					X

CAS = Chemical Abstract Service.
X = Load Line 4 analyte concentration is truly different than Load Line 1 concentration [Load Line 4 mean > Load Line 1 95% upper confidence limit; Load Line 4 mean > Load Line 1 mean per t-test; and spatial analysis (clustering minimum distance between highest concentrations is < 50 ft) indicates Load Line 4 is > Load Line 1] so subsequent hazard quotient (HQ) calculation is warranted.

SERA. The tables that contain the detailed information and comparisons for identifying the Load Line 4 analytes whose means truly are different based on t-test and spatial distribution evaluation are presented in Appendix R, as follows.

- Appendix R, Table R-18: Load Line 4 analytes whose mean concentrations exceeded the Load Line 1 exposure concentrations and whose means exceeded the means at Load Line 1, per the t-tests.

- Appendix R, Table R-19: Load Line 4 analytes whose mean concentrations exceeded the Load Line 1 exposure concentrations and whose means exceeded the means at Load Line 1, per the t-tests; plus, lists the mean, minimum, and maximum distances between the pairs of samples starting with the locations of the highest concentrations.

- Appendix R, Figures R-1 through R-10: Load Line 4 analytes whose mean concentrations at the Load Line 1, per t-tests, have at least five detects and seem clustered because many pairs are within 50 ft of each other.

Note that the spatial distribution figures show how copper, magnesium, and zinc are considerably more concentrated at Load Line 4 than at Load Line 1 at the Melt-Pour Area Drainage Ditches Aggregate of Load Line 4.

7.4.2 Load Line 4 Sediment Preliminary Chemicals of Potential Ecological Concern

Constituents in sediment that were retained after the EU-specific ESV and PBT screens were identified as preliminary COPECs and are summarized in Table 7-6. The rationale for retaining the analytes (i.e., maximum detect > ESV, PBT compound, or no ESV) is also presented in Table 7-6 for each retained analyte. Fourteen analytes (including 12 metals, 1 PCB, and 1 explosive) were retained in 1 or more of the 3 EUs. The EU with the most retained analytes (12) was the Main Stream Segment and Settling Pond Aggregate, but the rationale for retaining 8 of those 12 analytes was "no ESV." These preliminary COPECs will be analyzed for HQs beginning in Section 7.7.

Table 7-6. Summary of Sediment Analytes in Load Line 4 and the Rationale(s) Why They are to be Carried Forward to Receptor-specific Screening for Identification of Sediment COPECs

SRCs Remaining after the EU-specific ESV and PBT Pre-screen	Rationale for Selection		
	Main Stream Segment Upstream of Perimeter Road Aggregate	Main Stream Segment and Settling Pond Aggregate	Exit Drainages Aggregate
Inorganics			
Aluminum	—	No ESV	—
Barium	—	No ESV	—
Beryllium	No ESV	—	—
Cadmium	PBT compound	Max > ESV; PBT compound	PBT compound
Calcium	No ESV	No ESV	—
Iron	—	No ESV	—
Lead	—	PBT compound	—
Magnesium	No ESV	No ESV	—
Mercury	—	PBT compound	—
Nickel	—	Max > ESV	—
Thallium	—	No ESV	—
Vanadium	—	No ESV	—
Pesticide/PCBs			
PCB-1248	—	—	PBT compound
Explosives			
2,4,6-Trinitrotoluene	No ESV	No ESV	—

— = SRC not applicable to EU.
COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
EU = Exposure unit.
Max. = Maximum detected concentration.
PBT = Persistent, bioaccumulative, and toxic.
PCB = Polychlorinated biphenyl.
SRC = Site-related chemical.

The tables showing the sediment ESV and PBT screens for the three EUs are presented in Appendix R, as follows.

- Appendix R, Tables R-20 through R-22: sediment ESV and PBT screens for the three EUs at Load Line 4.

7.4.3 Load Line 4 Surface Water Preliminary Chemicals of Potential Ecological Concern

Constituents in surface water that were retained after the EU-specific ESV and PBT screens were identified as preliminary COPECs and are summarized in Table 7-7. The rationale for retaining the analytes (i.e., maximum detect > ESV, PBT compound, or no ESV) is also presented in Table 7-7 for each retained analyte. Seven metals and one pesticide were retained following the ESV and PBT screen for surface water. The EU with the most retained analytes (7) was the Main Stream Segment Upstream of Perimeter Road Aggregate. Only two of the seven retained analytes (iron and manganese) at that EU had a maximum detect that exceeded the ESV. Three of the seven retained analytes at that EU, as well as both of the retained analytes at the Exit Drainages Aggregate EU, had no ESV. These preliminary COPECs will be analyzed for HQs beginning in Section 7.7.

Table 7-7. Summary of Surface Water Analytes in Load Line 4 and the Rationale(s) Why They are to be Carried Forward to Receptor-specific Screening for Identification of Surface Water COPECs

SRCs Remaining after the EU-specific ESV and PBT Pre-screen	Rationale for Selection		
	Main Stream Segment Upstream of Perimeter Road Aggregate	Main Stream Segment and Settling Pond Aggregate	Exit Drainages Aggregate
Metals			
Cadmium	PBT compound	—	—
Calcium	No ESV	—	No ESV
Iron	Max > ESV	—	—
Magnesium	No ESV	—	No ESV
Manganese	Max > ESV	—	—
Mercury	PBT compound	PBT compound	—
Potassium	No ESV	—	—
Organics-Pesticides			
4,4-DDT	—	Max >ESV; PBT compound	—

— = SRC not applicable to EU.
COPEC = Chemical of potential ecological concern.
DDT = Dichlorodiphenyltrichloroethane.
ESV = Ecological screening value.
EU = Exposure unit.
Max. = Maximum detected concentration.
PBT = Persistent, bioaccumulative, and toxic.
SRC = Site-related chemical.

The tables showing the surface water ESV and PBT screens for the three EUs are presented in Appendix R, as follows.

- Appendix R, Tables R-23 through R-25: surface water ESV and PBT screens for the 3 EUs at Load Line 4.

7.4.4 Future Preliminary Risk to Ecological Receptors

The HQs for the terrestrial plants and animals at Load Line 1 are considered to be the same or similar in the future because soil contaminant concentrations are not expected to change much over time. Likewise, vegetation and animal species are expected to be the same or similar at the load line, although the same habitats may change through ecological succession.

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

7.4.5 Summary of Preliminary Chemicals 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 Load Line 1 that remain after the pre-screening step and have the potential to pose a hazard or risk to plants and animals.

For Load Line 4, the ESV part of the work was completed for sediment and surface water much as was done for Load Line 1. For Load Line 4, there were a few chemicals that were retained as candidates for later HQ work. For soil, additional steps were added in which comparisons of various types were made between Load Line 4 and Load Line 1 chemical concentrations. Many chemicals were determined to be of lesser concentrations, lower ESV, or other conditions at Load Line 4. Yet, there were a few that showed higher concentrations, and they are candidates for further work as presented in Section 7.7. For

example, antimony, beryllium, and others are higher at the Explosives Handling Areas Aggregate, and lead is higher at the Perimeter Area Aggregate at Load Line 4 compared to Load Line 1.

7.5 UNCERTAINTIES

Uncertainties in the Load Line 4 SERA are discussed in this section by the four interrelated steps of the EPA approach to SERA: problem formulation, exposure assessment, effects assessment, and risk characterization. The uncertainty section also contains specific evaluations of the COPECs.

7.5.1 Uncertainties in Problem Formulation

Environmental concentrations of analytes in the soil, sediment, and surface water at Load Line 4 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 UCL_{95} of the mean concentrations or MDC was used as the EPC concentration to calculate HQs at Load Line 1, the estimates of risk from COPECs are conservative (i.e., protective). Using UCL_{95} 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 Load Line 4 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 Load Line 4. 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 Load Line 4 to be an overestimate of risk.

It is possible that one (or more) unobserved species at Load Line 4 is more sensitive than the ecological receptors for which toxicity data are available for use in the SERA. 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.

7.5.2 Uncertainties in Exposure Assessment

The actual movement of analytes from the Load Line 4 constituent source media to ecological receptors has not been measured for this SERA. 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 SERA. Thus, the exposures could be overestimated based on the total measured concentration.

BAFs for soil and sediment to biota, and bioconcentration factor (BCF) for surface water to biota, used for the PBT evaluation are not available for some analytes. 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.

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 will be neither underestimated nor overestimated.

Exposure concentrations are likely to be overestimated because of conservative exposure factors. Exposure factors include published BAFs, irrespective of species and environmental conditions. In particular, it should be noted that, while the largest BAFs may overestimate bioaccumulation at Load Line 4 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.

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

7.5.3 Uncertainties in Effects Assessment

The preferred ESVs for the three media were based on concentrations reported to have no observed effects on most organisms. This SERA 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.

There are no available ESVs for some analytes, especially organics, for each of the three media. 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 reactor-specific screens. Sometimes, lack of ESVs based on soil-plant studies caused use of ESVs based on hydroponic studies; hydroponic studies are inferior to soil-plant studies and this contributed additional uncertainty.

7.5.4 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 Load Line 4. Five additional areas of uncertainty in the risk characterization exist: off-site risk, cumulative risk, future risk, background risk, and extrapolation risk.

7.5.4.1 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. However, those analyses are beyond the scope of this SERA. 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 Load Line 4 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.

7.5.4.2 Cumulative risk

The SERA 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. 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 Load Line 4 may underestimate actual risks to plants and animals from cumulative risks.

7.5.4.3 Future risk

A third area of uncertainty in the ecological risk characterization is the future risk to plants and animals from contamination at Load Line 4. The SERA 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.

7.5.4.4 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.

7.5.4.5 Extrapolation risk

Yet another source of uncertainty revolves around the extrapolations of Load Line 1 data, including HQs, to Load Line 4. No one load line and no one EU is exactly like its companion. Differences in concentrations and chemical mixtures introduce variation into extrapolations.

7.5.5 Summary of Uncertainties

The most important uncertainties in the Load Line 4 SERA are those surrounding the estimates of the constituent concentrations to which ecological receptors are actually exposed (exposure concentrations), the concentrations that present an acceptable level of risk of harmful effects (ESVs), and the extrapolation of HQs from Load Line 1 to Load Line 4. 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, 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 for the identification of preliminary COPECs that require calculation of screening HQs under a deferred scope of work not addressed in this SERA. The Load Line 4 COPECs are defined as sediment and surface water analytes whose maximum detect exceeds the preferred ESV, or that are PBT compounds, or have no ESV; or soil analytes that either (1) were not detected at comparable EUs at Load Line 1, (2) had means less than the exposure concentrations at comparable EUs at Load Line 1 but had maximum detects > background and a Load Line 1 HQ > 1, or (3) had means greater than

exposure concentrations at comparable EUs at Load Line 1 and means greater than means at comparable EUs at Load Line 1 (per t-test and spatial evaluation). Thus, the purpose of the SERA is fulfilled.

7.6 SUMMARY OF THE SCREENING ECOLOGICAL RISK ASSESSMENT

7.6.1 Methods

A screening SERA was performed in accordance with written guidance from the EPA, as well as the Army's final protocol for site-wide ecological risk assessment at Ravenna. One of the most important features of the Army's protocol is the value of extrapolation from one AOC to another. This SERA utilized the Army's protocol to extrapolate ecological risk finding for soils at Load Line 1 EUs to soils from comparable EUs at Load Line 4. This guidance recognizes step-by-step procedures. The present SERA includes problem formulation, exposure assessment and effects assessment, and culminates in risk characterization with attention to uncertainties and summarization. The scope of this SERA was to identify preliminary COPECs, which can be eliminated from further consideration or require calculation of screening HQs under a separate scope of work not addressed by this SERA.

The Load Line 4 site contains sufficient terrestrial and aquatic (surface water and sediment) habitat to support various classes of ecological receptors. For example, terrestrial habitats at Load Line 4 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 SERA. Thus, Ohio EPA protocol (Level I) was met and Level II was needed.

The identification of preliminary COPECs for sediment and surface water began with the SRCs from each of the three EUs associated with these media. The three EUs included the Main Stream Segment Upstream Perimeter Road Aggregate; Main Stream Segment and Settling Pond Aggregate; and the Exit Drainage Aggregate. The MDCs of each SRC were compared to the corresponding preferred ESV. Each SRC was also evaluated to determine if it qualified as a PBT compound (i.e., had a BAF $\geq$ 2 for inorganics, or a log $K_{ow} \geq 4$ for organics). A sediment or surface water SRC was identified as a preliminary COPEC at a Load Line 4 EU if it met any of the following conditions: (1) its MDC > the preferred ESV, (2) it had no ESV, or (3) it was a PBT compound.

Identifying soil preliminary COPECs entailed a multi-step process that first compared the Load Line 4 mean concentrations of analytes from each of the five EUs to the exposure concentration concentrations from comparable EUs at Load Line 1 to see if the concentrations were different. If the Load Line 4 means did not exceed the Load Line 1 exposure concentration, then the maximum screening HQs from Load Line 1 were applied to Load Line 4. If the Load Line 1 HQ exceeded 1 and the Load Line 4 MDC exceeded background, the Load Line 4 analyte was considered a preliminary COPEC. If the Load Line 1 HQ was < 1, but the Load Line 4 MDC > background, the Load Line 4 analyte underwent an ESV and PBT screen. Soil analytes in the ESV and PBT screen were identified as preliminary COPEC per the same criteria as was described for sediment and surface water. Lastly, any Load Line 4 analytes whose means exceeded the means at comparable EUs at Load Line 1 (as verified by SERAs and spatial distribution analysis) were identified as preliminary COPECs.

7.6.2 Soil Chemicals of Potential Ecological Concern

A summary of the Load Line 4 soil preliminary COPECs, organized by EUs, and the rationales for why the analytes were preliminary COPECs is presented in Table 7-8. The Explosives Handling Areas Aggregate contained the most preliminary COPECs for soil (16 metals, 2 pesticides, and 1 PCB), whereas the Perimeter Area Aggregate had the fewest preliminary COPECs for soil (five metals). The Preparation and Receiving Areas Aggregate and Packaging and Shipping Areas Aggregate tied for having the second highest number of preliminary COPECs (seven metals and one PCB). The Melt-Pour Area Drainage Ditches Aggregate had eight metals that were identified as preliminary COPECs. At all EUs, except the Melt-Pour Area Drainage Ditches Aggregate, the rationale that was responsible for identifying the most preliminary COPECs was the "maximum detection exceeded the ESV." The rationale that was responsible for identifying the fewest preliminary COPECs was "No ESV," which only identified PCB-1254 at three of the four EUs. There is no new analyte detected at Load Line 4 compared to Load Line 1. All of these preliminary COPECs require further evaluation by having screening HQs calculated, but that process will be performed under a separate scope of work not addressed by this SERA.

7.6.3 Sediment Chemicals of Potential Ecological Concern

A summary of the Load Line 4 sediment preliminary COPECs, organized by the three EUs, and the rationales for why the analytes were preliminary COPECs is presented in Table 7-9. The Main Stream Segment and Settling Pond Aggregate contained the most preliminary COPECs for sediment (11 metals and 1 explosive), whereas the Exit Drainages Aggregate had the fewest preliminary COPECs for sediment (one metal and one PCB). The Main Stream Segment Upstream of Perimeter Road Aggregate had the second highest number of preliminary COPECs (four metals and one explosive). At all EUs, except the Exit Drainage Aggregate, the rationale that was responsible for identifying the most preliminary COPECs was No ESV. The rationale that was responsible for identifying the fewest preliminary COPECs was "Maximum detection > ESV," which only identified cadmium and nickel at the Main Stream Segment and Settling Pond Aggregate. All of these preliminary COPECs require further evaluation by having screening HQs calculated, but that process will be performed under a separate scope of work not addressed by this SERA.

7.6.4 Surface Water Chemicals of Potential Ecological Concern

Rationales for why the analytes were preliminary COPECs is presented in Table 7-10. The Main Stream Segment Upstream of Perimeter Road Aggregate contained the most preliminary COPECs for surface water (seven metals), whereas the Main Stream Segment and Settling Pond Aggregate and the Exit Drainages Aggregate each had two preliminary COPECs. At all EUs, except the Main Stream Segment and Settling Pond Aggregate, the rationale that was responsible for identifying the most preliminary COPECs was No ESV. The rationale that was responsible for identifying the fewest preliminary COPECs was Maximum detection > ESV, which only identified two metals at one EU, one pesticide at another EU, and no preliminary COPECs at the Exit Drainages Aggregate. All of these preliminary COPECs require further evaluation by having screening HQs calculated beginning in Section 7.7.

Table 7-8. Summary of Soil Preliminary COPECs at Load Line 4

Load Line 4 mean < Load Line 1 Exposure Concentration			Load Line 4 mean > Load Line 1 mean
Maximum Detection > ESV	**No ESV**	**PBT Compound**	
Explosives Handling Areas Aggregate			
Aluminum	PCB-1254	Cadmium	Beryllium
Arsenic		Lead	Calcium
Barium		Mercury	Magnesium
Cadmium		Zinc	Sodium
Chromium		4,4'-DDT	Thallium
Copper		Dieldrin	Selenium
Iron		PCB-1254	
Lead			
Mercury			
Zinc			
4,4'-DDT			
Dieldrin			
Preparation and Receiving Areas Aggregate			
Arsenic	PCB-1254	Cadmium	
Cadmium		Lead	
Chromium		Zinc	
Iron		PCB-1254	
Lead			
Nickel			
Zinc			
Packaging and Shipping Areas Aggregate			
Cadmium	PCB-1254	Cadmium	
Chromium		Lead	
Copper		Mercury	
Iron		Zinc	
Lead		PCB-1254	
Manganese			
Mercury			
Zinc			
Perimeter Area Aggregate			
Iron		Cadmium	Lead
Manganese		Zinc	
Zinc			
Melt-Pour Area Drainage Ditches Aggregate			
Arsenic		Cadmium	Copper
Chromium		Lead	Magnesium
Iron			Zinc

COPEC = Chemical of potential ecological concern.
DDT = Dichlorodiphenyltrichloroethane.
ESV = Ecological screening value.
PBT = Persistent, bioaccumulative, and toxic.
PCB = Polychlorinated biphenyl.

Table 7-9. Summary of Sediment Preliminary COPECs at Load Line 4

Load Line 4 Mean < Load Line 1 Exposure Concentration		
Maximum Detection > ESV	**No ESV**	**PBT Compound**
Mainstream Segment Upstream of Perimeter Road Aggregate		
	Beryllium	Cadmium
	Calcium	
	Magnesium	
	2,4,6-Trinitrotoluene	
Mainstream Segment and Settling Pond Aggregate		
Cadmium	Aluminum	Cadmium
Nickel	Barium	Lead
	Calcium	Mercury
	Iron	
	Magnesium	
	Thallium	
	Vanadium	
	2,4,6-Trinitrotoluene	
Exit Drainages Aggregate		
	PCB-1248	Cadmium
		PCB-1248

COPEC = Chemical of potential ecological concern.
ESV = Ecological screening value.
PBT = Persistent, bioaccumulative, and toxic.
PCB = Polychlorinated biphenyl.

Table 7-10. Summary of Surface Water Preliminary COPECs at Load Line 4

Load Line 4 Mean < Load Line 1 Exposure Concentration		
Maximum Detection > ESV	**No ESV**	**PBT Compound**
Mainstream Segment Upstream of Perimeter Road Aggregate		
Iron	Calcium	Cadmium
Manganese	Magnesium	Mercury
	Potassium	
Mainstream Segment and Settling Pond Aggregate		
4,4'-DDT		Mercury
		4,4'-DDT
Exit Drainages Aggregate		
	Calcium	
	Magnesium	

COPEC = Chemical of potential ecological concern.
DDT = Dichlorodiphenyltrichloroethane.
ESV = Ecological screening value.
PBT = Persistent, bioaccumulative, and toxic.

7.6.5 Conclusions

In conclusion, there were many constituents eliminated by the methodical comparative and extrapolation approach of Load Line 1 to Load Line 4. However, there still remained a few preliminary COPECs for soil at all five of the terrestrial EUs, for sediment at all three EUs, and for surface water at all three EUs. The soil preliminary COPECs included many by virtue of the maximum Load Line 4 detect exceeding the ESV, as well as several Load Line 4 analytes whose EU means were greater than the means at comparable EUs at Load Line 1. A few Load Line 4 soil analytes were preliminary COPECs by virtue of

being PBT compounds, but most of them were already preliminary COPECs by virtue of other rationales. Most of the sediment preliminary COPECs were identified by virtue of having no ESV, although one to three analytes were selected by virtue of being PBT compounds at each of the three EUs. Only two sediment analytes at one EU were preliminary COPECs by virtue of having a maximum detect that exceeded the ESV. Most of the surface water preliminary COPECs were identified by virtue of having no ESV and were nutrients. PBT compounds comprised two preliminary COPECs at all EUs except the Exit Drainages Aggregate. Preliminary COPECs based on maximum detects exceeding ESVs were limited to two metals and one pesticide. All of the preliminary COPECs identified in this SERA require further evaluation by having screening HQs calculated, as presented beginning in Section 7.7.

7.7 SCOPE AND OBJECTIVES FOR THE BASELINE ECOLOGICAL RISK ASSESSMENT

The scope of the BERA or Ohio Level III ERA is to characterize the risk to plant and animal populations at Load Line 4, including its aquatic environments, from analytes that are present in the surface soil, sediment, and surface water. The principal tool is the HQ for a variety of specific ecological receptors. Details about the general, as well as the SERA, scope and objectives are found in Section 7.1.

7.8 PROCEDURAL FRAMEWORK FOR THE BASELINE ECOLOGICAL RISK ASSESSMENT

According to the *Framework for Ecological Risk Assessment* (EPA 1992c), the BERA process (like the SERA) consists of three interrelated phases: problem formulation, analysis (composed of exposure assessment and ecological effects assessment), and risk characterization. See Section 7.2 for details about these phases.

The BERA is organized by the four interrelated steps of the EPA framework. Sections 7.9 and 7.10 detail the technical issues and data evaluation procedures associated with each step followed by the HQ results. Section 7.11 evaluates the degree of reliability or uncertainty of these methodological steps and the data used. Finally, Section 7.12 provides the summary of BERA methods and results.

7.9 PROBLEM FORMULATION FOR THE BASELINE ECOLOGICAL RISK ASSESSMENT

The first step of EPA's approach to the BERA process, problem formulation (data collection and evaluation), includes the same parts as the SERA detailed in Section 7.3.

7.9.1 Ecological Conceptual Site Model

The ecological CSM of Load Line 4 has been developed for the BERA 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 recognized. Figure 7-1 shows the ecological CSM whose parts are explained in Section 7.3.1. The big difference between the SERA and BERA CSMs is the greater specificity of ecological receptors for the BERA.

7.9.2 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. The

BERA depends on the same six terrestrial EUs and the same sediment/surface water EUs as did the SERA (see Section 7.3.2).

7.9.3 Description of Habitats and Populations

The habitats and populations are defined in a multi-page section in the SERA (see Section 7.3.3).

7.9.4 Review of Preliminary Chemicals of Potential Ecological Concern from the Screening Ecological Risk Assessment

Part of the SERA activities examined the interrelationships of Load Line 1 and Load Line 4. Sections 7.1 through 7.6 provided the scope, methods, results, and uncertainties associated with that relationship as governed by the Army's RVAAP site-wide ERA (USACE 2003). Even though the results are provided in Section 7.4 and summarized in Section 7.6, the findings are restated below to facilitate the set-up and subsequent analysis in the BERA. Therefore, the preliminary COPEC identification process and results will not be repeated in detail but will be briefly summarized in this section. The purpose of this review is to clearly identify in one place those preliminary COPECs that will be used in the BERA.

A summary of the process that was used to identify preliminary COPECs is presented in Section 7.9.4.1, whereas summaries of the results of the identification of COPECs for soil, sediment, and surface water are presented in Sections 7.9.4.2 through 7.9.4.4, respectively. The preliminary COPECs that were identified as part of the Level II Screening were inputted into this Level III BERA as the starting constituents for which receptor-specific HQs are calculated as an indication of ecological risk.

7.9.4.1 Summary of the methodology to identify preliminary COPECs for the Level II Screening

Media- and EU-specific COPECs for surface soil (0 to 1 ft depth), sediment, and surface water were identified from SRCs by applying a multi-step process of sequential screening activities that were each designed to either eliminate the SRC from further consideration for risk evaluation, or to carry the SRC forward for further evaluation that led to the SRC being identified as a preliminary COPEC. The process for identifying soil COPECs at Load Line 4 was more complex than the process for identifying sediment and surface water COPECs because it entailed various comparisons between the soil constituents at Load Line 4 and Load Line 1, as described in detail in Section 7.4.3.2. Although the identification of soil COPECs was the most complex process of the three media, two processes were utilized in the COPEC identification for all three media: (1) comparison of EU-specific MDCs of SRCs against media- and contaminant-specific ESVs, and (2) identifying SRCs that were considered PBT compounds. PBT compounds were identified as any inorganic SRC whose maximum BAF was ≥ 2, or any organic SRC whose log octanol-water partition coeficient (K_{ow}) was ≥ 4. Thus, SRCs for surface soil, sediment, and surface water were subjected to EU-specific ESV and PBT screens, and were identified as preliminary COPECs and carried forward to this Level III BERA if they met one or more of the following three conditions: (1) their MDC > the ESV, (2) the SRC was a PBT compound, or (3) the SRC had no ESV.

For surface soil, three additional conditions led to a SRC being identified as a preliminary COPEC: (1) the SRC at Load Line 4 had not been detected at the comparable EU at Load Line 1, (2) the Load Line 4 mean concentration > the Load Line 1 mean per t-test plus spatial analysis (clustering minimum distance between highest concentrations is < 50 ft), or (3) if the Load Line 4 mean SRC concentration was not significantly greater than the mean from the comparable EU at Load Line 1 and the Load Line 1 maximum HQ > 1.

7.9.4.2 Summary of soil preliminary COPECs from Level II Screen

The Level II Screen identified the following EU-specific list of soil preliminary COPECs from six EUs based on the results of the ESV and PBT screen, as well as the Load Line 4 versus Load Line 1 SRC comparisons.

Explosives Handling Area Aggregate Soil Preliminary COPECs

- Aluminum (maximum detect > ESV)
- Arsenic (maximum detect > ESV)
- Barium (maximum detect > ESV)
- Beryllium (Load Line 4 mean > Load Line 1 mean)
- Cadmium (maximum detect > ESV; PBT compound)
- Calcium (Load Line 4 mean > Load Line 1 mean)
- Chromium (maximum detect > ESV)
- Copper (maximum detect > ESV)
- Iron (maximum detect > ESV)
- Lead (maximum detect > ESV; PBT compound)
- Magnesium (Load Line 4 mean > Load Line 1 mean)
- Mercury (maximum detect > ESV; PBT compound)
- Sodium (Load Line 4 mean > Load Line 1 mean)
- Selenium (Load Line 4 mean > Load Line 1 mean)
- Thallium (Load Line 4 mean > Load Line 1 mean)
- Zinc (maximum detect > ESV; PBT compound)
- PCB-1254 (no ESV; PBT compound)
- 4,4'-DDT (maximum detect > ESV; PBT compound)
- Dieldrin (maximum detect > ESV; PBT compound)

Preliminary COPECs per the Load Line 4 SRC mean ≤ the Load Line 1 mean, and the maximum Load Line 1 HQ > 1 (not subjected to new HQ calculations in the Level III BERA):

- Manganese

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Preparation and Receiving Areas Aggregate Soil Preliminary COPECs

- Arsenic (maximum detect > ESV)
- Cadmium (maximum detect > ESV; PBT compound)
- Chromium (maximum detect > ESV)
- Iron (maximum detect > ESV)
- Lead (maximum detect > ESV; PBT compound)
- Nickel (maximum detect > ESV)
- Zinc (maximum detect > ESV; PBT compound)
- PCB-1254 (no ESV; PBT compound)

Preliminary COPECs based on the Load Line 4 SRC means ≤ the Load Line 1 means, and the maximum Load Line 1 HQ > 1 (not subjected to new HQ calculations):

- Mercury

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Packaging and Shipping Areas Aggregate Soil Preliminary COPECs

- Cadmium (maximum detect > ESV; PBT compound)
- Chromium (maximum detect > ESV)
- Copper (maximum detect > ESV)
- Iron (maximum detect > ESV)
- Lead (maximum detect > ESV; PBT compound)
- Manganese (maximum detect > ESV)
- Mercury (maximum detect > ESV; PBT compound)
- Zinc (maximum detect > ESV; PBT compound)
- PCB-1254 (no ESV; PBT Compound)

Preliminary COPECs per the Load Line 4 SRC mean ≤ the Load Line 1 mean, and the maximum Load Line 1 HQ > 1 (not subjected to new HQ calculations in the Level III BERA):

- Selenium

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Perimeter Area Aggregate Soil Preliminary COPECs

- Cadmium (PBT compound)
- Iron (maximum detect > ESV)
- Lead (Load Line 4 mean > Load Line 1 mean)
- Manganese (maximum detect > ESV)
- Zinc (maximum detect > ESV; PBT compound)

Preliminary COPECs per the Load Line 4 SRC mean ≤ the Load Line 1 mean, and the maximum Load Line 1 HQ >1 (not subjected to new HQ calculations in the Level III BERA):

- Chromium

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Melt-Pour Drainage Ditches Aggregate Soil Preliminary COPECs

- Arsenic (maximum detect > ESV)
- Cadmium (PBT Compound)
- Chromium (maximum detect > ESV)
- Copper (Load Line 4 mean > Load Line 1 mean)
- Iron (maximum detect > ESV)
- Lead (PBT Compound)
- Magnesium (Load Line 4 mean > Load Line 1 mean)
- Zinc (Load Line 4 mean > Load Line 1 mean)

There were no preliminary COPECs per the Load Line 4 SRC mean ≤ the Load Line 1 mean, and the maximum Load Line 1 HQ > 1.

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

7.9.4.3 Summary of sediment preliminary COPECs from Level II Screen

The Level II Screen identified the following EU-specific list of sediment preliminary COPECs from the three sediment EUs, based on the results of the ESV and PBT screen.

Main Stream Segment Upstream of Perimeter Road Aggregate Sediment Preliminary COPECs

- Beryllium (no ESV)
- Cadmium (PBT Compound)
- Calcium (no ESV)
- Magnesium (no ESV)
- 2,4,6-TNT (no ESV)

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Main Stream Segment and Settling Pond Aggregate Sediment Preliminary COPECs

- Aluminum (no ESV)
- Barium (no ESV)
- Cadmium (maximum detect > ESV; PBT Compound)
- Calcium (no ESV)
- Iron (no ESV)
- Lead (PBT Compound)
- Magnesium (no ESV)
- Mercury (PBT Compound)
- Nickel (maximum detect > ESV)
- Thallium (no ESV)
- Vanadium (no ESV)
- 2,4,6-TNT (no ESV)

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Exit Drainages Aggregate Sediment Preliminary COPECs

- Cadmium (PBT Compound)
- PCB-1248 (no ESV; PBT Compound)

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

7.9.4.4 Summary of surface water preliminary COPECs from Level II Screen

The Level II Screen identified the following EU-specific list of surface water preliminary COPECs from the three EUs, based on the results of the ESV and PBT screen.

Main Stream Segment Upstream of Perimeter Road Aggregate Surface Water Preliminary COPECs

- Calcium (no ESV)
- Cadmium (PBT Compound)
- Iron (maximum detect > ESV)

- Magnesium (no ESV)
- Manganese (maximum detect > ESV)
- Mercury (PBT Compound)
- Potassium (no ESV)

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Main Stream Segment and Settling Pond Aggregate Surface Water Preliminary COPECs

- Mercury (PBT Compound)
- 4,4'-DDT (maximum detect > ESV; PBT Compound)

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

Exit Drainages Aggregate Surface Water Preliminary COPECs

- Calcium (no ESV)
- Magnesium (no ESV)

This list of preliminary COPECs carried forward to, and was inputted into, the Level III BERA.

7.9.5 Level III Ecological Exposure Assessment

For Level III, mathematical models are used to calculate the exposure of specific ecological receptors to COPECs, and the exposures are compared to chemical TRVs. COPECs are constituents that remain after the screening step (Sections 7.1 through 7.6). Published chemical- and receptor-specific TRVs were used for COPECs. Each of these toxicity benchmarks is defined later in the text. The BERA steps (Sections 7.7 through 7.12) culminate in a sample management decision plan, which will result in (1) NFA, (2) a sample management decision plan to decide whether to conduct a removal or other remedial action, or (3) a decision to conduct a more detailed ERA, including field surveys and sampling.

The methods for performing ecological exposure assessment are presented in the following subsections, which describe:

- the Level III approach to using screening and analysis methods (Section 7.9.5.1);
- receptor-specific parameters to be used in the exposure equations (Section 7.9.5.2);
- methods and equations to estimate exposure to COPECs (Section 7.9.5.3); and
- receptor- and chemical-specific exposure parameters (Section 7.9.5.4).

7.9.5.1 Site-specific methods approach

The Level III evaluation used an estimate of the reasonable maximum exposure (RME) concentrations in environmental media at each EU to identify COPECs and ecological receptors that require no further analysis. The RME concentration was defined as the lower of the UCL_{95} of the mean and the MDC. RME concentrations and the methods used to calculate the RME concentration for each COPEC at each EU are described in Chapter 4.0.

For direct exposure (terrestrial plants, terrestrial invertebrates, aquatic biota, and benthic invertebrates), the HQ was calculated by dividing the RME concentration in soil, surface water, or sediment by the TRV. For ingestion exposures (mammals and birds), the average daily dose (ADD) was calculated using the

exposure equations presented in Section 7.9.5.2. The HQ was calculated by dividing the ADD by the TRV (Section 7.9.6).

Internal concentrations of COPECs were calculated for terrestrial plants, terrestrial invertebrates, aquatic biota, and benthic invertebrates by multiplying the RME concentration of the COPEC by a chemical- and species-specific BCF) or BAF (BCFs and BAFs are defined and described in Section 7.9.5.4). Internal concentrations in plants, terrestrial invertebrates, benthic invertebrates, aquatic plants, and aquatic biota were used to calculate ADDs to terrestrial herbivores, terrestrial invertivores, riparian herbivores, and riparian carnivores. Internal concentrations of COPECs in animal prey (small mammals and fish) were used to calculate ADDs to carnivores (Section 7.9.5.3).

Internal concentrations of COPECs in small mammals were calculated by multiplying the ADD by a chemical- and species-specific BAF (Section 7.9.5.4). Internal concentrations of COPECs in fish were used along with sediment or surface water concentrations to calculate the ADD of riparian carnivores (Section 7.9.5.3).

7.9.5.2 Receptor parameters

Calculation of receptor-specific ADDs requires parameters that describe the home range, body weight, food and water intake rates, and diet distribution. The representative receptors for the Level III BERA are described in Section 7.9.5.3. Receptor parameters are not needed for plants, earthworms, benthic invertebrates, or aquatic biota because doses for these receptors are empirically based on contaminant concentrations in soil, sediment, or surface water, rather than calculated. Receptor parameters for the other indicator receptors are shown in Tables R-26 through R-33.

7.9.5.3 Ecological receptors and exposure evaluation for COPECs

The dose that results from the exposure of a receptor to chemicals in soil, sediment, or surface water, both directly and through food chains, is the product of the concentration of the chemical in the ingested medium and exposure factors. Exposure factors describe how much of the available chemical is taken up by the receptor per unit of concentration in the medium. Exposures were calculated for the EU-specific Level III analysis assuming that the most likely contaminated food item makes up 100% of the diet and all of the ingested food is absorbed. It is further assumed that the receptor is present in the vicinity of the site 100% of the time, but it does not necessarily feed on the site all of the time. Therefore, an area use factor (AUF) is calculated for each receptor at each EU (see Section 7.9.5.4).

Equations used to calculate exposure to COPECs were adapted from equations presented in Ohio EPA guidance (Ohio EPA 2003); terms used in this section may differ from those used in the guidance, but the mathematical meaning of each equation matches the corresponding equation in the Ohio EPA guidance (Ohio EPA 2003). Equations are given here for:

- terrestrial plants,
- terrestrial invertebrates,
- terrestrial mammals and birds (rabbit, shrew, fox, and hawk),
- aquatic biota (aquatic invertebrates and fish),
- benthic invertebrates (aquatic insect larvae, crayfish, snails, clams, and bivalves),
- riparian herbivores (muskrat and mallard), and
- riparian carnivores (mink and heron).

Terrestrial plants and invertebrates are exposed by direct contact with soil. Terrestrial animals and birds are exposed to COPECs by ingestion of food and soil. Three kinds of equations were required to calculate

the exposures of all terrestrial receptors: an equation for exposure by ingestion of plants and soil; an equation for exposure by ingestion of terrestrial invertebrates and soil; and an equation for exposure of carnivores by ingestion of animal prey and soil.

Terrestrial plants

Exposure equations are not needed for exposure of terrestrial plants to COPECs because the TRV for plants is the concentration in soil. Therefore, the measure of exposure for plants to a COPEC is the RME concentration of the COPEC in soil at each EU (mg/kg dry weight).

Terrestrial soil invertebrates

Exposure equations are not needed for terrestrial invertebrates because the TRV for terrestrial invertebrates is the concentration in soil. Therefore, the measure of exposure for terrestrial invertebrates is the RME concentration of the COPEC in soil at each EU (mg/kg dry weight).

Terrestrial herbivores (cottontail rabbit)

It was assumed that terrestrial herbivores are exposed by ingestion of plants and soil. The equation for exposure of terrestrial herbivores to a single COPEC in contaminated soil by ingestion of plants and soil (Ohio EPA 2003) is:

$$ADD_{total} = ADD_P + ADD_S \quad \textbf{(7-1)}$$

where

ADD_{total}	=	Average daily dose (mg/kgBW/d) from all ingestion combined,
ADD_P	=	Average daily dose (mg/kgBW/d) from ingestion of plants,
ADD_S	=	Average daily dose (mg/kgBW/d) from ingestion of soil.

The equation for exposure by ingestion of plants (Ohio EPA 2003) is:

$$ADD_P = RME \times SP_v \times CF \times I_P \times AUF \quad \textbf{(7-2)}$$

where

RME	=	RME concentration of COPEC in soil (mg/kg dry weight),
SP_v	=	Soil-to-plant BCF [mg/kg dry weight per mg/kg dry soil (= kg dry soil/kg dry weight)]. SP_v indicates a diet of vegetative plants,
CF	=	Correction factor, dry weight to wet weight; assuming 85% water content of plants (Ohio EPA 2003), CF = (1 – 0.85) = 0.15,
I_P	=	Plant ingestion rate (kg fresh plant/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of soil (Ohio EPA 2003) is:

$$ADD_S = RME \times I_S \times AUF \quad \textbf{(7-3)}$$

where

RME	=	RME concentration of COPEC in soil (mg/kg dry weight),
I_S	=	Soil ingestion rate (kg dry soil/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

Terrestrial invertivore (short-tailed shrew)

It was assumed that terrestrial invertivores were exposed by ingestion of terrestrial invertebrates (earthworms) and soil. The equation for exposure of terrestrial invertivores to a single COPEC in contaminated soil by ingestion of terrestrial invertebrates and soil (Ohio EPA 2003) is:

$$ADD_{total} = ADD_A + ADD_S \quad \textbf{(7-4)}$$

where

ADD_{total}	=	Average daily dose (mg/kgBW/d) from all ingestion combined,
ADD_A	=	Average daily dose (mg/kgBW/d) from ingestion of animals,
ADD_S	=	Average daily dose (mg/kgBW/d) from ingestion of soil.

The equation for exposure by ingestion of animals (terrestrial invertebrates) (Ohio EPA 2003) is:

$$ADD_A = RME \times BAF_i \times CF_i \times I_A \times AUF \quad \textbf{(7-5)}$$

where

RME	=	RME concentration of COPEC in soil (mg/kg dry weight),
BAF_i	=	Soil-to-soil invertebrate BCF [mg/kg dry weight per mg/kg dry soil for inorganic COPECs (= kg dry soil/kg dry weight)],
CF_i	=	Correction factor (earthworms) [(0.13) for As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn, PCBs, and 1 for all other COPECs—fraction dry weight worm/kg wet weight],
I_A	=	Animal ingestion rate (kg fresh animal/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of soil (Ohio EPA 2003) is:

$$ADD_S = RME \times I_S \times AUF \quad \textbf{(7-6)}$$

where

RME	=	RME concentration of COPEC in soil (mg/kg dry weight),
I_S	=	Soil ingestion rate (kg dry soil/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

Terrestrial carnivores (red fox and red-tailed hawk)

It was assumed that terrestrial carnivores were exposed by ingestion of small mammals (shrews) and soil. The equation for exposure of terrestrial carnivores by ingestion of animal prey and soil (Ohio EPA 2003) is:

$$ADD_{total} = ADD_P + ADD_A + ADD_S \quad \textbf{(7-7)}$$

where

ADD_{total} = Average daily dose (mg/kgBW/d) from all ingestion combined,
ADD_P = Average daily dose (mg/kgBW/d) from ingestion of plants,
ADD_A = Average daily dose (mg/kgBW/d) from ingestion of animals,
ADD_S = Average daily dose (mg/kgBW/d) from ingestion of soil.

The equation for exposure by ingestion of plants (Ohio EPA 2003) is:

$$ADD_P = RME \times SP_r \times CF \times I_P \times AUF \quad \textbf{(7-8)}$$

where

RME = RME concentration of COPEC in soil (mg/kg dry weight),
SP_r = Soil-to-plant BCF [mg/kg dry weight per mg/kg dry soil (= kg dry soil/kg dry weight)]. SP_r indicates a diet of fruit for the fox (hawks are assumed not to consume plant matter),
CF = Correction factor, dry weight to wet weight; assuming 90% water content of fruit, CF = (1 – 0.90) = 0.10,
I_P = Plant ingestion rate (kg fresh plant/kgBW/d),
AUF = Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of animals (terrestrial invertebrates) (Ohio EPA 2003) is:

$$ADD_A = C_s \times I_A \times AUF \quad \textbf{(7-9)}$$

where

C_s = Concentration in the prey resulting from RME exposure (mg/kgBW),
$C_s = ADD_{total(shrew)} \times BAF_{TP} / IR_{F(shrew)}$

where

BAF_{TP} = Food-to-prey BAF [mg/kgBW of prey per mg/kg food (= kg food/kg BW of prey),
$IR_{F(shrew)}$ = Ingestion rate of food by shrew,

I_A = Animal ingestion rate (kg fresh animal/kgBW/d),
AUF = Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of soil (Ohio EPA 2003) is:

$$ADD_S = RME \times I_S \times AUF \quad \textbf{(7-10)}$$

where

RME	=	RME concentration of COPEC in soil (mg/kg dry weight),
I_S	=	Soil ingestion rate (kg dry soil/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

Receptor-specific intake parameters are discussed in Section 7.9.5.2, and chemical-specific BCFs and BAFs are discussed in Section 7.9.5.4.

Benthic invertebrates

Exposure equations are not needed for benthic invertebrates because the TRV for benthic invertebrates is the concentration in sediment. Therefore, the measure of exposure of benthic invertebrates is the concentration of the COPEC in sediment (mg/kg dry weight).

Riparian herbivores (muskrat and mallard duck), sediment

Riparian herbivores are exposed to COPECs in sediment by ingestion of food and sediment. It was assumed that their food is rooted aquatic plants that have taken up COPECs from sediment. The equation for exposure of aquatic herbivores to a single COPEC in sediment (Ohio EPA 2003) is:

$$ADD_{total} = ADD_P + ADD_{Sed} \quad \textbf{(7-11)}$$

where

ADD_{total}	=	Average daily dose (mg/kgBW/d) from all ingestion combined,
ADD_P	=	Average daily dose (mg/kgBW/d) from ingestion of plants,
ADD_{Sed}	=	Average daily dose (mg/kgBW/d) from ingestion of sediment.

The equation for exposure by ingestion of plants (Ohio EPA 2003) is:

$$ADD_P = RME \times [0.5 \times (SP_v \times CF_v) + 0.5 \times (SP_r \times CF_r)] \times I_P \times AUF \quad \textbf{(7-12)}$$

where

RME	=	RME concentration of COPEC in sediment (mg/kg dry weight),
0.5	=	Exposure adjustment factor for a diet of 50% vegetative parts and 50% seeds for mallard ducks (Ohio EPA 2003),
SP_v	=	Sediment-to-plant BCF [mg/kg dry weight per mg/kg dry sediment (= kg dry sediment/kg dry weight)], SP_v is used for the dietary fraction comprising vegetative plants,
CF_v	=	Correction factor, dry weight to wet weight; assuming 85% water content of vegetative parts of plants (Ohio EPA 2003), $CF_v = (1 - 0.85) = 0.15$,
SP_r	=	Sediment-to-plant BCF [mg/kg dry weight per mg/kg dry sediment (= kg dry sediment/kg dry weight)], SP_r is used for the dietary fraction comprising plant seeds,

CF_r = Correction factor, dry weight to wet weight; assuming 10% water content of plant seeds (Ohio EPA 2003), CF = (1 – 0.1) = 0.9,
I_P = Plant ingestion rate (kg fresh plant/kgBW/d),
AUF = Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of sediment (Ohio EPA 2003) is:

$$ADD_{Sed} = RME \times I_S \times AUF \quad \textbf{(7-13)}$$

where

RME = RME concentration of COPEC in sediment (mg/kg dry weight),
I_S = Sediment ingestion rate (kg dry sediment/kgBW/d),
AUF = Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

Receptor-specific intake parameters are discussed in Section 7.9.5.2, and chemical-specific BAFs are discussed in Section 7.9.5.4.

Riparian carnivores (mink and heron), sediment

Riparian carnivores are exposed to COPECs in sediment by ingestion of food and sediment. It was assumed that their prey is fish at Trophic Level 4. The concentration of COPECs in prey, a food chain multiplier (FCM, Section 9.5.4) was used, as required by Ohio EPA (2003). The equation for exposure of riparian carnivores to a single COPEC in sediment (Ohio EPA 2003) is:

$$ADD_{total} = ADD_A + ADD_{Sed} \quad \textbf{(7-14)}$$

where

ADD_{total} = Average daily dose (mg/kgBW/d) from all ingestion combined,
ADD_A = Average daily dose (mg/kgBW/d) from ingestion of animals,
ADD_{Sed} = Average daily dose (mg/kgBW/d) from ingestion of sediment.

The equation for exposure by ingestion of animals (fish) (Ohio EPA 2003) is:

$$ADD_A = RME \times BSAF \times FCM \times I_A \times AUF \quad \textbf{(7-15)}$$

where

RME = RME concentration of COPEC in sediment (mg/kg dry weight),
BSAF = Sediment-to-benthic invertebrate BAF [mg/kgBW of benthic invertebrate per mg/kg dry sediment (= kg dry sediment/kgBW)],
FCM = Food-chain multiplier, 1.0 for inorganic COPECs and chemical-specific for organic COPECs (Ohio EPA 2003) (see Section 7.9.5.4),
I_A = Fish ingestion rate (kg wet weight/kgBW/d),
AUF = Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of sediment (Ohio EPA 2003) is:

$$ADD_{Sed} = RME \times I_S \times AUF \quad \textbf{(7-16)}$$

where

RME	=	RME concentration of COPEC in sediment (mg/kg dry weight),
I_S	=	Sediment ingestion rate (kg dry sediment/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

Receptor-specific intake parameters are discussed in Section 7.9.5.2, and chemical-specific BAFs are discussed in Section 7.9.5.4.

Aquatic biota

Exposure equations are not needed for aquatic biota because the TRV for aquatic biota is the concentration in surface water. Therefore, the measure of exposure of aquatic biota is the concentration of the COPEC in surface water at the EU (mg/L).

Riparian herbivores (muskrat and mallard), water

It was assumed that riparian herbivores are exposed to COPECs in surface water by ingestion of food and water. It was assumed that their food is floating aquatic plants that have taken up COPECs from surface water. The equation for exposure of aquatic herbivores to a single COPEC in surface water (Ohio EPA 2003) is:

$$ADD_{total} = ADD_P + ADD_W \quad \textbf{(7-17)}$$

where

ADD_{total}	=	Average daily dose (mg/kgBW/d) from all ingestion combined,
ADD_P	=	Average daily dose (mg/kgBW/d) from ingestion of plants,
ADD_W	=	Average daily dose (mg/kgBW/d) from ingestion of surface water.

The equation for exposure by ingestion of plants (Ohio EPA 2003) is:

$$ADD_P = RME \times WP \times I_P \times AUF \quad \textbf{(7-18)}$$

where

RME	=	RME concentration of COPEC in surface water (mg/L),
WP	=	Water-to-plant BCF [mg/kg wet weight per mg/L (= L/kg wet weight)],
I_P	=	Plant ingestion rate (kg fresh plant/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of surface water (Ohio EPA 2003) is:

$$ADD_W = RME \times IR_W \times AUF \quad \textbf{(7-19)}$$

where

RME	=	RME concentration of COPEC in surface water (mg/L),
IR_W	=	Water ingestion rate (L/kgBW/d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

Receptor-specific intake parameters are discussed in Section 7.9.5.2, and chemical-specific BAFs are discussed in Section 7.9.5.4.

Riparian carnivores (mink and heron), water

Riparian carnivores are exposed to COPECs in surface water by ingestion of food and water. It was assumed that their food is fish at Trophic Level 4. To calculate the concentration of COPECs in prey, an FCM (Section 9.5.4) was used, as required by Ohio EPA (2003). The equation for exposure of riparian carnivores to a single COPEC in contaminated surface water (Ohio EPA 2003) is:

$$ADD_{total} = ADD_A + ADD_{SW} \quad \textbf{(7-20)}$$

where

ADD_{total}	=	Average daily dose (mg/kgBW/d) from all ingestion combined,
ADD_A	=	Average daily dose (mg/kgBW/d) from ingestion of aquatic animals (assumed to be fish at Trophic Level 4),
ADD_{SW}	=	Average daily dose (mg/kgBW/d) from ingestion of surface water.

The equation for exposure by ingestion of aquatic animals (Ohio EPA 2003) is:

$$ADD_A = RME \times BAF_{aq} \times I_A \times AUF \quad \textbf{(7-21)}$$

where

RME	=	Concentration of COPEC in surface water (mg/L),
BAF_{aq}	=	Water-to-aquatic biota BAF for prey [mg/kg wet weight per mg/L surface water (=L surface water/kg fresh tissue)],
I_A	=	Animal intake (kg fresh animal/kg body weight-d),
AUF	=	Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

The equation for exposure by ingestion of surface water (Ohio EPA 2003) is:

$$ADD_{SW} = RME \times IR_W \times AUF \quad \textbf{(7-22)}$$

where

RME	=	RME concentration of COPEC in surface water (mg/L),

IR_W = Water ingestion rate (L/kgBW/d),
AUF = Area use factor, ratio of an organism's home range to the area of contamination (see Section 7.9.5.4).

Receptor-specific intake parameters are discussed in Section 7.9.5.2, and chemical-specific BCFs and BAFs are discussed in Section 7.9.5.4.

7.9.5.4 Uptake factors (BCFs and BAFs)

For some COPECs the BCF and BAF values used in the ADD equations are available in guidance or other published literature. For some COPECs these values must be estimated. The order of preference (Ohio EPA 2003) for use of BCFs and BAFs is: (1) government agency guidance; (2) published values in the open scientific literature; and (3) calculations based on chemical properties. BCFs and BAFs can be estimated using chemical properties of the COPECs such as the logarithm of the octanol-water partitioning coefficient [$\log(K_{ow})$] and the soil-to-water partitioning coefficient (K_d). Chemical-specific BCFs and BAFs for terrestrial plants, terrestrial invertebrates, mammals, and birds are presented in Table R-34. Chemical-specific BCFs and BAFs for aquatic plants, benthic invertebrates, and fish are presented in Table R-35. Receptor-specific parameters were also needed to calculate some BAFs when empirically derived factors were not available. Receptor-specific parameters are presented in Section 7.9.5.2 and in Tables R-26 through R-33.

BCFs for terrestrial plants (SP_V and SP_r)

Chemical concentrations in terrestrial plants were calculated by using factors for uptake from soil into the aboveground portion of plants. The concentration in aboveground vegetative and reproductive portions of plants through root uptake from soil is a function of the chemical-specific soil concentration and chemical-specific plant BCFs (SP_v for vegetative portions and SP_r for reproductive portions).

Empirically determined SP_vs and SP_rs were used in preference to calculated or estimated values. Default values were not used if values based on chemical properties were available.

As specified by Ohio EPA (2003), SP_vs and SP_rs for inorganic COPECs were taken from Baes et al. (1984). SP_vs for some organic COPECs were taken from EPA (1999). For organic COPECs with no published values, SP_vs were calculated using an equation developed by Travis and Arms (1988). The equation is:

$$\log(SP_v) = 1.588 - 0.578 \times \log(K_{ow}) \quad \textbf{(7-23)}$$

where

SP_v = soil-to-plant BCF (kg dry soil/kg plant or g dry soil/g plant), and
K_{ow} = octanol-water partitioning coefficient (L/kg).

Values of SP_v, SP_r, and $\log(K_{ow})$ are given in Table R-34.

BAFs for terrestrial invertebrates (BAF-S)

Chemical concentrations in terrestrial invertebrates were calculated using uptake factors from soil into the invertebrate tissue. The concentration accumulated in invertebrate tissues through direct contact with and ingestion of soil and detritus is a function of the chemical-specific soil concentration and chemical-specific invertebrate BAF-S.

There are few published BAFs for uptake of COPECs from soil by terrestrial invertebrates. Measured values for arsenic, cadmium, chromium, lead, manganese, mercury, nickel, and zinc (Sample et al. 1999) were used and are included in Table R-34. Additional values for inorganics were taken from EPA (1999). Following EPA (1999) guidance, BAF-S values for other inorganic COPECs were calculated as the average of available measured values (e.g., Sample et al. 1999).

For organic COPECs that have no published values, default values were calculated using the following equation (Ohio EPA 2003):

$$BAF\text{-}S = (yL/x \times f_{oc}) \times (K_{ow})^{b-a} \quad \textbf{(7-24)}$$

where

BAF-S	=	Soil-to-terrestrial invertebrate BAF (kg dry soil/kg fresh invertebrate),
yL	=	Organic lipid content [default value of 0.01 for earthworm (Ohio EPA 2003)], (kg lipid/kg fresh invertebrate),
x	=	Proportionality constant [0.66 (Ohio EPA 2003)],
f_{oc}	=	Fraction of organic carbon in soil, 0.01 (kg carbon/kg dry soil),
K_{ow}	=	Octanol-water partitioning coefficient (L/kg),
b-a	=	Non-linearity constant [0.07 (Ohio EPA 2003)].

The value of 0.01 for f_{oc} was the geometric mean of f_{oc} for soil EUs. These values are included in Table R-34.

BAFs for terrestrial mammals (BAF_{TP})

Published soil-to-animal BAFs are predominantly available only for terrestrial invertebrates. Ohio EPA (2003) guidance states that ingestion-to-beef uptake factors (B_a) presented by Baes et al. (1984) are to be used as BAFs to calculate uptake of inorganic COPECs by mammals and birds.

The units of B_a are (mg retained/kg tissue)/(mg ingested/d). This value is a measure of the fraction of each day's intake of a COPEC in beef that is retained in tissue. Ohio EPA (2003) guidance assumes that the fraction of COPEC that is retained is the same for mammals and birds and does not vary with body weight. To calculate the BAF for mammal or bird receptors (BAF_{TP}), B_a was multiplied by the body weight of the receptor to put the uptake factor in terms of total ingestion of COPEC per day. That is,

$$BAF_{TP} = Ba \times BW, \quad \textbf{(7-25)}$$

where

BAF_{TP}	=	BAF for mammal or bird receptor [mg retained / (mg ingested/d)],
Ba	=	Ingestion-to-beef transfer factor [(mg retained/kg tissue)/(mg ingested/d) (Baes et al. 1984)],
BW	=	Body weight of receptor (kg).

Values of B_a and BAF_{TP} are given in Table R-34.

BCFs for aquatic plants rooted in sediment

Aquatic plants rooted in sediment were assumed to have the same BCFs for vegetative and reproductive parts as for terrestrial plants (SP_V and SP_r, respectively). SP_Vs and SP_rs for inorganic COPECs were taken from EPA (1999) and Baes et al. (1984) and are provided in Table R-34. SP_rs for organic COPECs were assumed to be the same as SP_Vs.

BAFs for benthic invertebrates (BSAF)

There are few published BSAF values for uptake of COPECs from sediment. BSAFs from EPA (1999) were used for inorganic and organic COPECs when values were available in that reference. For inorganic COPECs without published values, the value proposed by EPA (1999), which was the arithmetic mean of all available values for inorganics, was 0.9. For organic COPECs without published values, the BSAFs were calculated by using the equation for terrestrial invertebrates (Section 7.9.5.4). The value of foc was 0.01, the measured value in Kelly's Pond. These values are included in Table R-35.

BCFs for floating aquatic plants (WP)

Floating aquatic plants were assumed to take up COPECs from water. The BCFs for water-to-plant bioaccumulation are termed WP. Values of WP for inorganic COPECs were taken from EPA (1999). Values of WP for organic COPECs were calculated by an empirically derived equation for uptake from water by algae (Southworth et al. 1978). The equation is:

$$\log(WP) = 0.819 \times \log(K_{ow}) - 1.146.$$

BAFs for aquatic animals (BAFaq)

Chemical concentrations in aquatic biota were calculated using factors for uptake from surface water into the tissue of aquatic biota. The concentration in aquatic macroinvertebrates through uptake from surface water is a function of the chemical-specific surface water concentration and chemical-specific BCFs. It was assumed that organic COPECs can bioaccumulate up the food chain. To calculate a BAFaq for an organic COPEC, the BCF is multiplied by the FCM for that COPEC. The hierarchy of sources for BAFs (Ohio EPA 2003) used in the SLERA was: (1) field-measured BAFs; (2) predicted BAFs derived by multiplying a laboratory-measured BCF by an FCM (EPA 1995); and (3) predicted BAFs derived by multiplying a BCF calculated from the Kow by an FCM (EPA 1995).

Published BCFaq values for aquatic animals are presented in Table R-35. Measured values for mercury and nickel were taken from EPA (1999). For organic COPECs that have no published BCFaq, the following equation (EPA 1999) was used to estimate the BCF:

$$\log(BCF_{aq}) = 0.91 \times \log(K_{ow}) - 1.975 \times \log[(6.8E\text{-}07 \times K_{ow}) + 1] - 0.786 \quad \textbf{(7-26)}$$

where

BCF_{aq} = Water-to-aquatic biota BCF [mg/kg fresh tissue per mg/L (= L/kg)],
K_{ow} = Octanol-water partitioning coefficient.

Calculated BCFaq values are also presented in Table R-35.

BAFaq is calculated by using FCMs that account for bioaccumulation of COPECs through the food chain (EPA 1995). BAFaq is calculated as:

$$BAF_{aq} = BCF \times FCM \quad \textbf{(7-27)}$$

where

BCF = Water-to-tissue BCF (L/kg body wt),
FCM = Food-chain multiplier (unitless). FCMs specific to Trophic Level 4 are assumed.

FCMs

FCMs are factors that are used to quantify bioaccumulation through the food chain. As chemicals from the environment pass up the food chain, they may become successively more concentrated at each trophic level. This is especially true of organic chemicals that are not metabolized rapidly. Typically, organic chemicals that dissolve in lipids bioaccumulate because they are stored in body fat, and the more soluble in lipids the chemical is, the more it bioaccumulates. To model this tendency quantitatively, EPA (1995) measured BAFs for organic chemicals taken up through the food chain from water by fish. An FCM was derived for each chemical tested by dividing the observed BAF by the K_{ow}. EPA (1995) was able to show an orderly relationship between FCM and K_{ow} for many organic chemicals taken up by fish at Trophic Levels 2, 3, and 4. By using this relationship, the concentration of a chemical in fish tissue, normalized to lipid content, can be calculated by multiplying the concentration of the chemical dissolved in water by the BCF of the chemical and by the chemical's FCM.

The FCM for inorganic COPECs is 1.0 (EPA 1995). The FCMs used for organic COPECs were those for Trophic Level 4 and are presented in Table R-35.

AUFs

Ecological receptors typically forage over a receptor-specific area termed the home range. Home ranges for many species of animals are available in published literature and compendia. It was assumed that receptors at each EU at Load Line 2 forage uniformly over a home range that includes the EU. The fraction of the ingestion exposure that comes from the EU is termed the AUF. For receptors with a home range larger than the EU, AUF is calculated as the area of the EU divided by the home range. For receptors with a home range smaller than the EU, such as the short-tailed shrew and muskrat, AUF is 1.0. AUFs for receptors exposed to COPECs in soil are shown in Table R-36, and AUFs for receptors exposed to COPECs in sediment and surface water are shown in Table R-37.

Ingestion rates

Exposure equations require ingestion rates of plants (I_P), soil (I_S), animal tissue (I_A), sediment (I_S), and surface water (IR_W). These values are shown in the receptor parameter tables (Tables R-26 through R-33) and are summarized in Table R-38.

7.9.6 Effects Evaluation for Chemicals of Potential Ecological Concern

Measures of toxicity were used as endpoints to compute HQs. Toxicity endpoints, termed TRVs were derived from published studies of exposure to contaminants under controlled conditions. TRVs were used for exposure of terrestrial plants, terrestrial invertebrates, terrestrial mammals, terrestrial birds, benthic invertebrates, riparian mammals, riparian birds, and aquatic biota.

7.9.6.1 Terrestrial plants and invertebrates

Toxicity endpoints for plants and terrestrial invertebrates were taken from Efroymson et al. (1997a) and Efroymson et al. (1997b), respectively (Ohio EPA 2003). These values are generally the LOAEL or the lower 5th percentile concentration for adverse effects for plants and earthworms exposed to soil amended with chemicals. TRVs for terrestrial plants are shown in Table R-39, and TRVs for terrestrial invertebrates are shown in Table R-40.

7.9.6.2 Terrestrial mammals and birds

The preferred endpoint for mammals and birds is a chronic NOAEL for a measure of population maintenance, such as reproduction. If a chronic NOAEL is not available, a substitute can be computed using one of the following procedures (Ohio EPA 2003).

- Divide a subchronic NOAEL for longer-term subchronic exposures by 3.
- Divide a subchronic NOAEL for sub-acute or short-term subchronic exposures by 10.
- Divide an acute NOAEL by 100.
- Divide a chronic LOAEL for a reproductive endpoint or a minor physiological change by 3.
- Divide a chronic LOAEL for an effect that would reduce survivability in the wild or a gross or severe physiological change by 10.
- Divide a subchronic LOAEL for longer-term subchronic exposure by 3 to convert to a chronic LOAEL, then divide by 3 or 10 to convert to a chronic NOAEL, as indicated in the third and fourth bullets.
- Divide a subchronic LOAEL for sub-acute or short-term subchronic exposure by 10 to convert to a chronic LOAEL, then divide by 3 or 10 to convert to a chronic NOAEL, as indicated in the third and fourth bullets.
- Divide an acute LOAEL by 1,000.
- Divide an LD_{50} by 10,000.

Chronic NOAELs for mammals, or their calculated equivalents, are shown in Table R-41. A TRV was calculated for each mammal by using allometric scaling to account for differences in toxicity related to body weight (Ohio EPA 2003). The equation used for this adjustment is:

$$TRV = \text{chronic NOAEL} \times (BW_t / BW_w)^{1/4} \quad \textbf{(7-28)}$$

where

TRV	=	Toxicity reference value (mg/kg body wt-d),
BW_t	=	Body weight of the species used in toxicity testing (kg),
BW_w	=	Body weight of the wildlife species (kg),
1/4	=	Allometric scaling factor for mammals.

These adjusted values were used as TRVs for the computation of HQs for mammals and are shown in Table R-42.

Chronic NOAELs for birds, or their calculated equivalents, are shown in Table R-43. Body weight scaling was not conducted for birds (Ohio EPA 2003). Instead, an adjustment was based on the taxonomic distance between the test species and the ecological receptor, as follows.

- If the test species and the ecological receptor were in the same genus, no adjustment was made.
- If the test species and the ecological receptor were in the same family but not the same genus, the chronic NOAEL was multiplied by one-half order of magnitude (0.33).
- If the test species and the ecological receptor were in the same order but not the same family, the chronic NOAEL was multiplied by 0.1.
- If the test species and the ecological receptor were not in the same order, the chronic NOAEL was multiplied by 0.01.

TRVs for birds are shown in Table R-44.

7.9.6.3 Aquatic biota

The Ohio EPA (2003) hierarchy of TRVs for aquatic biota is: (1) Ohio water quality criteria (Ohio EPA 2003); (2) National Ambient Water Quality Criteria (found in Suter and Tsao 1996), Tier II values (found in Suter and Tsao 1996), and other toxicity values presented in Suter and Tsao (1996). TRVs for aquatic biota are intended to protect most aquatic species from harm by chronic exposure most of the time. TRVs for aquatic biota are shown in Table R-45.

7.9.6.4 Benthic invertebrates

The Ohio EPA (2003) hierarchy of TRVs for benthic invertebrates is the same as the hierarchy for TRVs (Ohio EPA 2003): (1) consensus-based TEC values (MacDonald, Ingersoll, and Berger 2000) and (2) *EPA Region 5 Corrective Action, Ecological Screening Levels (2003),* which can be found at URL http://www.epa.gov/reg5rcra/ca/edql.htm. TRVs for benthic invertebrates are presented in Table R-46.

7.9.6.5 Riparian mammals and birds

TRVs for riparian mammals and birds were computed as described for terrestrial mammals and birds. The TRVs are shown in Tables R-42 (mammals) and R-44 (birds).

7.9.7 Summary of Methods

The Level III exposure and toxicity evaluation used an estimate of the RME concentrations in environmental media at each EU to identify COPECs and ecological receptors that require no further analysis. Internal concentrations of COPECs in plants, terrestrial invertebrates, benthic invertebrates, terrestrial prey, aquatic plants, aquatic biota, and fish were calculated and used to calculate ADDs to terrestrial herbivores, terrestrial invertivores, terrestrial carnivores, riparian herbivores, and riparian carnivores. Calculation of receptor-specific ADDs requires parameters that describe the home range, body weight, food and water intake rates, and diet distribution. Receptor parameters were compiled for the representative receptors for the Level III BERA.

Equations used to calculate exposure to COPECs were adapted from equations presented in Ohio EPA guidance (Ohio EPA 2003). Equations are given here for

- terrestrial plants exposed by direct contact with soil,
- terrestrial invertebrates exposed by direct contact with soil,
- terrestrial mammals and birds (rabbit, shrew, fox, and hawk) exposed to COPECs by ingestion of food and soil,
- benthic invertebrates (aquatic insect larvae, crayfish, snails, clams, and bivalves) exposed by direct contact with sediment,
- aquatic biota (aquatic invertebrates and fish) exposed by direct contact with water,
- riparian herbivores (muskrat and mallard) exposed by ingestion of food and sediment or surface water, and
- riparian carnivores (mink and heron) exposed by ingestion of food and sediment or surface water.

The BCFs and BAFs needed to parameterize bioconcentration and bioaccumulation were compiled and used in the exposure equations.

Measures of toxicity were used as endpoints to compute HQs. Toxicity endpoints, termed TRVs, were used for exposure of ecological receptors to COPECs in soil, sediment, and surface water. For direct exposure (terrestrial plants, terrestrial invertebrates, aquatic biota, and benthic invertebrates), the HQ was calculated by dividing the RME concentration in soil, surface water, or sediment by the TRV. The HQs for ingestion exposures were calculated by dividing the ADD by the TRV.

7.10 RESULTS OF LEVEL III HAZARD QUOTIENT CALCULATIONS FOR CHEMICALS OF ECOLOGICAL CONCERN

HQ calculation tables for all of the ecological receptors are presented in Tables R-47 through R-99. The HQ calculation tables are organized by media, EU, and receptor within each EU. This section will not discuss in detail each of the HQs for each receptor, but briefly summarizes (1) contaminants that qualify for NFA due to HQs ≤ 1 for all receptors applicable for the given media, (2) constituents of ecological concern (COECs) due to HQs > 1 for one or more receptors, and (3) COECs of uncertain risk due to "no TRVs" for one or more receptors. Note that COECs based on "No TRV" had three possible conditions: (1) 1 or more receptors did have a TRV and an HQ > 1, (2) 1 or more receptors had a TRV but the HQs were ≤ 1, or (3) all of the receptors had "No TRV," which are identified in Table 7-11. The results of HQ calculations and subsequent summary of NFA analytes and COECs for surface soil (0 to 1 ft), sediment, and surface water are discussed in Sections 7.10.1, 7.10.2, and 7.10.3, respectively.

7.10.1 Load Line 4 Soil Receptor Hazard Quotients

HQs were calculated for terrestrial receptors exposed to surface soil at five EUs and are discussed in Sections 7.10.1.1 through 7.10.1.5.

Table 7-11. Summary of COECs for Surface Soil at Load Line 4 Aggregates

COEC	Explosives Handling Aggregate		Preparation and Receiving Area Aggregate		Packaging and Shipping Area Aggregate		Perimeter Area Aggregate		Melt-Pour Ditches Aggregate	
COECs per HQ > 1										
Inorganics										
Aluminum	Plant Rabbit Shrew	219 182 694	NA		NA		NA		NA	
Arsenic	Rabbit Shrew	2.6 3.3	Plant Rabbit Shrew	1.4 2.8 4.9	NA		NA		Plant Shrew	1.1 3.7
Barium	Shrew	1.4	NA		NA		NA		NA	
Cadmium	No HQ > 1		Shrew	1.3	Shrew	1.9	No HQ > 1		No HQ > 1	
Chromium	Plant Worm	15 37	Plant Worm	35 88	Plant Worm	18 45	NA		Plant Worm	11 28
Iron	Plant	2038	Plant	3139	Plant	2677	Plant	1824	Plant	2176
Lead	Plant Shrew	5.5 4.0	Plant Shrew	7.7 5.6	Plant Shrew	4 2.6	Plant Shrew	4.5 3.3	No HQ > 1	
Manganese	NA		NA		Plant	2.7	Plant	1.3	NA	
Mercury	No HQ > 1		NA		No HQ > 1		NA		NA	
Selenium	Plant	1.1	NA		NA		NA		NA	
Thallium	Plant Rabbit Shrew	1.5 3.4 12.9	NA		NA		NA		NA	
Zinc	Plant Worm	5.2 1.3	Plant Worm	6.8 1.7	Plant Worm	11 2.8	Plant --	1.4	Plant --	1.6
Pesticides/PCBs										
PCB-1254	Shrew --	5	Rabbit Shrew	3.3 72	Shrew --	3.4	NA		NA	
COECs per No TRV										
Inorganics										
Aluminum	No TRV[a]		NA		NA		NA		NA	
Barium	No TRV[a]		NA		NA		NA		NA	
Beryllium	No TRV[b]		NA		NA		NA		NA	
Calcium	No TRV[c]		NA		NA		NA		NA	

Table 7-11. Summary of COECs for Surface Soil at Load Line 4 Aggregates (continued)

COEC	Explosives Handling Aggregate	Preparation and Receiving Area Aggregate	Packaging and Shipping Area Aggregate	Perimeter Area Aggregate	Melt-Pour Ditches Aggregate
Iron	No TRV[a]	No TRV[a]	No TRV[a]	No TRV[a]	No TRV[a]
Magnesium	No TRV[c]	NA	NA	NA	No TRV[c]
Manganese	NA	NA	No TRV[a]	No TRV[a]	NA
Sodium	No TRV[c]	NA	NA	NA	NA
Thallium	No TRV[a]	NA	NA	NA	NA
Pesticides/PCBs					
4,4'-DDT	No TRV[b]	NA	NA	NA	NA
PCB-1254	No TRV[a]	No TRV[a]	No TRV[a]	NA	NA
Dieldrin	No TRV[b]	NA	NA	NA	NA

[a] HQ > 1 for one or more receptors (see above).
[b] HQ > 1 for no receptors.
[c] No TRVs for all receptors.
COEC = Chemical of ecological concern.
DDT = Dichlorodiphenyltrichloroethane.
HQ = Hazard quotient.
NA = Not applicable because contaminant not a contaminant of preliminary ecological concern at this location.
PCB = Polychlorinated biphenyl.
TRV = Toxicity reference value.
-- = All other receptor HQs < 1 for this location.

7.10.1.1 Explosives Handling Area Aggregate

Sixteen inorganic, two pesticide, and one PCB preliminary COPECs were inputted for HQ calculations for plants and earthworms, cottontail rabbits, and shrews, which are presented in Tables R-47, R-48, and R-49, respectively. For foxes and red-tailed hawks, four inorganic, two pesticide, and one PCB PBT COPECs were inputted for HQ calculations, which are presented in Tables R-50 and R-51, respectively.

Soil NFAs. Three inorganics (cadmium, copper, and mercury) were the only inputted preliminary COPECs for surface soil that qualified for NFA following the BERA HQ calculations because their HQs were less than 1 for all the terrestrial receptors.

Soil COECs per Load Line 4 HQs > 1. Load Line 4 HQs exceeding 1 for the six terrestrial receptors are summarized in Table 7-11.

For plants, seven inorganics (aluminum, chromium, iron, lead, selenium, thallium, and zinc) were COECs due to Load Line 4 HQs > 1, with iron being highest (HQ = 2,038) followed by aluminum (HQ = 219). For earthworms, chromium and zinc were the only COECs based on a Load Line 4 HQ > 1, with chromium being highest (HQ = 38).

For cottontail rabbits, three inorganics (aluminum, arsenic, and thallium) were COECs due to Load Line 4 HQs > 1, with aluminum having the highest HQ (HQ = 182) followed by thallium (HQ = 3.4). For shrews, five inorganics (aluminum, arsenic, barium, lead, and thallium) and PCB-1254 were the six COECs whose Load Line 4 HQs > 1. For shrews, aluminum had the highest HQ (694), followed by thallium (HQ = 13).

For foxes and hawks, no Load Line 4 HQs > 1.

Soil COECs per "No TRV." Eight inorganics (aluminum, barium, beryllium, calcium, iron, magnesium, sodium, and thallium), 2 pesticides (4,4'-DDT and dieldrin), and 1 PCB (PCB-1254) were the 11 soil COECs based on no TRV for at least one terrestrial receptor at this EU (Table 7-11). Note that 4 of the 11 COECs based on "No TRV" were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

7.10.1.2 Preparation and Receiving Area Aggregate

Seven inorganic and one PCB preliminary COPECs were inputted for HQ calculations for plants and earthworms, cottontail rabbits, and shrews, which are presented in Tables R-52, R-53, and R-54, respectively. For foxes and red-tailed hawks, three inorganic and one PCB PBT COPECs were inputted for HQ calculations, which are presented in Tables R-55 and R-56, respectively.

Soil NFAs. Nickel was the only inputted preliminary COPEC for surface soil that qualified for NFA following the BERA HQ calculations.

Soil COECs per Load Line 4 HQs > 1. Load Line 4 HQs exceeding 1 for these receptors are summarized in Table 7-11.

For plants, five inorganics were COECs due to Load Line 4 HQs > 1 (arsenic, chromium, iron, lead, and zinc), with iron being highest (HQ = 3139) followed by chromium (HQ = 35). For earthworms, chromium and zinc were the only two COECs whose Load Line 4 HQs > 1, with chromium being the highest (HQ = 88).

For cottontail rabbits, one inorganic (arsenic) and 1 PCB (PCB-1254) were the two COECs whose Load Line 4 HQs > 1, with PCB-1254 being highest (HQ = 3.3). For shrews, three inorganics (arsenic, cadmium, and lead) and one PCB (PCB-1254) were the four COECs whose Load Line 4 HQs > 1. PCB-1254 had the highest HQ for shrews (HQ = 72), followed by lead (HQ = 5.6).

For foxes and hawks, no Load Line 4 HQs exceeded 1.

Soil COECs per "No TRV." One inorganic (iron) and one PCB (PCB-1254) were the two soil COECs based on "No TRV" for at least one terrestrial receptor at this EU (Table 7-11). Note that both of these COECs based on "No TRV" were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

7.10.1.3 Packaging and Shipping Area Aggregate

Eight inorganic and one PCB preliminary COPECs were inputted for HQ calculations for plants and earthworms, cottontail rabbits, and shrews, which are presented in Tables R-57, R-58, and R-59, respectively. For foxes and red-tailed hawks, four inorganic and one PCB PBT COPECs were inputted for HQ calculations, which are presented in Tables R-60 and R-61, respectively.

Soil NFAs. Two inorganics (copper and mercury) were the only inputted preliminary COPECs for surface soil that qualified for NFA following the BERA HQ calculations.

Soil COECs per Load Line 4 HQs > 1. Load Line 4 HQs exceeding 1 for these receptors are summarized in Table 7-11.

For plants, five inorganics were COEC due to Load Line 4 HQs > 1 (chromium, iron, lead, manganese, and zinc), with iron being highest (HQ = 2,677) followed by chromium (HQ = 18). For earthworms, chromium and zinc were the two COECs based on Load Line 4 HQs > 1, with chromium being the highest (HQ = 45).

For cottontail rabbits, no Load Line 4 HQs > 1. For shrews, two inorganics (cadmium and lead) and one PCB (PCB-1254) were the three COECs based on Load Line 4 HQ > 1, with PCB-1254 being highest (HQ = 3.4).

For foxes and hawks, no Load Line 4 HQs exceeded 1.

Soil COECs per "No TRV." Two inorganics (iron and manganese) and one PCB (PCB-1254) were the three soil COECs based on "No TRV" for at least one terrestrial receptor at this EU (Table 7-11). All three COECs based on "No TRV" were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

7.10.1.4 Perimeter Area Aggregate

Five inorganic preliminary COPECs were inputted for HQ calculations for plants and earthworms, cottontail rabbits, and shrews, which are presented in Tables R-62, R-63, and R-64, respectively. For foxes and red-tailed hawks, three inorganic PBT COPECs were inputted for HQ calculations, which are presented in Tables R-65 and R-66, respectively.

Soil NFAs. One inorganic (cadmium) was the only inputted preliminary COPEC for surface soil that qualified for NFA following the BERA HQ calculations.

Soil COECs per Load Line 4 HQs > 1. Load Line 4 HQs exceeding 1 for the receptors are summarized in Table 7-11.

For plants, four of the five inorganics were COECs due to Load Line 4 HQs > 1 (iron, lead, manganese, and zinc), with iron being highest (HQ = 1,820) followed by lead (HQ = 4.5). For earthworms, no Load Line 4 HQs were > 1.

For cottontail rabbits, no Load Line 4 HQs > 1. For shrews, lead was the only COEC based on a Load Line 4 HQ > 1 (HQ = 3.3).

For foxes and hawks, no Load Line 4 HQs > 1.

Soil COECs per "No TRV." Two inorganics, iron and manganese, were the only COECs for soil based on "No TRV" for at least one receptor at this EU. Both of these COECs were also COECs based on a Load Line 4 HQ > 1 for at least one receptor (Table 7-11).

7.10.1.5 Melt-Pour Drainage Ditches Aggregate

Eight inorganic preliminary COPECs were inputted for HQ calculations for plants and earthworms, cottontail rabbits, and shrews, which are presented in Tables R-67, R-68, and R-69, respectively. For foxes and red-tailed hawks, three inorganic PBT COPECs were inputted for HQ calculations, which are presented in Tables R-70 and R-71, respectively.

Soil NFAs. Three inorganics (cadmium, copper, and lead) were the only inputted preliminary COPECs for surface soil that qualified for NFA following the BERA HQ calculations.

Soil COECs per Load Line 4 HQs > 1. Load Line 4 HQs exceeding 1 for the receptors are summarized in Table 7-11.

For plants, four inorganics (arsenic, chromium, iron, and zinc) were the four COECs based on Load Line 4 HQs > 1, with iron having the largest HQ (HQ = 2,180) followed by chromium (HQ = 11). For earthworms, chromium was the only COEC based on a Load Line 4 HQ > 1 (HQ = 28).

For cottontail rabbits, no Load Line 4 HQ > 1.

For shrews, one inorganic (arsenic) was the only COEC based on Load Line 4 HQ > 1 (HQ = 3.7).

For foxes, and hawks, no Load Line 4 HQs > 1.

Soil COECs per "No TRV." There were two inorganic COECs (iron and magnesium) based on "No TRV" for at least one receptor at this EU (Table 7-11). Iron was also a COEC based on a Load Line 4 HQ > 1 for at least one receptor.

7.10.2 Load Line 4 Sediment Receptor Hazard Quotients

HQs were calculated for sediment receptors exposed to surface sediment at the three EUs, and are discussed in Sections 7.10.2.1 through 7.10.2.3 below.

7.10.2.1 Main Stream Segment Upstream of Perimeter Road Aggregate

Four inorganic and one explosives preliminary COPECs for sediment were inputted for HQ calculations for sediment biota, muskrats, and mallards, which are presented in Tables R-72, R-73, and R-74,

respectively. For mink and Great blue herons, one inorganic PBT COPEC was inputted for HQ calculations, which are presented in Tables R-75 and R-76, respectively.

Sediment NFAs. There were no sediment preliminary COPECs that qualified for NFA following the BERA HQ calculations because they all either had at least one HQ > 1 or had no TRV for at least one receptor.

Sediment COECs per HQs > 1. HQs exceeding 1 for these five receptors are summarized in Table 7-12.

For sediment biota, muskrats, and mallards, and mink there were no HQs > 1.

For Great blue herons, cadmium was the only COEC based on an HQ > 1. (HQ = 2.1).

Sediment COECs per "No TRV." Three inorganics (beryllium, calcium, and magnesium) and one explosive (2,4,6-TNT) were the four COECs for sediment based on no TRV for at least one receptor. None of the four COECs based on "No TRV" were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

7.10.2.2 Main Stream Segment and Settling Pond Aggregate

Eleven inorganics and one explosives preliminary COPECs for sediment were inputted for HQ calculations for sediment biota, muskrats, and mallards, which are presented in Tables R-77, R-78, and R-79, respectively. For mink and Great blue herons, three inorganic PBT COPECs were inputted for HQ calculations, which are presented in Tables R-80 and R-81, respectively.

Sediment NFAs. Mercury was the only inputted sediment preliminary COPEC that qualified for NFA following the BERA HQ calculations.

Sediment COECs per HQs > 1. HQs exceeding 1 for these five receptors are summarized in Table 7-12.

For sediment biota, nickel was the only COEC based on an HQ > 1 (HQ = 1.5).

For muskrats, mallards, and mink there were no HQs > 1.

For Great blue herons, three inorganics (aluminum, cadmium, and lead) were the three COECs based on HQs > 1. The maximum HQ was for lead (HQ = 273) followed by cadmium (HQ = 40).

Sediment COECs per "No TRV." Seven inorganics (aluminum, barium, calcium, iron, magnesium, thallium, and vanadium) and one explosive (2,4,6-TNT) were the eight COECs for sediment based on no TRV for at least one receptor. Note that of the eight COECs based on "No TRV," one (aluminum) was also a COEC based on a Load Line 4 HQ > 1 for at least one receptor.

7.10.2.3 Exit Drainages Aggregate

One inorganic and one PCB preliminary COPECs for sediment were inputted for HQ calculations for sediment biota, muskrats, and mallards, which are presented in Tables R-82, R-83, and R-84, respectively. For mink and Great blue herons, one inorganic and one PCB PBT COPECs were inputted for HQ calculations, which are presented in Tables R-85 and R-86, respectively.

Table 7-12. Summary of COECs for Sediment at Load Line 4 Exposure Units

COEC	Upstream of Perimeter Road		Settling Pond Aggregate		Exit Drainages Aggregate	
COECs per HQ > 1						
Inorganics						
Aluminum	NA		Heron	3.8	NA	
Cadmium	Heron	3.0	Heron	40	Heron	11
Lead	NA		Heron	273	NA	
Nickel	NA		Sed. Biota	1.5		
COECs per "No TRV"						
Inorganics						
Aluminum	NA		No TRV[a]		NA	
Barium	NA		No TRV[b]		NA	
Beryllium	No TRV[b]		NA		NA	
Calcium	No TRV[c]		No TRV[c]		NA	
Iron	NA		No TRV[c]		NA	
Magnesium	No TRV[c]		No TRV[c]		NA	
Thallium	NA		No TRV[b]		NA	
Vanadium	NA		No TRV[b]		NA	
Pesticides/PCBs						
PCB-1248	NA		NA		No TRV[b]	
Explosives						
2,4,6-Trinitrotoluene	No TRV[b]		No TRV[b]		NA	

[a] HQ > 1 for one or more receptors (see above).
[b] HQ > 1 for no receptors.
[c] No TRVs for all receptors.
COEC = Chemical of ecological concern.
HQ = Hazard quotient.
NA = Not applicable because contaminant not a contaminant of preliminary ecological concern at this location.
PCB = Polychlorinated biphenyl.
TRV = Toxicity reference value.

Sediment NFAs. Neither of the two inputted sediment preliminary COPEC qualified for NFA following the BERA HQ calculations because they either had at least one HQ > 1 or had "no TRV" for at least one receptor.

Sediment COECs per HQs > 1. HQs exceeding 1 for these five receptors are summarized in Table 7-12.

For sediment biota, muskrats, mallards, and mink there were no HQs > 1.

For Great blue herons, cadmium was the only COEC based on an HQ > 1 (HQ =11).

Sediment COECs per "No TRV." One PCB (PCB-1248) was the only COEC for sediment based on no TRV for at least one receptor.

7.10.3 Load Line 4 Surface Water Receptor Hazard Quotients

HQs were calculated for surface water receptors exposed to surface water at three EUs (Main Stream Segment Upstream of Perimeter Road Aggregate; Main Stream Segment and Settling Pond Aggregate; and Exit Drainages Aggregate) and are discussed in Section 7.10.3.1.

7.10.3.1 Main Stream Segment Upstream of Perimeter Road Aggregate

Seven inorganic preliminary COPECs for surface water were inputted for HQ calculations for aquatic biota, muskrats, and mallards, which are presented in Tables R-87, R-88, and R-89, respectively. There were two inorganic PBT preliminary COPECs for surface water inputted for HQ calculations for mink and herons, which are presented in Tables R-90 and R-91, respectively.

Surface Water NFAs. Two inorganics (cadmium and mercury) were the only two inputted preliminary COPECs that qualified for NFA following the BERA HQ calculations because their HQs were less than 1 for all receptors.

Surface Water COECs per HQs > 1. HQs exceeding 1 are summarized in Table 7-13.

For aquatic biota, iron and manganese were the only two COECs based on HQs > 1, with manganese being highest (HQ = 30).

For muskrats, mallards, mink, and herons there were no HQs > 1.

Table 7-13. Summary of COECs for Surface Water at Load Line 4 Exposure Units

COEC	Main Stream Segment Upstream of Perimeter Road		Main Stream Segment Settling Pond Aggregate		Exit Drainages Aggregate
COECs per HQ > 1					
Inorganics					
Iron	Aquatic biota	4.6	NA		NA
Manganese	Aquatic biota	30	NA		NA
Mercury	NA		Heron	13	NA
Pesticides/PCBs					
4,4'-DDT	NA		Aquatic biota Muskrat Duck Heron	28182 1.8 27 614888	NA
COECs per "No TRV"					
Inorganics					
Calcium	No TRV[b]		NA		No TRV[b]
Iron	No TRV[a]		NA		NA
Magnesium	No TRV[b]		NA		No TRV[b]
Potassium	No TRV[b]		NA		NA

[a] HQ > 1 for one or more receptors (see above).
[b] HQ > 1 for no receptors.
COEC = Chemical of ecological concern.
DDT = Dichlorodiphenyltrichloroethane.
HQ = Hazard quotient.
NA = Not applicable because contaminant not a contaminant of preliminary ecological concern at this location.
TRV = Toxicity reference value.

Surface Water COECs per "No TRV." Four inorganics (calcium, iron, magnesium, and potassium) were surface water COECs based on "No TRV" for one or both aquatic receptors. One of those four COECs (iron) was also a COEC based on an HQ > 1 for at least one receptor.

7.10.3.2 Main Stream Segment and Settling Pond Aggregate

One inorganic and one pesticide preliminary COPECs for surface water were inputted for HQ calculations for aquatic biota, muskrats, and mallards, which are presented in Tables R-92, R-93, and R-94, respectively. One inorganic and one pesticide PBT preliminary COPECs for surface water were inputted for HQ calculations for mink and heron, which are presented in Tables R-95 and R-96, respectively.

Surface Water NFAs. Neither of the two inputted preliminary COPECs qualified for NFA following the BERA HQ calculations because either they had at least one HQ > 1 or they had "no TRV."

Surface Water COECs per HQs > 1. HQs exceeding 1 are summarized in Table 7-13.

For aquatic biota, one pesticide (4,4'-DDT) was the only COEC based on an HQ > 1 (HQ = 28,182).

For muskrats, one pesticide (4,4'-DDT) was the only COEC based on an HQ > 1 (HQ = 1.8).

For mallards, one pesticide (4,4'-DDT) was the only COEC based on an HQ > 1 (HQ = 27).

For mink, there were no HQs > 1.

For herons, one pesticide (4,4'-DDT) was the only COEC based on an HQ > 1 (HQ = 614,888).

Surface Water COECs per "No TRV." There were no surface water COECs based on "No TRV" because TRVs were available for all of the inputted preliminary COPECs for all aquatic receptors.

7.10.3.3 Exit Drainages Aggregate

Two inorganic preliminary COPECs for surface water were inputted for HQ calculations for aquatic biota, muskrats, and mallards, which are presented in Tables R-97, R-98, and R-99, respectively. There were no PBT preliminary COPECs for surface water so HQ calculations were unnecessary for mink and herons.

Surface Water NFAs. Neither of the two inputted preliminary COPECs qualified for NFA following the BERA HQ calculations because they had "no TRV" for all receptors.

Surface Water COECs per HQs > 1. HQs exceeding 1 are summarized in Table 7-13.

For aquatic biota, muskrats, and mallards, there were no COECs based on HQs > 1 because TRVs were not available for any of the receptors for the two preliminary COPECs.

For mink and herons, there were no PBT preliminary COPECs for surface water at this EU so HQ calculations were unnecessary for these two receptors.

Surface Water COECs per "No TRV." Calcium and magnesium were surface water COECs based on "No TRV" for all three aquatic receptors.

7.10.4 Future Risk to Ecological Receptors

The current HQs for the terrestrial plants and animals at the Load Line 4 EUs are assumed to be the same or similar to future HQs because most of the soil COEC concentrations are not expected to change dramatically over time, assuming there are no disturbances to the soil. For example, most inorganic COECs like the heavy metals are fairly immobile in the soil and do not undergo biodegradation or transformation processes. Although some organic COECs can undergo biodegradation or transformations, these processes tend to be fairly slow for the types of COECs at Load Line 4 (e.g., pesticides, PAHs, and PCBs). Ecological succession could result in a change of specific vegetation composition, but the relatively small size of the terrestrial EUs at Load Line 4 should minimize changes in the types of ecological receptors. Thus, because the future concentrations of COECs, as well as the future types of ecological receptors, are not expected to change dramatically from the current conditions, future risk is expected to be similar to the current risk indicated by the HQs.

Future risk in the aquatic habitats is more likely to change due to yearly inputs of new sediment and changes in sedimentation, which could affect sediment and surface water COEC concentrations. Thus, future HQs for sediment and surface water could vary accordingly. If new inputs of sediment are clean (i.e., free of COECs), future risk would decrease because the contaminated sediments would be covered or at least "diluted" with clean sediment. Conversely, if future inputs of sediment are also contaminated with COECs, risks to ecological receptors could stay the same or even increase, depending on the contaminant concentrations.

7.10.5 Summary of Hazard Quotient Calculations

EU-specific preliminary COPECs for surface soil, sediment, and surface water from the Level II ESV screen were inputted to this Level III BERA where they underwent EU- and receptor-specific HQ calculations. Following the HQ calculations, the preliminary COPECs were classified into one of three categories: (1) NFA, (2) COECs per HQs > 1, or (3) COECs per "no TRV."

7.10.5.1 Soil HQ calculations summary

One or more NFAs were identified for the five terrestrial EUs. One or more COECs based on HQs > 1, as well as COECs based on "No TRV" for at least one receptor, were identified at all five terrestrial EUs. The summary of soil NFAs and COECs by EU is presented below.

Explosives Handling Area Aggregate

- Soil NFAs: three inorganics.
- Soil COECs per Load Line 4 HQs > 1: 10 COECs (9 inorganics and 1 PCB) with the highest HQ = 694 for aluminum for shrews.
- Soil COECs per "No TRVs": 11 COECs (8 inorganics, 2 pesticides, and 1 PCB), 5 of which were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

Preparation and Receiving Area Aggregate

- Soil NFAs: one inorganic.
- Soil COECs per Load Line 4 HQs > 1: seven COECs (six inorganics and one PCB) with the highest HQ = 3,139 for iron for plants.

- Soil COECs per "No TRVs": two COECs (one inorganic and one PCB), both of which were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

Packaging and Shipping Area Aggregate

- Soil NFAs: two inorganics.
- Soil COECs per Load Line 4 HQs > 1: seven COECs (six inorganics and one PCB) with the highest HQ = 2,677 for iron for plants.
- Soil COECs per "No TRVs": three COECs (two inorganics and one PCB), all three of which were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

Perimeter Area Aggregate

- Soil NFAs: one inorganic.
- Soil COECs per Load Line 4 HQs > 1: four COECs (inorganics) with the highest HQ = 1,824 for iron for plants.
- Soil COECs per "No TRVs": two (inorganics), both of which were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

Melt-Pour Drainage Ditches Aggregate

- Soil NFAs: three inorganics.
- Soil COECs per Load Line 4 HQs > 1: four COECs (inorganics), with the highest HQ = 2,176 for iron for plants.
- Soil COECs per "No TRVs": two (inorganics), one of which (iron) was also a COEC based on a Load Line 4 HQ > 1 for at least one receptor.

7.10.5.2 Sediment HQ calculations summary

Only one NFA was identified at one of the three sediment EUs. One or more COECs based on HQs > 1 were identified at all three sediment EUs. One or more COECs based on "no TRVs" were identified at all three sediment EUs. The summary of sediment NFAs and COECs by EU is presented below.

Main Stream Segment Upstream of Perimeter Road Aggregate

- Sediment NFAs: none.
- Sediment COECs per Load Line 4 HQs > 1: one COEC (cadmium) with the HQ = 2.1 for herons.
- Sediment COECs per "No TRVs": four COECs (three inorganics and one explosive), of which none were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

Main Stream Segment and Settling Pond Aggregate

- Sediment NFAs: one inorganic.

- Sediment COECs per Load Line 4 HQs > 1: four COECs (inorganics) with the largest HQ = 273 for lead for herons.

- Sediment COECs per "No TRVs": eight COECs (seven inorganics and one explosive), of which aluminum was also a COEC based on a Load Line 4 HQ > 1 for at least one receptor.

Exit Drainages Aggregate

- Sediment NFAs: none.

- Sediment COECs per Load Line 4 HQs > 1: one COEC (cadmium) with the HQ = 11 for herons.

- Sediment COECs per "No TRVs": one COEC (PCB-1248).

7.10.5.3 Surface Water HQ Calculations Summary

Only two NFAs were identified at one of the three surface water EUs. One or more COECs based on HQs > 1 were identified at two of the three surface water EUs. Two or more COECs based on "no TRVs" were identified at two of the three surface water EUs. The summary of surface water NFAs and COECs is presented below.

Main Stream Segment Upstream of Perimeter Road Aggregate

- Surface water NFAs: two inorganics (cadmium and mercury).

- Surface water COECs per Load Line 4 HQs > 1: two COECs (iron and manganese) for aquatic biota with the largest HQ = 30 for manganese.

- Surface water COECs per "No TRVs": four (inorganics), one of which (iron) was also a COEC based on an HQ > 1 for at least one receptor.

Main Stream Segment and Settling Pond Aggregate

- Surface water NFAs: none.

- Surface water COECs per Load Line 4 HQs > 1: two COECs (mercury and 4,4'-DDT), with the largest HQ = 614,888 for 4,4'-DDT for herons, followed by HQ = 28,182 for 4,4'-DDT for aquatic biota.

- Surface water COECs per "No TRVs": none.

Exit Drainages Aggregate

- Surface water NFAs: none.

- Surface water COECs per Load Line 4 HQs > 1: none.

- Surface water COECs per "No TRVs": two (calcium and magnesium) based on "no TRV" for any receptor.

7.11 UNCERTAINTIES FOR THE BASELINE ECOLOGICAL RISK ASSESSMENT

Uncertainties in the Load Line 4 BERA are discussed briefly in this section by the four interrelated steps of the EPA approach to a BERA: problem formulation, exposure assessment, effects assessment, and risk characterization. An uncertainty section of a more general and SERA-specific nature is found in Section 7.5.

7.11.1 Uncertainties in Problem Formulation

Environmental concentrations of analytes in the soil, sediment, and surface water at Load Line 4 were based on a limited number of samples, and the uncertainties associated with this are found in the SERA, Section 7.5.1.

7.11.2 Uncertainties in Exposure Assessment

The actual movement of analytes from the Load Line 4 constituent source media to ecological receptors has not been measured for this BERA. 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 SERA. Thus, the exposures could be overestimated based on the total measured concentration.

BAFs for soil and sediment to biota, and BAFs for surface water to biota, used for the PBT evaluation, are not available for some analytes. 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.

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 BAFs, irrespective of species and environmental conditions. In particular, it should be noted that, while the largest BAFs may overestimate bioaccumulation at Load Line 4 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.

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

7.11.3 Uncertainties in Effects Assessment

The preferred TRVs for the three media were based on concentrations reported to have no observed effects or NOAELs for various organisms. This BERA provides findings for COPEC-specific HQs. An evaluation of risk from COPEC mixtures cannot be conducted without additional data and evaluation of alternative models of COPEC interaction.

There are no available TRVs for some analytes, especially organics, for each of the three media. This contributes to uncertainty associated with likely underestimates of risk. Sometimes, lack of TRVs based on soil-plant studies caused use of TRVs based on hydroponic studies; hydroponic studies are inferior to soil-plant studies and this contributed additional uncertainty.

Some of this uncertainty can be offset by field studies. For example, at RVAAP, there was a facility-wide surface water investigation that was performed by USACE with cooperation of Ohio EPA. In the investigation, water and sediment samples were taken from locations along the major stream and tributaries, ponds, and wetlands throughout RVAAP at locations that could have been impacted by former facility activities and sites where the streams entered RVAAP. Fish were caught, identified, and released in the sampling locations corresponding to the water and sediment sample locations. Invertebrate biota was collected by Hester-Dendy samplers set in the same locations and by qualitative sampling of organic debris and rocks in the stream reach. Funnel traps were additionally placed in ponds and wetlands for further invertebrate sampling. The details of the study, locations, techniques, and results from this study are published in the Ravenna facility-wide surface water study: Streams (USACE 2004) and Ravenna facility-wide surface water study: ponds and wetlands (USACE 2004).

The Load Line 4 pond was sampled for the facility-wide surface water study; the detailed results are published in the ponds and wetlands volume. The results of analytical sampling indicate no significant residual contamination from facility processes. The biological parameters are still under investigation; however, they appear to be un-impacted based on initial review.

The Load Line 4 pond drains to a stream south of the site, which was also investigated in the facility-wide surface water study and is published in the streams volume. The analytical results indicated a very low concentration of RDX and HMX in the surface water in the second sampling round 6 weeks after the high water event. This may indicate low levels of facility-related contamination in this stream reach; however, the levels are below Ohio-set thresholds for aquatic impact. Biotic results will be discussed in the surface water documents.

7.11.4 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 Load Line 4. Five additional areas of uncertainty in the risk characterization exist: off-site risk, cumulative risk, future risk, background risk, and extrapolation risk. See the SERA, Section 7.5.5, for additional information.

There is an additional topic for uncertainty—qualitative estimation for subsurface soil and quantitative risk estimation for surface soil. Table 7-14 shows that almost all chemicals are more concentrated in the upper soil horizon compared to the deeper ones, where exposure of deep plant roots and some burrows may occur, but that a few show a reverse pattern. This comparison is narrated below.

Comparisons were made between surface soil and subsurface soil contaminants for both the mean and maximum concentrations. Those EUs with contaminants that were found to have maximum concentrations equal to or greater in subsurface soil than surface soil are discussed below. EUs with subsurface and surface soil data available were the Explosives Handling Areas, the Preparation and Receiving Areas, the Packaging and Receiving Areas, and the Perimeter Area. Subsurface soil samples were not collected from the Change Houses EU. Surface soil samples were collected from 0 to 1 ft bgs and subsurface samples were collected from 1 to 3 ft bgs. There were no maximum concentrations of explosives, pesticides, SVOCs, or VOCs in subsurface contaminants that were greater than surface contaminants at any EU.

Table 7-14. Summary of Soil COECs, by Exposure Unit, for Load Line 4

BERA for Load Line 4 COECs per Load Line 4 HQ > 1			Load Line 4 Mean ≤ Load Line 1 Mean* COECs per Load Line 1 HQ > 1		BERA for Load Line 4 COECs per "No TRV"	
Explosive Handling Areas Aggregate						
Aluminum	Selenium		Manganese		Aluminum[a]	Sodium[b]
Arsenic	Thallium				Barium[a]	Thallium[a]
Barium	Zinc				Beryllium[b]	PCB-1254[a]
Chromium	PCB-1254				Calcium[b]	4,4'-DDT[b]
Iron					Iron[a]	Dieldrin[b]
Lead					Magnesium[c]	
Preparation and Receiving Areas Aggregate						
Arsenic	Iron	PCB-1254	Mercury		Iron[a]	
Cadmium	Lead				PCB-1254[a]	
Chromium	Zinc					
Packaging and Shipping Areas Aggregate						
Cadmium	Lead	PCB-1254	Selenium		Iron[a]	
Chromium	Manganese				Manganese[a]	
Iron	Zinc				PCB-1254[a]	
Perimeter Area Aggregate						
Iron	Manganese		Chromium		Iron[a]	
Lead	Zinc				Manganese[a]	
Melt-Pour Ditches Aggregate						
Arsenic	Iron		None		Iron[a]	
Chromium	Zinc				Magnesium[c]	

[a] No TRV for some receptors but an HQ > 1 for one or more other receptors.
[b] No TRV for some receptors but no HQ > 1 for any other receptors.
[c] No TRV for any ecological receptors at the exposure unit.
* Not significantly different at $p < 0.05$ (t-test).
BERA = Baseline ecological risk assessment.
COEC = Chemical of ecological concern.
DDT = Dichlorodiphenyltrichloroethane.
HQ = Hazard quotient.
PCB = Polychlorinated biphenyl.
TRV = Toxicity reference value.

In the Explosives Handling Area Aggregate, arsenic was found to have the maximum concentration in subsurface soil equal to surface soil (1.8 mg/kg; Table 7-15). The mean concentration was 1.1 times greater in subsurface soil (10.0 mg/kg) than surface soil (8.8 mg/kg).

In the Preparation and Receiving Areas Aggregate, eight inorganics were found to have maximum concentrations in subsurface soil higher than or equal to surface soil: aluminum, barium, beryllium, calcium, manganese, potassium, selenium, and sodium (Table 7-15). These contaminants were approximately 2 to 3 times greater in subsurface soil, except calcium, which was equal to surface soil concentrations (175,000 mg/kg). All mean concentrations were greater in subsurface soil with concentrations ranging from 1.2 to 4.0 times greater. Also, all potassium concentrations were not above site background criteria.

In the Packaging and Shipping Areas Aggregate, only thallium was found to have the maximum concentration higher in subsurface soil (0.66 mg/kg; Table 7-15), which was 1.1 times greater than surface soil (0.58 mg/kg). However, the mean was 2.2 times greater in subsurface soil (0.66 versus 0.30 mg/kg).

Table 7-15. Comparison of Surface and Subsurface Maximum and Mean Concentrations at Load Line 4

Contaminant Group	Number of Maximum Concentrations > in Subsurface	Contaminant > in Subsurface	Soil Horizon Maximum Concentrations (mg/kg)			Soil Horizon Mean Concentrations (mg/kg)			Highest HQ and Implication for Ecological Risk
			Surface (0 to 1 ft)	Subsurface (1 to 3 ft)	Number of Times Greater	Surface (0 to 1 ft)	Subsurface (1 to 3 ft)	Number of Times Greater	
Explosives Handling Areas Aggregate									
Inorganics	1 of 24	Arsenic[a]	1.8E+01	1.8E+01	1.0	8.8E+00	1.0E+01	1.1	None
Explosives	0 of 3	--							
Pesticides	0 of 16	--							
SVOCs	0 of 18	--							
VOCs	0 of 3	--							
Preparation and Receiving Areas Aggregate									
Inorganics	8 of 24	Aluminum	1.6E+04	3.7E+04	2.3	9.0E+03	2.0E+04	2.2	None
		Barium	2.0E+02	4.0E+02	2.0	8.6E+01	2.1E+02	2.4	None
		Beryllium	1.6E+00	5.0E+00	3.1	5.2E-01	2.1E+00	4.0	None
		Calcium	1.7E+05	1.7E+05	1.0	3.6E+04	6.8E+04	1.9	None
		Manganese	1.8E+03	4.7E+03	2.6	5.4E+02	2.1E+03	3.9	None
		Potassium[a]	1.2E+03	2.5E+03	2.1	6.5E+02	1.3E+03	2.0	None
		Selenium	1.2E+00	2.8E+00	2.3	1.1E+00	1.3E+00	1.2	None
		Sodium	2.6E+02	6.4E+02	2.5	1.8E+02	3.5E+02	1.9	None
Explosives	0 of 1	--							
Pesticides	0 of 2	--							
SVOCs	0 of 4	--							
VOCs	0 of 3	--							

Table 7-15. Comparison of Surface and Subsurface Maximum and Mean Concentrations at Load Line 4 (continued)

Contaminant Group	Number of Maximum Concentrations > in Subsurface	Contaminant > in Subsurface	Soil Horizon Maximum Concentrations (mg/kg)			Soil Horizon Mean Concentrations (mg/kg)			Highest HQ and Implication for Ecological Risk
			Surface (0 to 1 ft)	Subsurface (1 to 3 ft)	Number of Times Greater	Surface (0 to 1 ft)	Subsurface (1 to 3 ft)	Number of Times Greater	
Packaging and Shipping Areas Aggregate									
Inorganics	1 of 22	Thallium[a]	5.8E-01	6.6E-01	1.1	3.0E-01	6.6E-01	2.2	None
Explosives	0 of 1	--							
Pesticides	0 of 8	--							
SVOCs	0 of 10	--							
VOCs	0 of 1	--							
Perimeter Area Aggregate									
Inorganics	5 of 21	Aluminum[a]	1.5E+04	1.5E+04	1.0	1.1E+04	1.5E+04	1.4	None
		Arsenic[a]	1.2E+01	1.4E+01	1.2	8.1E+00	1.2E+01	1.5	None
		Copper[a]	1.6E+01	1.7E+01	1.1	1.1E+01	1.7E+01	1.5	None
		Iron[a]	2.4E+04	2.5E+04	1.0	1.6E+04	2.4E+04	1.5	None
		Nickel[a]	1.9E+01	2.1E+01	1.1	1.2E+01	2.0E+01	1.7	None
SVOCs	0 of 10	--							
VOCs	0 of 1	--							

[a] Maximum concentration not greater than background.
Highlighted values indicate mean values were higher than max values in tables.
None means no contaminant had an HQ because below background or other reason.
HQ = Hazard quotient.
SVOC = Semivolatile organic compound.
VOC = Volatile organic compound.

In the Perimeter Area Aggregate, five inorganics were found to have maximum concentrations in subsurface soil higher than or equal to surface soil: aluminum, arsenic, copper, iron, and nickel (Table 7-15), and those concentrations that were higher were no more than 1.2 times greater. All mean concentrations were greater in subsurface soil with concentrations ranging from 1.4 to 1.7 times greater. Also, all concentrations were not above site background criteria.

The biggest finding of these comparisons is that most all chemicals are more highly concentrated in the surface soil (0 to 1 ft). In the few opposite cases, all have no impact on HQs.

7.11.5 Extrapolation Risk

Yet another source of uncertainty revolves around the extrapolations of Load Line 1 data, including HQs, to Load Line 4. No one load line and no one EU is exactly like the others. Differences in concentrations and chemical mixtures introduce variation into extrapolations.

7.11.6 Summary of Uncertainties

The most important uncertainties in the Load Line 4 BERA 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 (TRVs). 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, 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 are believed to provide a sufficiently credible picture of ecological risk that management decisions can be made with confidence.

7.12 SUMMARY OF EXTRAPOLATION OF LOAD LINE 1 HAZARD QUOTIENTS AND LOAD LINE 4 LEVEL III BASELINE RISK ASSESSMENT

7.12.1 Soil Chemicals of Ecological Concern

Soil COECs. Multiple COECs for surface soil (0 to 1 ft depth) were identified for each of the five terrestrial EUs at Load Line 4 (Table 7-14). The EU-specific soil COECs were identified by having met one of three conditions: (1) the preliminary COPEC RME concentration yielded an HQ > 1 for at least one ecological receptor exposed to the surface soil, (2) the Load Line 4 mean concentration for the soil SRC was ≤ the mean for that analyte at Load Line 1 so the maximum HQ for that SRC for soil receptors at Load Line 1 was applicable to Load Line 4 and the Load Line 1 maximum HQ > 1, or (3) the Load Line 4 preliminary COPEC had no TRV for one or more receptors.

The Explosives Handling Area Aggregate had 17 COECs (14 inorganics, 2 pesticides, and 1 PCB). Ten of the COECs were based on Load Line 4 HQs > 1, 1 was based on a Load Line 1 maximum HQ > 1, and 11 were based on “No TRVs” for at least one receptor. Note that 5 of the 11 COECs based on “No TRV” were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

The Preparation and Receiving Area Aggregate had eight COECs (seven inorganics and one PCB), with seven COECs based on Load Line 4 HQs > 1, one based on a Load Line 1 maximum HQ > 1, and two COECs based on “No TRV” for at least one receptor. Both of the COECs based on “No TRV” were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

The Packaging and Shipping Area Aggregate had eight COECs (seven inorganics and one PCB), seven of which were based on the Load Line 4 HQs > 1, one inorganic (arsenic) based on a Load Line 1 maximum HQ > 1, and three COECs based on "No TRV" for at least one receptor. All three of the COECs based on "No TRV" were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

The Perimeter Area Aggregate had five COECs (all inorganics), four of which were based on Load Line 4 HQs > 1, one based on a Load Line 1 maximum HQ > 1, and two COECs based on "No TRVs" for at least one receptor. Note that both COECs based on "No TRV" were also COECs based on Load Line 4 HQs > 1 for at least one receptor.

The Melt-Pour Drainage Ditches Aggregate had five COECs (all inorganics), four of which were based on a Load Line 4 HQ > 1, none based on a Load Line 1 maximum HQ > 1, and two COECs based on "No TRV" for at least one receptor. One of the COECs based on "No TRV" (iron) was also a COEC based on a Load Line 4 HQ > 1 for at least one receptor.

7.12.2 Sediment Chemicals of Ecological Concern

Sediment COECs. COECs for sediment were identified at the three EUs at Load Line 4 (Table 7-16). The EU-specific sediment COECs were identified by having met one of two conditions: (1) the preliminary COPEC RME concentration yielded an HQ > 1 for one or more ecological receptors exposed to the sediment, or (2) there was no TRV for one or more receptors exposed to sediment at the EU.

The Main Stream Segment Upstream of Perimeter Road Aggregate had five sediment COECs (four inorganics and one explosive), one of which was based on a Load Line 4 HQ > 1 and the rest based on "No TRV" for at least one receptor. Of the four COECs based on "No TRV," none were also COECs based on a Load Line 4 HQ > 1 for at least one receptor.

Table 7-16. Summary of Sediment COECs for Load Line 4

BERA for Load Line 4 COECs per Load Line 4 HQ > 1		BERA for Load Line 4 COECs per "No TRV"	
Main Stream Segment Upstream of Perimeter Road Aggregate			
Cadmium		Beryllium[b]	Magnesium[c]
		Calcium	2,4,6-Trinitrotoluene[b]
Main Stream Segment and Settling Pond Aggregate			
Aluminum	Lead	Aluminum[a]	Magnesium[c]
Cadmium	Nickel	Barium[b]	Thallium[b]
		Calcium[c]	Vanadium[b]
		Iron[c]	2,4,6-Trinitrotoluene[b]
Exit Drainages Aggregate			
Cadmium		PCB-1248[b]	

[a] No TRV for some receptors but an HQ > 1 for one or more other receptors.
[b] No TRV for some receptors but no HQ > 1 for any other receptors.
[c] No TRV for any ecological receptors at the exposure unit.
BERA = Baseline ecological risk assessment.
COEC = Chemical of ecological concern.
HQ = Hazard quotient.
PCB = Polychlorinated biphenyl.
TRV = Toxicity reference value.

The Main Stream Segment and Settling Pond Aggregate had 11 sediment COECs (10 inorganics and 1 explosive), 4 of which were based on Load Line 4 HQs > 1 and 7 based on "No TRV" for at least one receptor. Of the seven COECs based on "No TRV," one (aluminum) was also a COEC based on a Load Line 4 HQ > 1 for at least one receptor.

The Exit Drainages Aggregate had two sediment COECs (cadmium and PCB-1248). Cadmium was a COEC based on a Load Line 4 HQ > 1 for one or more receptors, whereas PCB-1248 was a COEC based on "No TRV" for at least one receptor.

7.12.3 Surface Water Chemicals of Ecological Concern

Two or more COECs were identified for surface water at all three surface water EUs (Table 7-17). The EU-specific surface water COECs were identified by having met one of two conditions: (1) the preliminary COPEC RME concentration yielded an HQ > 1 for one or more ecological receptors exposed to the surface water, or (2) there was no TRV for one or more receptors exposed to surface water at the EU.

Table 7-17. Summary of Surface Water COECs for Load Line 4

BERA for Load Line 4 COECs per Load Line 4 HQ > 1		BERA for Load Line 4 COECs per "No TRV"	
Main Stream Segment Upstream of Perimeter Road Aggregate			
Iron		Calcium[b]	Magnesium[b]
Manganese		Iron[a]	Potassium[b]
Main Stream Segment and Settling Pond Aggregate			
Mercury	4,4'-DDT	None	
Exit Drainages Aggregate			
None		Calcium[b]	Magnesium[b]

[a] No TRV for some receptors but an HQ > 1 for one or more other receptors.
[b] No TRV for some receptors but no HQ > 1 for any other receptors.
* Not significantly different at p < 0.05 (t-test).
BERA = Baseline ecological risk assessment
COEC = Chemical of ecological concern.
DDT = Dichlorodiphenyltrichloroethane.
HQ = Hazard quotient.
TRV = Toxicity reference value.

The Main Stream Segment Upstream of Perimeter Road Aggregate had five surface water COECs (inorganics), two of which were based on a Load Line 4 HQ > 1 for at least one receptor and four were based on "No TRV" for at least one receptor. Of the four COECs based on "No TRV," one (iron) was also a COEC based on a Load Line 4 HQ > 1 for at least one receptor.

The Main Stream Segment and Settling Pond Aggregate had two surface water COECs (mercury and 4,4'-DDT), both of which were based on a Load Line 4 HQ > 1 for at least one receptor. There were no COECs based on "No TRV" because TRVs were available for all the inputted preliminary COECs for all receptors at this surface water EU.

The Exit Drainages Aggregate had two surface water COECs (calcium and magnesium), both of which were based on "No TRV" for any receptor. There were no COECs based on a Load Line 4 HQ > 1 for at least one receptor because there were no TRVs for any of the inputted preliminary COPECs for all aquatic receptors at this EU.

8.0 SUMMARY AND CONCLUSIONS

The Load Line 4 Phase II RI Report presents a detailed analysis of the environmental data collected during the Phase I and II RI field efforts. The following sections present an overview of the major findings of the nature and extent of contamination, modeling of contaminant fate and transport, and human health and ERAs. A revised site-specific conceptual model is presented to integrate results of the evaluations presented in this report. The CSM denotes, based on available data, where source areas occur, the mechanisms for contaminant migration from source areas to receptor media (e.g., streams and groundwater), and exit pathways from the AOC. The conclusions of the Phase II RI are presented by media, with an emphasis on the degree of contamination and the potential risks to human receptors.

8.1 SUMMARY

8.1.1 Contaminant Nature and Extent

The Phase II RI evaluated the nature and extent of contamination in surface soil from 0 to 0.3 m (0 to 1 ft) bgs, subsurface soil from 0.3 to 0.9 m (1 to 3 ft) bgs, sediment, surface water, groundwater, storm and sanitary sewers, and selected buildings and structures.

8.1.1.1 Data aggregates/exposure units and data reduction

Surface and subsurface soil, sediments, and surface water were further divided into spatial aggregates based on AOC operational history, proximity of sampling stations to source areas, drainage patterns, and viability of aquatic habitat. These aggregates form the basis for EUs evaluated in the human health and ecological risk evaluations (Chapters 6.0 and 7.0, respectively). Surface soil and subsurface soil were divided into six aggregates based on the criteria above. The aggregates demarcate areas believed to be impacted by different process-related activities, as well as areas believed to be relatively non-contaminated.

Sediment and surface water were grouped based on drainage patterns (e.g., upstream versus downstream) and to focus on the receptor exposure points for the human health and ecological risk evaluations. Sediments collected from intermittent, primarily dry drainage conveyances were addressed as surface soil media in the nature and extent evaluation and risk evaluations. A few surface water samples collected from intermittent ditches or puddles were considered as non-viable ecological habitat and addressed as a separate miscellaneous surface water aggregate. Groundwater was evaluated on an AOC-wide basis. Storm and sanitary sewer systems, and samples from buildings and structures, were also considered separately in the nature and extent evaluation; these samples were not subjected to risk evaluations, as they are not representative of the exposure scenarios (e.g., recreational, NGB, or residential) evaluated in this RI.

Summary statistics for data within each aggregate were calculated for the purposes of identifying SRCs. SRCs were identified by screening data against frequency of detection criteria, essential human nutrient criteria, and RVAAP facility-wide background values for inorganics. The nature and extent evaluation focused on only those constituents identified as site-related.

8.1.1.2 Surface soil

A total of 82 surface soil samples from 0- to 0.3-m (0- to 1-ft) depth were collected for the purpose of determining nature and extent of surface soil contamination across Load Line 4. Within the production

area of the load line, sampling locations were biased to the building perimeters and drainage conveyances where contaminants most likely would have accumulated over time. Random-grid sampling was applied in non-production areas (Perimeter Area Aggregate).

Explosive and propellant compounds in surface soil at Load Line 4 are relatively few in number, concentrations are comparatively low relative to Load Lines 1 through 3, and extent is limited to the immediate proximity of source areas. Pervasive inorganic SRCs in surface soil include barium, cadmium, chromium, copper, lead, thallium, and zinc. SVOCs detected in surface soil were primarily PAHs, which were observed frequently although at generally low concentrations. Few VOCs were detected in surface soil samples from Load Line 4 and concentrations were generally low. PCBs are not nearly as widespread as compared to the other melt-pour load lines at RVAAP. Some pesticides were detected sporadically at low concentrations.

Explosives Handling Area Aggregate

This EU contained the highest concentrations and most extensive SRCs within Load Line 4. Explosives within this aggregate are limited in extent to the proximity of the major production and processing buildings. Concentrations were generally low, with a maximum detected value of 19 mg/kg for RDX near Building G-8. Numerous inorganic SRCs were identified in this aggregate; aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, and zinc were most pervasive. SVOCs were detected frequently, although the highest concentrations were clustered near Building G-8 and along the walkway between Building G-8 and Building G-12. VOCs are generally absent in this aggregate. Generally low concentrations of PCBs were detected at a number of samples with the highest concentrations (up to 28 mg/kg) clustered in the vicinity of the former production buildings. Low concentrations of pesticides were detected.

Preparation and Receiving Areas Aggregate

Contaminants in surface soil in this aggregate were limited primarily to inorganics. Explosives were not detected in samples submitted for laboratory analysis. Nitrocellulose was present at low concentrations at one location north of Building G-1A. Pervasive inorganic SRCs include arsenic, barium, chromium, cobalt, copper, cyanide, lead, manganese, nickel, vanadium, and zinc. Although their distribution is widely variable, the highest overall concentrations of inorganics appear to be clustered on the south side of Building G-4. Low concentrations of a few PAHs were detected; most observed detections were clustered near Building G-4. PCBs appear to be clustered near Building G-4 at concentrations up to 48 mg/kg. VOCs are generally absent. No pesticides were detected.

Packaging and Shipping Areas Aggregate

Contaminants in surface soil in this aggregate were also limited primarily to inorganics. Explosives were not detected in this aggregate. Nitrocellulose was detected in one sample south of Building G-19. Pervasive inorganic SRCs include barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, thallium, and zinc. SVOCs (primarily PAHs) were detected in only two samples with the highest concentrations occurring near Building G-19. Low levels of PCBs (up to 1.3 mg/kg) and trace levels of pesticides were observed in the vicinity of Building G-19. VOCs, with exception of trace levels of toluene, were not detected.

Change Houses Aggregate

Surface soil in this EU is relatively uncontaminated. No explosives compounds greater than 1 mg/kg were detected during field analyses. Few inorganic results exceeded RVAAP background values; lead occurred

at the highest concentrations. Low estimated concentrations of 16 PAHs and 3 VOCs were detected on the east side of Building G-6. PCB-1260 was detected once at an estimated concentration of 0.059 mg/kg in a sample collected on the east side of Building G-6. Pesticides were not detected in this aggregate.

Perimeter Area Aggregate

Surface soil in this EU contained little contamination, with the exception of the immediate vicinity of the WW-23 Water Tower Area. Field analyses of samples collected near the WW-23 Water Tower detected TNT at concentrations up to 2.8 mg/kg. Few background exceedances for inorganics were observed in the Perimeter Area Aggregate. Inorganics greater than background were clustered in the vicinity of the WW-23 Water Tower with lead occurring most frequently at concentrations up to 1,340 mg/kg. Low, estimated concentrations of several PAHs and bis(2-ethylhexyl)phthalate were detected at station LL4-068, near the WW-23 Water Tower. VOCs, with the exception of trace levels of toluene, were not detected.

Melt-Pour Drainage Ditches Aggregate

Surface soil in this EU also exhibited little contamination. No explosives compounds were detected at a concentration of 1.0 mg/kg or greater during field analyses. Extent and distribution of inorganic SRCs in this aggregate were limited and maximum concentrations rarely exceeded background values by factors of more than 2 times. Low, estimated concentrations of several PAHs were detected in one sample. VOCs, with exception of trace levels of acetone, were not detected.

8.1.1.3 Subsurface soil

A total of 11 soil samples from 0.3- to 0.9-m (1- to 3-ft) depths were collected based on field analyses of explosives to determine the nature and extent of subsurface soil contamination and to assess vertical migration. Based on Phase II RI data, contamination in subsurface soil within Load Line 4 is limited, with inorganics representing the primary SRCs. Explosives and propellants were not detected. Metals detected at concentrations exceeding background criteria include barium, beryllium, cadmium, lead, and zinc. The highest concentrations of metals above background occur in the vicinity of Building G-1A in the Preparation and Receiving Areas Aggregate and Building G-9 in the Explosives Handling Areas Aggregate.

8.1.1.4 Sediment and surface water

Sediment in Main Stream and Settling Pond Exposure Units

Explosive compounds were detected in sediment samples, although at concentrations less than 1 mg/kg. Inorganic SRCs were identified in sediment; however, the maximum concentrations for all detected constituents were only between 2 and 3 times established background criteria. Cadmium was detected in sediment collected from all three EUs established within the main stream and settling pond, although all values were estimated concentrations of 1 mg/kg or less. The number and concentrations of inorganics are greatest in sediment within the settling pond. One PCB compound was detected at a concentration of less than 0.5 mg/kg. Pesticides and SVOCs were not detected in sediment. VOCs were only sporadically detected at low concentrations.

Surface Water in Main Stream and Settling Pond Exposure Units

Explosives were not detected in water samples collected from any of the three EUs established within the main stream and settling pond. Vanadium and manganese were the only two inorganic SRCs detected consistently in surface water above background criteria; maximum concentrations of manganese occurred within the aggregate upstream of the Load Line 4 Perimeter Road. The pesticide 4,4'-DDT was detected

in one water sample from the settling pond; no SVOCs or PCBs were detected. VOCs were only sporadically detected at low concentrations.

8.1.1.5 Groundwater

Groundwater at Load Line 4 contains few contaminants that can be related to historical operations. Explosives, propellants, pesticides, and PCBs were not detected. Low concentrations of metals identified as SRCs were observed; however, their occurrence and distribution above background criteria were sporadic. One SVOC and two VOCs were detected at low, estimated concentrations detected in three groundwater samples collected from monitoring wells in Load Line 4.

8.1.1.6 Storm and sanitary sewer system

Accumulation of explosives in sediment within the storm and sanitary sewer systems is not evident based on Phase II RI results. Trace levels of RDX; 2-amino-4,6-DNT and 4-amino-2,6-DNT were detected in water collected from three manholes. Sediment collected from several manholes contained inorganic SRCs at concentrations between 5 and 9 times RVAAP background values for sediment. Associated water samples from several of these manholes contained inorganics that were also elevated in the associated sediment samples. Low levels of PAHs, PCBs, and pesticides were detected in the sewer system sediment samples; these constituents were not detected in corresponding water samples. VOCs are generally absent in sediment and water within the storm and sanitary sewer systems.

8.1.1.7 Buildings and structures

Soil collected from beneath building sub-floors is generally uncontaminated, based upon a limited number of samples collected from beneath building floor slabs.

Sediment collected from the Building G-8 washout basin contained elevated levels of metals, explosives, propellants, PCBs, and pesticides. The associated water sample contained elevated levels of many constituents observed at high concentrations in sediment.

Sediment collected from the Building G-16 sedimentation basin contained elevated concentrations of several metals related to historical processes (chromium, copper, and lead). No water was present within this basin.

Floor sweep samples were comprised of a high percentage of iron. Copper, cadmium, chromium, and lead were present at high concentrations. Low concentrations of explosives were detected only in samples collected from Buildings G-8 and G-19. Low concentrations of PCBs, pesticides, and various PAHs were also detected. Cadmium and lead were detected in TCLP extracts; however, no constituent exceeded their respective criteria for characteristically hazardous wastes.

8.1.2 Contaminant Fate and Transport

Contaminant fate and transport modeling performed as part of the Phase II RI included leachate modeling (SESOIL) at the source area within Load Line 4 demonstrating the highest levels of process-related contaminants (Building G-8 vicinity). Groundwater modeling (AT123D) was conducted from this source to selected receptors or exit points from the AOC. The receptor and exit points selected for groundwater transport modeling included the main stream at its closest point to Building G-8; the main stream is the nearest presumed groundwater baseflow discharge point. In addition, groundwater transport modeling from the source area to the RVAAP facility boundary was conducted to evaluate the potential for off-site migration of any identified CMCOPCs.

SESOIL Modeling

Chromium, selenium, and RDX were the only chemicals identified as initial CMCOPCs based on source loading predicted by the leachability analysis near the selected primary source (Building G-8). The SESOIL modeling results indicate that all of these three constituents may leach from surface soil to groundwater with concentrations beneath the source area above groundwater MCLs or RBCs. The timeframe for RDX to exceed its criteria is 6 years, suggesting that such leaching has already occurred. The timeframes for chromium and selenium are 411 and 119 years, respectively, suggesting that concentrations may increase in the future. None of these constituents were detected in groundwater at Load Line 4. The leaching modeling is conservative and migration of these constituents may be attenuated because of moderate to high retardation factors for these constituents.

AT123D Modeling

Modeling of contaminant transport in shallow groundwater was conducted for five identified CMCOPCs (chromium, selenium, and RDX from SESOIL modeling results, and iron and manganese based on observed groundwater concentration) from the Building G-8 source area (Table L-13) to two endpoints. The first endpoint evaluated was the main stream at the closest point to the source area; the main stream is presumed to be a discharge area for shallow groundwater based on potentiometric data. The second endpoint modeled was the RVAAP facility boundary at its closest point downgradient of the source area.

AT123D modeling results indicate that migration of RDX to the main stream endpoint may occur with concentrations at the endpoint above RBCs. None of the metals (chromium, iron, manganese, and selenium) were predicted to exceed RBCs or MCLs at the main stream within the 1,000-year model period. Modeling results indicated that migration of the five CMCOPCs to the RVAAP boundary endpoint at concentrations exceeding MCLs or RBCs will not occur within the 1,000-year modeling period.

8.1.3 Human Health Risk Evaluation

A SHHRA was conducted to identify COCs and RGOs for contaminated media at the RVAAP Load Line 4 AOC for three potential future use scenarios: National Guard use, recreational use, and residential use. Results have been presented for all scenarios and exposure pathways. The following steps were used to generate conclusions regarding human health risks and hazards associated with contaminated media at Load Line 4:

- identification of COPCs,
- calculation of EPCs for COPCs,
- calculation of screening RGOs,
- identification of COCs, and
- calculation of risk-based RGOs to move forward to the FS.

COCs are determined for National Guard receptors (Trainee, Security Guard/Maintenance Worker, and Fire/Dust Suppression Worker), recreational receptors (Hunter/Trapper/Fisher), and residential receptors (Resident Subsistence Farmer Adult and Child). A COC summary is presented in Table 8-1, with results discussed below for each medium. Risk-based RGOs have been calculated and presented for all medium-specific COCs (see Tables 6-5 through 6-10). Risk-based RGOs are calculated for all chemicals identified as COCs for any receptor [e.g., arsenic is identified as a COC in surface water for the National Guard Trainee and for the Resident Farmer (adult and child), but not for the Fire/Dust Suppression Worker or the Hunter/Trapper/Fisher; however, risk-based RGOs are calculated for this metal for all five receptors exposed to surface water].

Table 8-1. Chemicals Exceeding RGOs (COCs) by Receptor/Medium/Exposure Unit Combination at Load Line 4

COC	Groundwater			Surface Water					Sediment				
	National Guard Trainee	Resident Farmer Adult	Resident Farmer Child	Dust/Fire Control Worker	National Guard Trainee	Hunter/ Trapper/ Fisher	Resident Farmer Adult	Resident Farmer Child	Dust/Fire Control Worker	National Guard Trainee	Hunter/ Trapper/ Fisher	Resident Farmer Adult	Resident Farmer Child
Inorganics													
Aluminum										MS			MS
Arsenic	LL4	LL4	LL4		MU		MU	MU					
Manganese	LL4	LL4	LL4		MU		MU	MU					
Thallium													MS
Organic PCBs													
PCB-1254													
PCB-1260													
Organic Pesticides													
4,4'-DDT					MS		MS	MS					
Organic Semivolatiles													
Benz(*a*)anthracene													
Benzo(*a*)pyrene													
Benzo(*b*)fluoranthene													
Dibenz(*a,h*)anthracene													
Indeno(1,2,3-*cd*)pyrene													

Table 8-1. Chemicals Exceeding RGOs (COCs) by Receptor/Medium/Exposure Unit Combination at Load Line 4 (continued)

COC	Shallow Surface Soil					Deep Surface Soil	Subsurface Soil	
	Security Guard/ Maintenance Worker	Dust/Fire Control Worker	Hunter/ Trapper/ Fisher	Resident Farmer Adult	Resident Farmer Child	National Guard Trainee	Resident Farmer Adult	Resident Farmer Child
Inorganics								
Aluminum					EH	EH,PR		PR
Arsenic	EH,MP,PR			EH,MP,PR	EH,MP,PR	EH,MP,PR		
Manganese					EH,PA,PR,PS	EH,PA,PR,PS	PR	PR
Thallium					CH,EH,MP,PR			
Organic PCBs								
PCB-1254	EH,PR			EH,PR,PS	EH,PR,PS	PR		
PCB-1260	EH,PR			EH,PR,PS	EH,PR,PS			
Organic Pesticides								
4,4'-DDT								
Organic Semivolatiles								
Benz(*a*)anthracene				EH				
Benzo(*a*)pyrene	CH,EH,PA			CH,EH,PA,PS	CH,EH,PA,PS			
Benzo(*b*)fluoranthene	EH			CH,EH	EH			
Dibenz(*a,h*)anthracene	EH			CH,EH	EH			
Indeno(1,2,3-*cd*)pyrene				EH				

COCs are shown for each medium/receptor/area of concern combination. Chemicals whose exposure point concentration exceeds its screening risk-based RGO are COCs. Area of concern codes are as follows:

LL4 = Load Line 4.
CH = Change Houses Aggregate.
ED = Exit Drainage Aggregate.
EH = Explosives Handling Areas Aggregate.
MP = Melt-Pour Area Drainage Ditches Aggregate.
MS = Main Stream Segment and Settling Pond Aggregate.
MU = Main Stream Segment Upstream of Perimeter Road Aggregate.
PA = Perimeter Area Aggregate.
PR = Preparation and Receiving Areas Aggregate.
PS = Packaging and Shipping Areas Aggregate.

COC = Chemical of concern.
DDT = Dichlorodipheyltrichloroethane.
PCB = Polychlorinated biphenyl.
RGO = Remedial goal option. Screening risk-based RGOs are based on a cancer risk level of 10^{-6} or a hazard level of 0.1 (whichever is smaller) and are shown in Tables Q-10 through Q-15. Screening of Load Line 3 data to determine COCs is shown in Tables Q-16 through Q-21.

8.1.3.1 Groundwater

Two COCs (arsenic and manganese) were identified for the National Guard Trainee exposed via potable use of groundwater; these COCs were also identified for the On-Site Residential Farmer scenarios. For these groundwater COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be slightly greater than 10^{-5} for the National Guard Trainee and slightly greater than 10^{-4} for the residential farmer scenarios. These are hypothetical future scenarios; no receptors are currently using groundwater from the AOC for any purpose.

8.1.3.2 Surface water and sediment

Exposure to surface water and sediment was evaluated for five receptor scenarios: National Guard Fire/Dust Suppression Worker, National Guard Trainee, Hunter/Trapper/Fisher, and Resident Farmer (adult and child). The following summarizes the resulting COCs in surface water and sediment at Load Line 4.

- Three Load Line 4 COCs were identified for the National Guard Trainee exposed to surface water, including two metals (arsenic and manganese) and one pesticide (4,4'-DDT). All three COCs were also identified for the On-Site Residential Farmer scenarios. Two COCs (arsenic and manganese) were identified for the Main Stream Segment Upstream of Perimeter Road Bridge Aggregate and one COC (4,4'-DDT) was identified for the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond Aggregate; no surface water COCs were identified for the Exit Drainage Aggregate. For the surface water COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be less than 10^{-6} for the Fire/Dust Suppression Worker and the Hunter/Trapper/Fisher and between 10^{-6} and 10^{-5} for the National Guard Trainee and the residential farmer scenarios.

- Aluminum was the only COC identified for the National Guard Trainee exposed to sediment; this COC and thallium were also identified for the On-Site Residential Farmer Child. Both COCs were identified for the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond Aggregate; no sediment COCs were identified for the Main Stream Segment Upstream of Perimeter Road Bridge or the Exit Drainage Aggregates. Aluminum and thallium are both non-carcinogenic chemicals.

8.1.3.3 Soil

Soil was evaluated at six EUs. Direct contact (ingestion, dermal contact, and inhalation) with surface and subsurface soils was evaluated for six receptors: National Guard Security Guard/Maintenance Worker (shallow surface soil), National Guard Fire/Dust Suppression Worker (shallow surface soil), National Guard Trainee (deep surface soil), Hunter/Trapper/Fisher (shallow surface soil), and Resident Farmer (adult and child) (shallow surface soil and subsurface soil). The following summarizes the resulting COCs in soil at Load Line 4.

Shallow surface soil

Eleven Load Line 4 COCs were identified for shallow surface soil, including four metals (aluminum, arsenic, manganese, and thallium), two PCBs (PCB-1254 and PCB-1260), and five PAHs [benz(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, dibenz(*a,h*)anthracene, and indeno(1,2,3-*cd*)pyrene]. The number of shallow surface soil COCs varied for each receptor: none for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher; six COCs for the Security Guard/Maintenance Worker; eight COCs for the Resident Farmer Adult; and nine COCs for the Resident Farmer Child. The number of

shallow surface soil COCs identified for each EU also varied: 2 for both the Melt-Pour Drainage Ditches and Perimeter Area Aggregates; 4 for both the Packaging and Shipping Areas and the Change Houses Aggregates; 5 for the Preparation and Receiving Areas Aggregate; and 11 for the Explosives Handling Areas Aggregate.

Ratios of EPCs to RGOs provide an indication of estimated cancer risks. All estimated risks for shallow surface soil COCs would be less than 10^{-6} for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher. For the Security Guard/Maintenance Worker, most COCs would produce a cancer risk at or slightly above 10^{-6}, with one exception: the estimated cancer risk would be slightly larger than 10^{-5} for PCB-1254 in the Preparation and Receiving Areas Aggregate. For the resident farmer scenarios, estimated cancer risks would exceed 10^{-5} for several shallow surface soil COCs, including arsenic in the Explosives Handling Areas, the Preparation and Receiving Areas, and the Melt-Pour Drainage Ditches Aggregates; PCB-1254 in the Preparation and Receiving Areas Aggregate; PCB-1260 in the Explosives Handling Areas Aggregate; and benzo(*a*)pyrene in the Explosives Handling Areas Aggregate.

Deep surface soil

Four Load Line 4 COCs were identified for the National Guard Trainee exposed to deep surface soil, including three metals (aluminum, arsenic, and manganese), and one PCB (PCB-1254). The number of deep surface soil COCs identified for each EU varied: none for the Change Houses Aggregate; one for the Melt-Pour Drainage Ditches, the Packaging and Shipping Areas, and the Perimeter Area Aggregates; three for the Explosives Handling Areas Aggregate; and four for the Preparation and Receiving Areas Aggregate.

Ratios of EPCs to RGOs indicate that estimated cancer risks would be below 10^{-6} for most deep surface soil COCs; two COCs would result in estimated cancer risk to the National Guard Trainee of slightly larger than 10^{-6} at the Explosives Handling Areas Aggregate (arsenic); at the Preparation and Receiving Areas Aggregate (arsenic and PCB-1254); and at the Melt-Pour Drainage Ditches Aggregate (arsenic).

Subsurface soil

Two metals were identified as Load Line 4 subsurface soil COCs for the resident farmer scenarios: aluminum and manganese. The COCs were identified for the Preparation and Receiving Areas Aggregate only; no subsurface soil COCs were identified for the Explosives Handling Areas, Packaging and Shipping Areas, and the Perimeter Area Aggregates. Aluminum and manganese are both non-carcinogenic chemicals.

8.1.4 Ecological Risk Evaluation

The Load Line 4 site contains sufficient terrestrial and aquatic (surface water and sediment) habitat to support various classes of ecological receptors such as vegetation, small and large mammals, and birds. Due to the presence of suitable habitat and observed receptors at the site, a SERA was performed. The SERA was performed in accordance with written guidance from the USACE, Louisville District and Ohio EPA, and also utilized Ohio's water quality standard. Following the SERA, a Level III BERA was performed on the preliminary COPECs. The methods followed the Army and Ohio EPA protocols and resulted in COECs. Groundwater was not evaluated considering that direct exposure to receptors would be expected to occur as discharge to surface water features. Soil deeper than 0.3 m (1 ft) was also not evaluated considering that contaminant concentrations in surface soil represent the probable worst-case exposures for most contaminants. (See Section 7.11.4, in which a comparison is made and a conclusion reached of no influence to HQs.) A BERA followed the SERA. BERA activities depended on the following ecological receptors: vegetation, soil invertebrates, cottontail rabbits, shrews, foxes, and hawks.

8.1.4.1 Soil

Risks were evaluated for five EUs for surface soil based on historical use and geographic proximity, as described in Section 4.1.2 and Chapter 7.0. At all EUs, except the Melt-Pour Area Drainage Ditches Aggregate, most preliminary COPECs were identified by comparing the maximum detection to the ESV. Few constituents were identified as COPECs due to lack of an ESV; only PCB-1254 at three of the four EUs. All of these preliminary COPECs were further evaluated by having HQs calculated (Section 7.7). There were no new analytes detected at Load Line 4 compared to Load Line 1.

The Explosives Handling Areas Aggregate contained the most preliminary COPECs for soil (16 metals, 2 pesticides, and 1 PCB), whereas the Perimeter Area Aggregate had the fewest preliminary COPECs for soil (5 metals). The Preparation and Receiving Areas Aggregate and Packaging and Shipping Areas Aggregate tied for having the second highest number of preliminary COPECs (seven metals and one PCB). The Melt-Pour Area Drainage Ditches Aggregate had eight metals that were identified as preliminary COPECs. A summary of the Load Line 4 soil preliminary COPECs, organized by EUs, and the rationales for why the analytes were preliminary COPECs is presented in Chapter 7.0, Table 7-8. BERA activities reduced the number of COPECs in all locations. The Explosives Handling Areas Aggregate had 10 COECs (down from 19 COPECs in the SERA), the Preparation and Receiving Areas Aggregate showed 7 (was previously 8), and the Packaging and Shipping Areas Aggregate had 7 (previously 8). The Melt-Pour Area Drainage Ditches Aggregate remained one of the two lowest locations with four COECs (down from eight) and the Perimeter Area Aggregate was also intermediate with four (previously five). A summary of Load Line 4 soil COECs is provided in Table 7-12.

8.1.4.2 Sediment and Surface Water

Sediment

The Main Stream Segment and Settling Pond Aggregate contained the most preliminary COPECs for sediment (11 metals and 1 explosive), whereas the Exit Drainages Aggregate had the fewest preliminary COPECs for sediment (1 metal and 1 PCB). The Main Stream Segment Upstream of Perimeter Road Aggregate had the second highest number of preliminary COPECs (four metals and one explosive). At all EUs, except the Exit Drainage Aggregate, the rationale that was responsible for identifying the most preliminary COPECs was no ESV. The rationale that was responsible for identifying the fewest preliminary COPECs was maximum detection > ESV, which only identified cadmium and nickel at the Main Stream Segment and Settling Pond Aggregate. All of these preliminary COPECs were further evaluated by having HQs calculated. A summary of the Load Line 4 sediment preliminary COPECs and the rationales for why the analytes were preliminary COPECs is presented in Chapter 7.0, Table 7-9. BERA activities utilized the following ecological receptors: benthic invertebrates, riparian herbivores (muskrats and mallards), and riparian carnivores (mink and herons). BERA activities reduced the number of COPECs in all three locations. For example, at the Main Stream Segment and Settling Pond Aggregate there were 4 COECs (down from 12 COPECs from the SERA). Further, at the Main Stream Segment Upstream of Perimeter Road Aggregate there is one COEC (down from five) and at the Exit Drainage Aggregte there is one COEC (previously two COPECs). A summary of Load Line 4 sediment COECs is provided in Table 7-12.

Surface Water

The Main Stream Segment Upstream of Perimeter Road Aggregate contained the most preliminary COPECs for surface water (seven metals), whereas the Main Stream Segment and Settling Pond Aggregate and the Exit Drainages Aggregate each had two preliminary COPECs. At all EUs, except the Main Stream Segment and Settling Pond Aggregate, the rationale that was responsible for identifying the

most preliminary COPECs was no ESV. The rationale that was responsible for identifying the fewest preliminary COPECs was maximum detection > ESV, which only identified two metals at one EU, one pesticide at another EU, and no preliminary COPECs at the Exit Drainages Aggregate. All of these preliminary COPECs were further evaluated by having HQs calculated. A summary of the Load Line 4 surface water preliminary COPECs and the rationales for why the analytes were preliminary COPECs is presented in Chapter 7.0, Table 7-10. BERA activities used the following ecological receptors: aquatic life, riparian herbivores (muskrats and mallards), and riparian carnivores (mink and herons). BERA activities further screened the seven COPECs to two COECs at the Main Stream Segment Upstream of Perimeter Road Aggregate. Further, at the Main Stream Segment and Settling Pond Aggregate there were two COECs (same as the previously listed two COPECs) and at the Exit Drainage Aggregate there were no COECs (down from two COPCEs). A summary of Load Line 4 surface water COECs is provided in Table 7-13.

8.2 CONCEPTUAL SITE MODEL

The preliminary Load Line 4 CSM, developed as part of the Phase II RI SAP Addendum, was summarized in Chapter 2.0. A revised CSM is presented in this section that incorporates Phase II RI data and the results of contaminant fate and transport modeling and risk evaluations. Elements of the CSM include

- primary contaminant source areas and release mechanisms,
- contaminant migration pathways and exit points, and
- data gaps and uncertainties.

An illustrated version of the revised CSM is provided in Figure 8-1 to assist in visualizing the concepts discussed below.

8.2.1 Source-Term and Release Mechanisms

Results of the Phase II RI soil sampling indicate that the Explosives Handling Areas Aggregate, particularly areas surrounding Building G-8, contain the greatest numbers and concentrations of contaminants. Metals, explosives, PAHs, and PCBs/pesticides are present in soil in these areas at concentrations greater than background or risk-screening criteria. Other source areas defined by Phase II RI data include the vicinity of Building G-4 (inorganics and PCBs), the WW-23 Water Tower (primarily elevated inorganics), and the vicinity of Building G-19 (PAHs, low levels of nitrocellulose, and inorganics). Inorganic contaminants and SVOCs were observed in other locations; however, their distribution is sporadic.

The majority of soil contamination at Load Line 4 is within the surface soil interval less than a depth of 0.3 m (1.0 ft). Explosives were not detected in subsurface soil; some inorganics in subsurface soil exceed background criteria to varying degrees, primarily in the vicinity of Building G-1A in the Preparation and Receiving Areas Aggregate and Building G-9 in the Explosives Handling Areas Aggregate.

Two primary mechanisms for release of contaminants from the source areas are identified (1) erosional and/or dissolved phase transport of contaminants from soil sources with transport into the storm drain network or drainage ditches, and (2) leaching of constituents to groundwater via infiltration of rainwater through surface and subsurface soils. Evaluation of these release mechanisms was done through sampling of storm drainage network (ditches and storm sewers) and numerical modeling of soil leaching processes. Discussion of the results of evaluation of data for preferred contaminant migration pathways and exit

Water Tower
Source for metals in surface soil. Low levels of explosives also detected. Not evaluated separately in risk assessments. Part of Perimeter Area Aggregate.

Packaging and Shipping Areas Aggregate
Primary accumulation areas near Buildings G-17, G-18, and G-19/19A. Four COCs identified in surface soil. Manganese a COC for National Guard Trainee. No COCs for Resident Farmer. Seven metals and PCB-1254 are COECs.

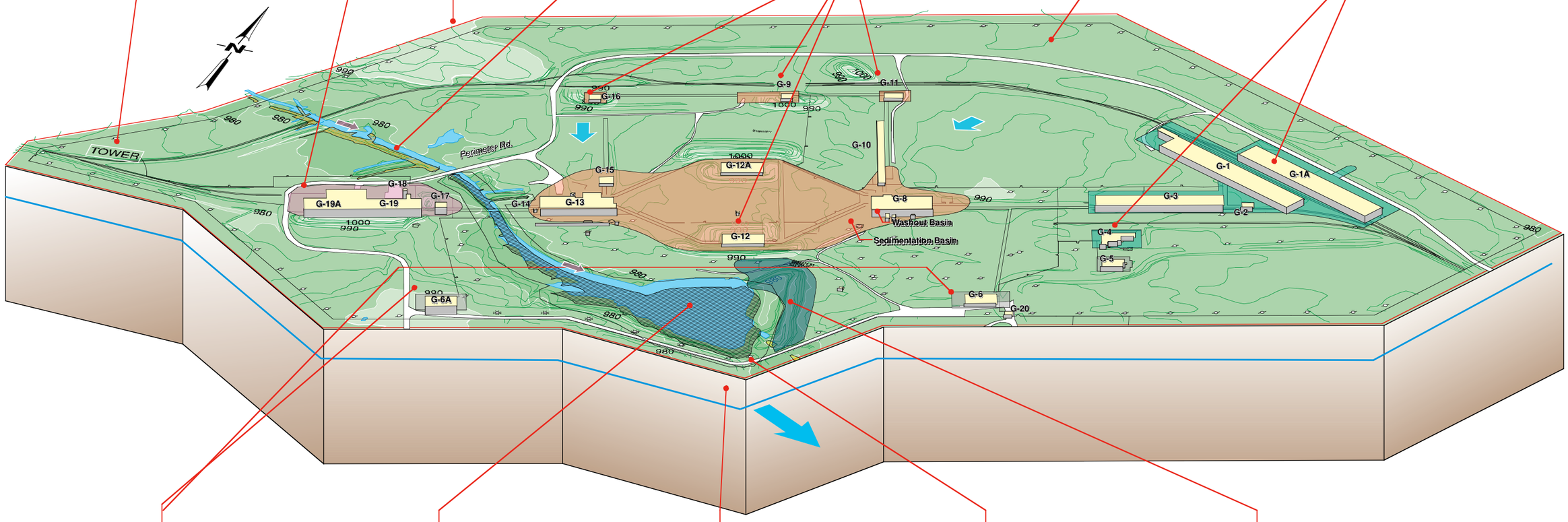
Main Stream Segment Upstream of Perimeter Road
Primary exit pathway. Arsenic and manganese identified as COCs in surface water for National Guard Trainee and Residential Farmer scenarios. Five metals are COECs in surface water; 4 metals and 2,4,6-TNT are COECs in sediment.

Explosives Handling Areas Aggregate
Primary source areas near Buildings G-8, G-9, G-11, and G-12 through G-16. Eight COCs identified in surface soil. Three COCs identified for National Guard Trainee. No COCs for Resident Farmer. Numerous metals, PCB-1254, and two pesticides are COECs.

Perimeter Area Aggregate
Two COCs identified in surface soil. Manganese a COC for National Guard Trainee. No COCs for Resident Farmer. Five metals are COECs.

Preparation and Receiving Areas Aggregate
Primary source areas near Buildings G-1, G-1A, G-2, G-3, and G-4. Five COCs identified in surface soil. Four COCs identified for National Guard Trainee. Two COCs identified for Resident Farmer. Seven metals and PCB-1254 are COECs.

AOC Boundary



Change Houses Aggregate (G-6/6A)
Not a significant source area. Four COCs identified in surface soil. No COCs identified for National Guard Trainee or Resident Farmer.

Main Stream Segment Down Stream of Perimeter Road Bridge and Settling Pond
4,4'-DDT a COC in surface water for National Guard Trainee and Resident Farmer. Aluminum a COC in sediment for National Guard Trainee and Resident Farmer (child). Thallium a sediment COC for Resident Farmer (child) only. Primary exit pathway. Multiple metals and 2,4,6,-TNT are COECs in sediment; mercury and 4,4'-DDT are COECs in surface water.

Groundwater Aggregate
Little observed contamination. Arsenic and manganese identified as COCs for all groundwater receptor scenarios.

Exit Drainage from Settling Pond Aggregate
Primary exit pathway. No COCs identified in surface water or sediment. Two metals are COECs in surface water; cadmium and PCB-1254 are COECs in sediment.

Melt-Pour Drainage Ditches Aggregate
Two COCs identified in shallow surface soil. No COCs identified for National Guard Trainee or Resident Farmer. Five metals identified as COECs.

surface water flow
groundwater flow
till
water table

G04-0085 LL4 3D Conceptual

Figure 8-1 Conceptual Site Model for Load Line 4

points is presented below. Airborne dispersion of contaminants was not quantified or modeled. The chemical characteristics of the SRCs present high, annual precipitation levels, and heavy vegetation cover at Load Line 4 likely precludes any substantial dispersion of contaminants via this pathway.

8.2.2 Contaminant Migration Pathways and Exit Points

Surface Water Pathways

Migration of contaminants from soil sources via surface water occurs primarily by (1) movement of particle-bound (e.g., clays or colloids) contaminants in surface water runoff, and (2) transport of dissolved constituents in surface water. Surface runoff is directed to drainage ditches and the storm drainage network, most of which terminate at the main stream or settling pond within the AOC. The main stream flows from northwest to southeast across the AOC and eventually exits the facility at PF-8.

Upon reaching quiescent portions of surface water conveyances, flow velocities decrease and particle-bound contaminants are expected to settle out as sediment accumulation. Sediment-bound contaminants may be re-mobilized during storm events. Sediment-bound contaminants may also partition to surface water and be transported in dissolved phase. Sampling of the dry sediment from the Melt-Pour Area Drainage Ditches Aggregate indicates minimal contaminant accumulation from the Explosives Handling Areas and sedimentation basin through these conveyances into the main stream that exits the AOC to the south. Results of sediment and water sampling from the storm sewer network indicate very little accumulation of explosives in sediment and only trace concentrations in water; however, inorganics and low levels of PCBs do appear to have accumulated. Some inorganics in storm sewer sediment appear to be partitioning to water. The sanitary sewer system is a closed system (except where pipes may be cracked) and is not open to receiving substantial surface water runoff.

Substantial contaminant accumulation within the main stream and settling pond is not evident based on Phase I and II RI data. Accumulated explosive compounds were less than 1 mg/kg in stream and pond sediment and partitioning to water with subsequent dissolved phase transport is not evident. SVOCs and PCBs were not detected in stream and pond sediment. Inorganic SRCs were detected in stream and pond sediment and the highest concentrations appear to have accumulated within the settling pond. However, the magnitude of background exceedances is generally low and partitioning of contaminants from sediment to water is not evident based on available data. The highest observed concentrations for inorganics relative to background occurred in the Main Stream Segment Upstream of Perimeter Road Aggregate.

Leaching and Groundwater Pathways

Theoretical numerical modeling of leaching potential for soil source areas indicates that only chromium, selenium, and RDX may be expected to leach from the contaminated surface soil into the groundwater and reach concentrations exceeding groundwater MCLs or RBCs. The absence of these constituents and lack of overall substantial contamination in groundwater at Load Line 4 suggest that retardation processes (e.g., sorption, degradation, etc.) effectively attenuate contaminants within the vadose zone. Iron and manganese were observed in groundwater above secondary MCLs; therefore, they were also considered as CMCOPCs.

Shallow groundwater flow follows stream drainage and topographic patterns with flow to the south toward the AOC and RVAAP boundaries. Modeling results indicate that migration of RDX via shallow groundwater to the main stream closest to the major sources at concentrations above RBCs may occur. None of the metals (chromium, iron, manganese, and selenium) were predicted to exceed RBCs or MCLs at the main stream within the 1,000-year modeling period. Modeling results indicated that migration of the five CMCOPCs to the RVAAP boundary endpoint at concentrations exceeding MCLs or RBCs will not occur

within the 1,000-year modeling period. However, the lack of detectable RDX in groundwater suggests that the conservative modeling results do not fully represent retardation and attenuation effects in the subsurface.

Given that a portion of the storm and sanitary sewer system at Load Line 4 is flooded, these utility networks may serve as preferential conduits for shallow groundwater movement. These systems were evaluated to determine if they facilitate transport of contaminants dissolved in groundwater or function as sources of dissolved phase contaminants to groundwater. As noted above, the storm drain network contains some accumulated inorganics and PCBs that appear to be partitioning to water, although concentrations are not grossly elevated relative to available background values. The storm drain network likely facilitates the movement of shallow groundwater in the vicinity of cracked or broken pipes where inflow or outflow may occur. The sanitary sewer system at Load Line 4 contains some accumulated inorganics and may contribute some level of contaminant flux to groundwater; however, the sanitary sewer system is a closed system (except where pipes may be cracked) and contaminant concentrations were not grossly elevated. Considering the relative lack of data and characteristics of the sewer systems, it is not conclusive if these systems are a primary source to groundwater or migration pathways.

8.2.3 Uncertainties

The CSM is developed based on available site characterization and chemical data. Uncertainties are inherent in the CSM where selected data do not exist or are sparse. The uncertainties within the CSM for Load Line 4 include the following.

- Groundwater monitoring wells installed during the Phase II RI targeted the water table interval only. The observed extent and magnitude of contamination in AOC soil and shallow groundwater do not indicate substantial contamination of groundwater within the AOC and conservative modeling results suggest that off-AOC migration of contaminants will not occur. However, groundwater within deeper flow zones was not characterized and conclusions regarding groundwater contaminant transport are representative of only the source areas modeled and hydrostratiographic intervals that were characterized.

- The exact source(s) of PAHs at Load Line 4 is unknown, although they may, in part, be anthropogenic combustion products derived from coal and/or fuel oil-fired power and boiler plant emissions.

- Leachate and transport modeling is limited by uncertainties in the behavior and movement of contaminants in the presence of multiple solutes. In addition, heterogeneity, anisotropy, and spatial distributions of permeable zones (e.g., sand or gravel zones) could not be fully characterized during the field investigation nor addressed in the modeling. Therefore, effects of these features on contaminant transport at Load Line 4 are uncertain and modeling results are considered as conservative representations.

- The exact source(s) of some inorganics (e.g., manganese) in surface water and sediment in the Main Stream Segment Upstream of Perimeter Road Aggregate is unknown. Data evaluated in the nature and extent and risk evaluations address all accumulated contamination within the main stream and settling pond, whether from natural or anthropogenic sources. Results of the evaluations may reflect, in part, contributions from sources other than Load Line 4.

8.3 CONCLUSIONS

The conclusions presented below, by medium, combine the findings of the contaminant nature and extent evaluation, fate and transport modeling, and the human health and ecological risk evaluations. To support

remedial alternative selection and evaluation in future CERCLA documents (e.g., FS), the contaminant levels for identified COCs in surface soil, subsurface soil, surface water, sediment, and groundwater at Load Line 4 were compared to risk-based RGOs.

A target excess individual lifetime cancer risk for carcinogens of 1×10^{-5} and a target HI of 1 for non-carcinogens was identified as appropriate for calculating RGOs for Load Line 4 based on the small number of COC's identified for each exposure medium and the type of COCs (carcinogenic or non-carcinogenic). A summary of the results of the RGO comparisons is provided in Chapter 6.0, Tables 6-4, 6-6, and 6-9.

8.3.1 Surface and Subsurface Soil

Explosives Handling Areas Aggregate

The primary identified source areas in the Explosives Handling Areas Aggregate include Buildings G-8 and G-12. Metals, explosives, PAHs, and PCBs represent the most pervasive SRCs in the former production areas. The spatial distribution and concentrations of contaminants were highly variable in the vicinity of these source areas. With respect to vertical distribution, the numbers and concentrations of SRCs in subsurface soil at these source areas decreased substantially relative to surface soil.

Theoretical numerical modeling of leaching potential for soil source areas indicates that chromium, selenium, and RDX near Building G-8 may be expected to leach from the contaminated surface soils into the groundwater and reach concentrations exceeding groundwater MCLs or RBCs. The migration of metals constituents from the source areas to the closest groundwater baseflow discharge at concentrations in excess of risk-based criteria was not predicted to occur within a timeframe of 1,000 years from the Building G-8 source area. Migration of RDX from Building G-8 to the closest groundwater baseflow discharge point may occur with concentrations above RBCs. The predicted timeframe for migration is 1,000 years. Migration of most of the constituents is expected to be attenuated because of moderate to high retardation factors, as well as degradation of organic compounds; these processes are not reflected in the conservative modeling results.

Eleven shallow surface soil COCs were identified for the Security Guard/Maintenance Worker, and Resident Farmer (adult and/or child). These COCs included

- four metals: aluminum, arsenic, manganese, and thallium;
- two PCBs: PCB-1254 and PCB-1260; and
- five PAHs: benz(*a*)anthracene and indeno(1,2,3-*cd*)pyrene, both for the Resident Farmer Adult only; and benzo(*a*)pyrene, benzo(*b*)fluoranthene, and dibenz(*a,h*)anthracene.

For the Security Guard/Maintenance Worker, most COCs would produce a cancer risk at or slightly above 10^{-6}. For the resident farmer scenarios, estimated cancer risks would exceed 10^{-5} for arsenic, PCB-1260, and benzo(*a*)pyrene in the Explosives Handling Areas Aggregate.

Three metals were identified as deep surface soil COCs for the National Guard Trainee: aluminum, arsenic, and manganese. In deep surface soil, arsenic would result in an estimated cancer risk to the National Guard Trainee of slightly larger than 10^{-6}.

No COCs were identified in subsurface soil in the Explosives Handling Areas Aggregate.

Preparation and Receiving Areas Aggregate

The primary identified source areas in the Preparation and Receiving Areas Aggregate include Buildings G-1A and G-4. Metals, PAHs, and PCBs represent the most pervasive SRCs in these areas. The spatial distribution and concentrations of contaminants were highly variable. With respect to vertical distribution, the numbers and concentrations of SRCs in subsurface soil at these source areas decreased substantially relative to surface soil.

Five shallow surface soil COCs were identified for the Security Guard/Maintenance Worker, and Resident Farmer (adult and/or child). These COCs included

- three metals: manganese, thallium, and arsenic; and
- two PCBs: PCB-1254 and PCB-1260.

All estimated risks for shallow surface soil COCs would be less than 10^{-6} for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher. For the Security Guard/Maintenance Worker, most COCs would produce a cancer risk at or slightly above 10^{-6}, with the exception of PCB-1254. The estimated cancer risk for this COC would be slightly larger than 10^{-5}. For the resident farmer scenarios, estimated cancer risks would exceed 10^{-5} for arsenic and PCB-1254.

Four deep surface soil COCs were identified for the National Guard Trainee. These COCs included

- three metals: aluminum, arsenic, and manganese; and
- one PCB: PCB-1254.

Two deep surface soil COCs would result in estimated cancer risk to the National Guard Trainee of slightly larger than 10^{-6} at the Preparation and Receiving Areas Aggregate: arsenic and PCB-1254.

Two metals were identified as subsurface soil COCs at the Preparation and Receiving Areas Aggregate; aluminum (Resident Farmer Child Only) and manganese (for both the Resident Farmer Adult and Resident Farmer Child).

Packaging and Shipping Areas Aggregate

The primary identified source area in the Packaging and Shipping Areas Aggregate is Building G-19. Metals are the most pervasive SRCs in these areas; low concentrations of PAHs and PCBs were detected sporadically. The spatial distribution and concentrations of contaminants were highly variable. With respect to vertical distribution, the numbers and concentrations of SRCs in subsurface soil at these source areas decreased substantially relative to surface soil.

Four shallow surface soil COCs were identified for the Resident Farmer Adult and/or Child. These COCs include

- one metal: manganese;
- two PCBs: PCB-1254 and PCB-1260; and
- one PAH: benzo(*a*)pyrene.

All estimated risks for shallow surface soil COCs would be less than 10^{-6} for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher. For the Security Guard/Maintenance Worker, surface soil COCs would produce a cancer risk at or slightly above 10^{-6}.

One metal was identified as a deep surface soil COC for the National Guard Trainee: manganese. Estimated cancer risks for the deep surface soil COC (manganese) would be below 10^{-6} .

No COCs were identified in subsurface soil in the Packaging and Shipping Areas Aggregate.

Change Houses Aggregate

Surface soil in this EU is relatively uncontaminated. Few inorganic results exceeded RVAAP background values; the distribution of exceedances was very sporadic. No explosives compounds greater than 1 mg/kg were detected during field analyses. Accordingly, subsurface soil samples were not collected. Maximum levels of SRCs were detected in the vicinity of Building G-6.

Four shallow surface soil COCs were identified for the Security Guard/Maintenance Worker, and Resident Farmer (adult and/or child). These COCs included

- one metal: thallium; and
- three PAHs: benzo(*b*)fluoranthene, dibenz(*a,h*)anthracene, and benzo(*a*)pyrene.

All estimated risks for shallow surface soil COCs would be less than 10^{-6} for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher. For the Security Guard/Maintenance Worker, surface soil COCs would produce a cancer risk at or slightly above 10^{-6}.

No deep surface soil COCs were identified for the Change Houses Aggregate, as all EPCs were less than their respective screening RGOs.

Subsurface soil samples were not collected at the Change Houses Aggregate.

Perimeter Area Aggregate

The only identified contaminant source in this aggregate is the WW-23 Water Tower vicinity. Low concentrations of TNT (field analyses only), inorganics (primarily lead), and PAHs were clustered in the vicinity of the water tower. Lead concentrations in subsurface soil decreased substantially from those observed in surface soil.

Two shallow surface soil COCs [manganese and benzo(a)pyrene] were identified for the Security Guard/Maintenance Worker, and Resident Farmer (adult and/or child). All estimated risks for shallow surface soil COCs would be less than 10^{-6} for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher. For the Security Guard/Maintenance Worker, benzo(*a*)pyrene would produce a cancer risk at or slightly above 10^{-6}.

One metal was identified as a deep surface soil COC for the National Guard Trainee: manganese. Ratios of EPCs to RGOs indicate that estimated cancer risks would be below 10^{-6} for the deep surface soil COC (manganese) in the Perimeter Area Aggregate.

No COCs were identified in subsurface soil in the Perimeter Area Aggregate.

Melt-Pour Area Drainage Ditches Aggregate

Surface soil in this EU exhibited little contamination. Explosives compounds were not detected at a concentration of 1.0 mg/kg or greater during field analyses. Inorganic SRCs rarely exceeded background values by factors of more than 2 times and only low concentrations of PAHs were observed. Subsurface

soil samples were not collected from this aggregate due to the lack of detectable field explosives in surface soil.

Two metals were identified as shallow surface soil COCs for the Security Guard/Maintenance Worker, and Resident Farmer (adult and/or child): arsenic and thallium. All estimated risks for shallow surface soil COCs would be less than 10^{-6} for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher. For the Security Guard/Maintenance Worker, arsenic would produce a cancer risk at or slightly above 10^{-6}. For the resident farmer scenarios, arsenic would produce a cancer risk above 10^{-5}.

One metal was identified as a deep surface soil COC for the National Guard Trainee: arsenic. Ratios of EPCs to RGOs indicate that the estimated cancer risk to the National Guard Trainee would be slightly larger than 10^{-6} for the deep surface soil COC (arsenic) in the Melt-Pour Drainage Ditches Aggregate.

Subsurface soil samples were not collected from the Melt-Pour Drainage Ditches.

8.3.2 Sediment and Surface Water

Sediment

Explosives contamination in sediment in all three Load Line 4 main stream aggregates is not widespread. Concentrations of explosives are less than 1 mg/kg, inorganic SRCs exceeded background criteria by factors of only 2 to 3 times, and only trace concentrations of one PCB compound were detected. The number and concentrations of inorganics are greatest in the Main Stream and Settling Pond Aggregate.

Two metals were identified as sediment COCs at the aggregate designated as the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond. Both are non-carcinogenic chemicals.

- Aluminum, for the National Guard Trainee and Resident Farmer Child; and
- Thallium, for the Resident Farmer Child only.

No COCs were identified in the Main Stream Upstream of Perimeter Road Bridge or Exit Drainages Aggregates.

Surface Water

Explosives were not detected in water samples collected from any of the three EUs established within the main stream at Load Line 4. Vanadium and manganese were the only two inorganic SRCs detected consistently in surface water above background criteria; maximum concentrations of manganese occurred within the aggregate upstream of the Load Line 4 Perimeter Road. The pesticide 4,4'-DDT was detected in one water sample from the settling pond; no SVOCs or PCBs were detected. VOCs were only sporadically detected at low concentrations.

Three Load Line 4 COCs (arsenic; manganese; and 4,4'-DDT) were identified for the National Guard Trainee exposed to surface water. All three COCs were also identified for the On-Site Residential Farmer scenarios. Two COCs (arsenic and manganese) were identified for the Main Stream Segment Upstream of Perimeter Road Bridge Aggregate and one COC (4,4'-DDT) was identified for the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond Aggregate; no surface water COCs were identified for the Exit Drainage Aggregate. For the surface water COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be less than 10^{-6} for the Fire/Dust Suppression Worker and the Hunter/Trapper/Fisher and between 10^{-6} and 10^{-5} for the National Guard Trainee and the residential farmer scenarios.

8.3.3 Groundwater

Groundwater within the AOC contains few contaminants that can be related to historical operations. Low concentrations of metals identified as SRCs were observed; however, their occurrence and distribution above background criteria was sporadic. SVOCs and VOCs were detected in groundwater samples collected from monitoring wells in Load Line 4.

Two COCs were identified for the National Guard Trainee. One COC (arsenic) is a carcinogen and the other COC (manganese) is a non-carcinogen. These COCs were also identified for the On-Site Residential Farmer scenarios. For these groundwater COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be slightly greater than 10^{-5} for the National Guard Trainee and slightly greater than 10^{-4} for the residential farmer scenarios. These are hypothetical future scenarios; no receptors are currently using groundwater from the AOC for any purpose.

8.3.4 Storm and Sanitary Sewers

The storm sewer system does not contain accumulated explosives based on Phase II RI sampling results, although accumulated inorganics and low levels of PAHs, PCBs, and pesticides are present. Inorganics and PCBs appear to be partitioning to water at low concentrations. The storm drain network likely facilitates the movement of shallow groundwater in the vicinity of cracked or broken pipes where inflow or outflow may occur.

The sanitary sewer system does not contain accumulated explosives based on Phase II RI sampling results, although accumulated inorganics are present that may be partitioning to accumulated water within the system. The sanitary sewer system does not receive large influxes of storm runoff and is largely a closed system, except where pipes may be cracked. Considering the relative lack of data and the characteristics of the sewer system, it is not conclusive if these systems are a primary source to groundwater or migration pathways.

8.3.5 Buildings and Structures

Data collected during the Phase II RI indicate an overall absence of contamination in soil beneath building sub-floors. However, this is based on a limited number of samples collected from beneath building slabs.

Any future demolition of the Building G-8 washout basin should consider that sediment in this structure contained elevated levels of metals, explosives, propellants, PCBs, and pesticides. The associated water sample contained elevated levels of many constituents that were detected at high concentrations in sediment.

Any future demolition of the Building G-16 sedimentation basin should consider that sediment in this structure contained elevated concentrations of several metals related to historical processes (chromium, copper, and lead).

Floor sweeping samples collected from Buildings G-3, G-8, and G-19 were comprised of a high percentage of iron. Copper, cadmium, chromium, and lead were present at high concentrations, particularly in Buildings G-8 and G-19. Low concentrations of explosives were detected in samples from Buildings G-8 and G-19. Low concentrations of PCBs, pesticides, and various PAHs were also detected. Cadmium and lead were detected in TCLP extracts; however, no constituent exceeded their respective criteria for characteristically hazardous wastes.

8.4 LESSONS LEARNED

A key project quality objective for the Phase II RI at Load Line 4 is to document lessons learned so that future projects may benefit from lessons learned and constantly improve data quality and performance. Lessons learned are derived from process improvements that were implemented or corrective measures for nonconformances. The Phase II RIs for Load Lines 2, 3, and 4 were planned and implemented under one mobilization; therefore, the key lessons learned discussed below are applicable to all of the investigations conducted in 2001.

- The Phase II RI for Load Lines 2, 3, and 4 were integrated under a single SAP, QAPP, and Health and Safety Plan Addendum. Preparation for field efforts, including logbook preparation, sampling database pre-population, readiness reviews, and personnel training assignments were conducted under one combined mobilization. Field sampling operations for all three load lines were coordinated under one Field Operations Manager, Site Health and Safety Officer, and Sample Manager, and utilized the same sampling teams. Set up and operation of the field laboratory was likewise done once for all three investigations. The integrated effort allowed subcontractors (drilling, test pit excavation, video camera surveys, concrete coring, etc.) to conduct their operations under one mobilization. This integrated effort for multiple sites eliminated redundant start up operations, compressed the field investigation schedules, reduced costs, and improved data quality by utilizing staff familiar with the project DQOs and sampling procedures.

- The Phase II RI efforts for Load Lines 2, 3, and 4 were the first conducted by SAIC at RVAAP to designate a formal IDW Compliance Officer. A single person with waste operations and management experience was designated to coordinate the packaging, labeling, tracking, and disposition of all project IDW. This person reported directly to the Field Operations Manager and SAIC Project Manager. Implementation of this position resulted in greater efficiencies in IDW management and no compliance issues related to IDW during the course of the project.

- Analytical difficulties were encountered for some floor sweep and other sample types collected within or near buildings and railroad tracks were encountered due to the suspected presence of paint chips, creosotes, or other materials. Prior notification to the analytical laboratory is advised when such unusual samples may be collected so that they can adjust extraction or analytical protocols, as needed, to avoid gross contamination or even damage to instrumentation and to improve overall data quality.

- Use of field portable X-ray fluorescence (XRF) analyses for metals was not employed to help guide the placement of sampling locations, although the method may have provided useful information regarding the distribution of inorganic contaminants. Re-evaluation of previous applications of XRF at RVAAP is to be conducted, including implementation of a revised analytical method. Upon completion of the evaluation and testing of the new method(s), use of field XRF to help guide characterization sampling activities or conduct remediation verification sampling should be considered.

- Incorporation of undesignated contingency samples into the project planning provides a useful tool and flexibility to sample additional locations based on field observations. Examples of the application of contingency samples include small sedimentation basins discovered at Load Lines 3 and 4 near explosives preparation buildings and collection of Cr^{+6} at multiple stations at Load Line 2.

- The presence of Ohio EPA and USACE staff on-site during field operations was beneficial in that potential changes to the project work plan due to field conditions could be quickly discussed, resolved, and implemented.

- The availability of on-site facilities for use as a field staging area and to house the field explosives laboratory was extremely beneficial. Having high-quality shelter facilities for sample storage and management operations, equipment decontamination, and the field laboratory improves sample quality and project efficiency. The facility provides a central and secure location to store equipment and supplies, as well as to conduct safety meetings and other site-specific training.

- Field operations were temporarily suspended for 5 days beginning September 12, 2001, due to RVAAP security measures in response to the terrorist attacks of September 11, 2001. As a result, field operations were placed in a safe and compliant standby condition, including:

  – Communication of events and planned actions to the appropriate SAIC, USACE, and RVAAP management personnel;

  – Removal of environmental samples that were in refrigerated storage in order to deliver these to analytical laboratories;

  – Inspection and securing of IDW containers to ensure safe and compliant storage;

  – Removal of rental vehicles and rented field equipment; and

  – Sealing of project field records in coolers securing of the field staging building.

Future SAP Addenda for investigations at RVAAP may include a section containing instructions for unplanned events resulting in the immediate suspension of field operations.

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9.0 RECOMMENDATIONS

To provide decision makers with the information necessary to evaluate remedial alternatives to reduce or eliminate potential risks to human and/or ecological receptors, it is recommended that the Load Line 4 proceed to the FS phase under the RVAAP CERCLA process. It is recommended that the FS phase employ a streamlined remedial alternatives evaluation process based on the most likely land use assumptions and evaluate a range of effective alternatives and technologies and associated costs. The intent of this strategy is to accelerate site-specific analysis of remedies by focusing the FS efforts to appropriate remedies that have been evaluated at other sites with operational histories similar to Load Line 4.

The future land uses and controls envisioned for Load Line 4 should be determined prior to selection of the path forward for the site. Establishment of the most likely land use scenario(s) will allow decision makers the initial information necessary to determine the correct remedial action, such as source removal, land use controls, and/or continued monitoring, to achieve requisite protection of human health and the environment. The envisioned future use of the AOC, or a portion of the AOC, is an important consideration in determining the extent of remediation necessary to achieve the required degree of protectiveness. For example, a residential versus a National Guard land use scenario influences how much cleanup is needed to lower the risk to protective levels. Establishment of land use will also allow for streamlined evaluation of remedies and will be necessary for documentation in a remedial decision.

Areas having the same projected land use within Load Line 4 (and at other melt-pour lines at RVAAP) will incorporate the same RGOs into remedial alternative development. Also, the FS should consider potential future separate actions related to surface water systems and recognize the connection of surface water exit pathways among the four major melt-pour lines (Load Lines 1 through 4), as well as Load Line 12. The FS should apply results of the ecological field truthing effort at the WBG (pending agreement by Ohio EPA) to remedial goal development for Load Line 4 to the extent practicable.

Key data uncertainties have been identified in the RI to help guide any future sampling efforts. Details of additional nature and extent assessment, as needed to fill any remaining data gaps in order to evaluate remedial alternatives, are deferred to the FS planning stage. The following components may be necessary for a thorough FS evaluation or may be considered under a separate remedial action process for integrator media, such as surface water or groundwater:

- Refinement of EU boundaries, if remedial decisions by EU are considered most feasible by decision makers. Such a delineation would allow:

    1. Prioritization of EUs or areas from highest potential risk to lowest potential risk.

    2. Selection of cleanup actions and exit strategies per EU and/or per buildings in each EU, (e.g., certain areas may remediated by soil removal, whereas remediation of other areas, such as a process building vicinity, may require an alternate approach).

    3. Potential elimination of all or portions of certain EUs from additional investigation or further action, such as portions of the Perimeter Area Aggregate, thus reducing the footprint of the AOC.

- Assessment of shallow groundwater at Load Line 4 indicated little, if any, contamination related to historical process operations. Subsurface soil data at Load Line 4 indicated very low levels of SRCs below the surface interval. Although little evidence of vertical migration of contaminants exists, assessment of deep groundwater at the site has not been performed and may be a potential data gap.

Characterization or monitoring of deeper groundwater may be necessary to evaluate certain potential remedial actions or support future resource use decisions.

- Sediment in stream and pond aggregates and the dry conveyances in the Melt-Pour Area Drainage Ditches were characterized to typical depths of 0.15 m (0.5 ft). Characterization of deeper sediment in drainage conveyances and the settling pond is a potential data gap and additional sampling at deeper intervals may be necessary to evaluate potential remedial actions or support future resource use decisions.

- The requirements of the Toxic Substances and Control Act should be evaluated to determine if they may be an applicable or appropriate and relevant requirement for future remedial actions involving soil or sediment containing PCBs above certain threshold criteria.

- Additional subsurface soil data may be required to fill subsurface soil data gaps at Load Line 4. Characterization needs associated with addressing such data gaps will be outlined in a white paper that will be prepared as part of planning under a future remedial action.

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