7.0 SCREENING OR PRELIMINARY ECOLOGICAL RISK ASSESSMENT

An ecological risk assessment (ERA) defines the likelihood of harmful effects on plants and animals as a result of exposure to chemical constituents. There are two types of ERAs: screening and baseline. A screening or preliminary ERA depends on available site data and is conservative in all regards. A baseline ERA 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 screening or preliminary ERA is needed to evaluate the possible risk to plants and wild animals from current and future exposure to contamination at WBG and its nearby aquatic environment at RVAAP.

The initial regulatory guidance for the ERA is contained in the EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume II, Environmental Evaluation Manual* (EPA 1989b) and subsequent documents (EPA 1991f, 1992c). 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 1989e). Other early 1990s guidance is provided in the *Framework for Ecological Risk Assessment* (EPA 1992d). 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 its replacement, the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al. 1996). In addition, the newly published *Ecological Risk Assessment Guidance* (EPA 1997d) supersedes RAGS, Volume II (EPA 1989b). This latter guidance makes the distinction between the interrelated roles of screening and baseline ERAs. Briefly, screening ERAs utilize conservative assumptions for exposures and effects, while baseline ERA means increasingly exposure unit-specific, more realistic (and generally less conservative) exposures and effects. Newly published EPA guidance (EPA 1997d) was used because it provides the clearest information on preliminary or screening ERAs.

These documents discuss an overall approach to considering ecological effects and 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. Team members are representatives from the USACE (Louisville), OEPA, USACHPPM, and the Army's contractor, SAIC. The various inputs were recorded in the *SAP Addendum for the Phase II Remedial Investigation at WBG and Determination of Facility-Wide Background at RVAAP* (USACE 1998a).

The following section presents the scope and objectives, the procedural framework, and the steps to complete the screening or preliminary ERA, hereafter referred to as ERA.

7.1 SCOPE AND OBJECTIVES

The scope of the ERA is to characterize in a preliminary way the risk to plant and animal populations at WBG and nearby aquatic environment. This is done for both current and future conditions. The ERA assesses the risk to ecological receptors, especially terrestrial and aquatic animals. Unlike the human health risk assessment, which focuses on individuals, the ERA focuses on populations or groups of interbreeding individuals. In the ERA process, individuals are addressed only if they are protected under the Endangered Species Act. Chemical constituents are called constituents of potential ecological concern (COPECs). When it has been demonstrated that these COPECs cause risk, they are called constituents of ecological concern (COECs). The COECs are associated with the more definitive or baseline ERAs.

To assess the potential for an analyte to pose a risk at the WBG, the analytes were subjected to a screening step that consists of comparing the maximum measured concentration at any location at WBG to a background concentration. Analytes whose concentrations exceeded the background levels were designated SRCs. SRCs were renamed COPECs and were further subjected to more quantitative estimates of exposure. First, a WBG-wide comparison was made, and it was followed by an assessment on a pad-by-pad basis to various ecological receptors. This was done for the most important pathways involving surface soil, sediment, and surface water. Benchmark concentrations of analytes obtained from published literature served as toxicity reference values or thresholds (concentrations below which there are no unacceptable adverse effects). The ratio of the exposure point concentration to the toxicity reference value results in a risk or hazard quotient. A risk quotient is calculated for each COPEC and each receptor. Each risk quotient is compared to an assessment endpoint, which is a pre-established ecological goal expressed as a ratio, to determine whether the risk quotient exceeds or does not exceed the assessment endpoint. If the risk quotient exceeds the assessment endpoint, a Phase II or baseline ERA and/or site remediation may be required to protect the ecological receptors. Uncertainties in the measured, estimated, and calculated concentrations on the final characterization of ecological risk at WBG are discussed qualitatively.

7.2 PROCEDURAL FRAMEWORK

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

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

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

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

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

The discussion of the ERA presented in this report is organized by the four interrelated steps of the EPA framework. Sections 7.3 through 7.6 detail the technical issues and data evaluation procedures associated with each step. Section 7.7 evaluates the degree of reliability or uncertainty of these methodological steps and the data used. The major findings are summarized in Section 7.8.

Figure 7-1 shows the relationship of screening (first part) and baseline (second part) ERAs. Again, this chapter deals only with the screening ERA.

7.3 PROBLEM FORMULATION

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

- determination of the scope of the assessment (as discussed in Section 7.1);
- formulation of a conceptual site model of the WBG based on existing information and reasonable assumptions, including habitats and populations, and any threatened and endangered species (Section 7.3.1);
- identification of COPECs (Section 7.3.2);
- selection of exposure unit and ecological receptors (Sections 7.3.3 and 7.3.4);
- selection of assessment and measurement endpoints for the ERA (Section 7.3.5); and
- summary of COPECs (Section 7.3.6).

7.3.1 Ecology Conceptual Site Model

The Ecology CSM of the WBG was developed for the ERA using the available site-specific information and professional judgment. The constituent source, exposure media, the routes by which they are exposed, and receptors to chemicals are described below. **Figure 7-2** shows the Ecology CSM.

7.3.1.1 Constituent Source and Source Media

Constituent sources at WBG are defined in earlier chapters. Chemicals from these sources are now present in surface soil, sediment, and surface water. Groundwater is shown for the sake of completeness.

7.3.1.2 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.

7.3.1.3 Exposure Media

Sufficient time—over 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.

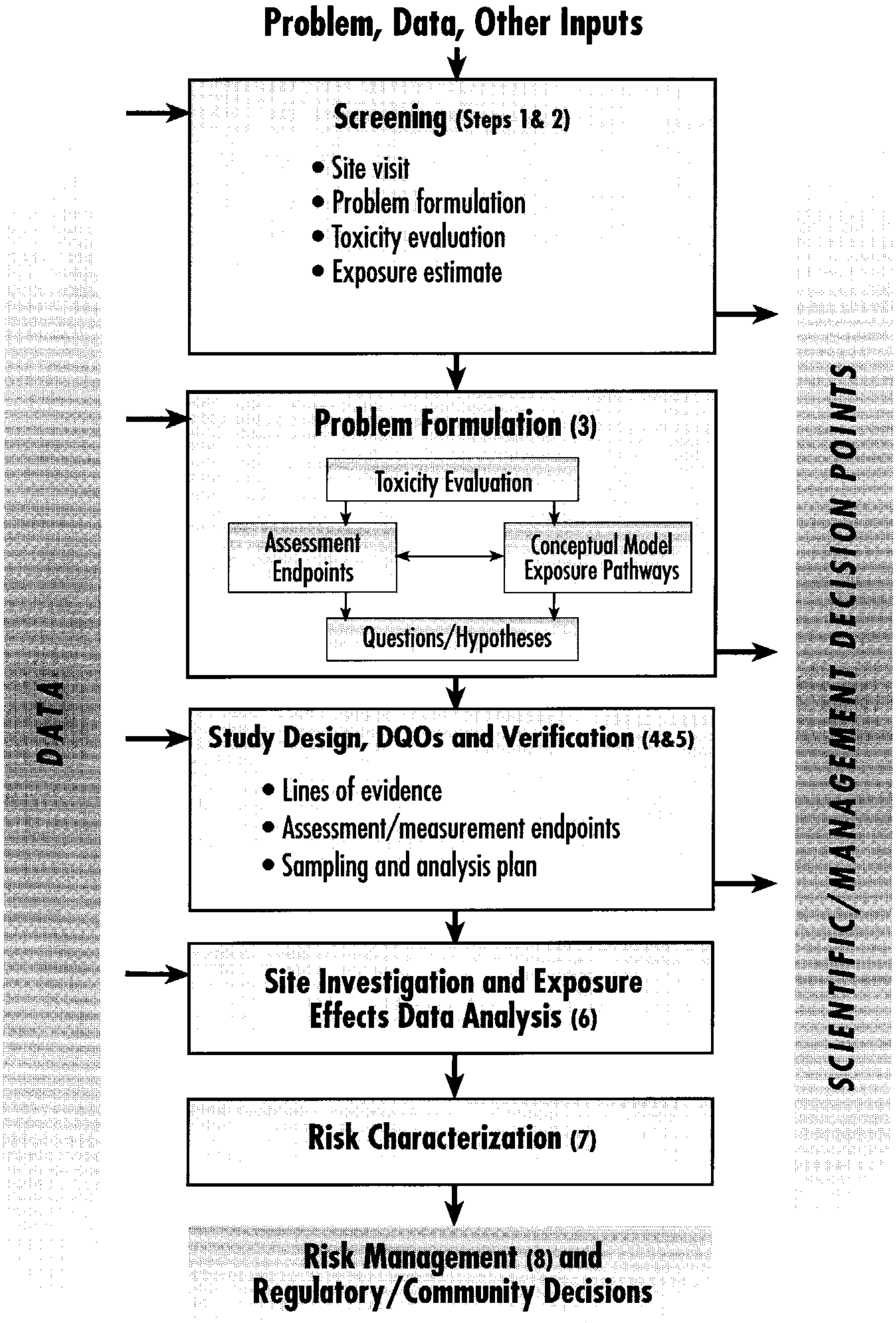

Figure 7-1. The ERA Process for Ecological Risk

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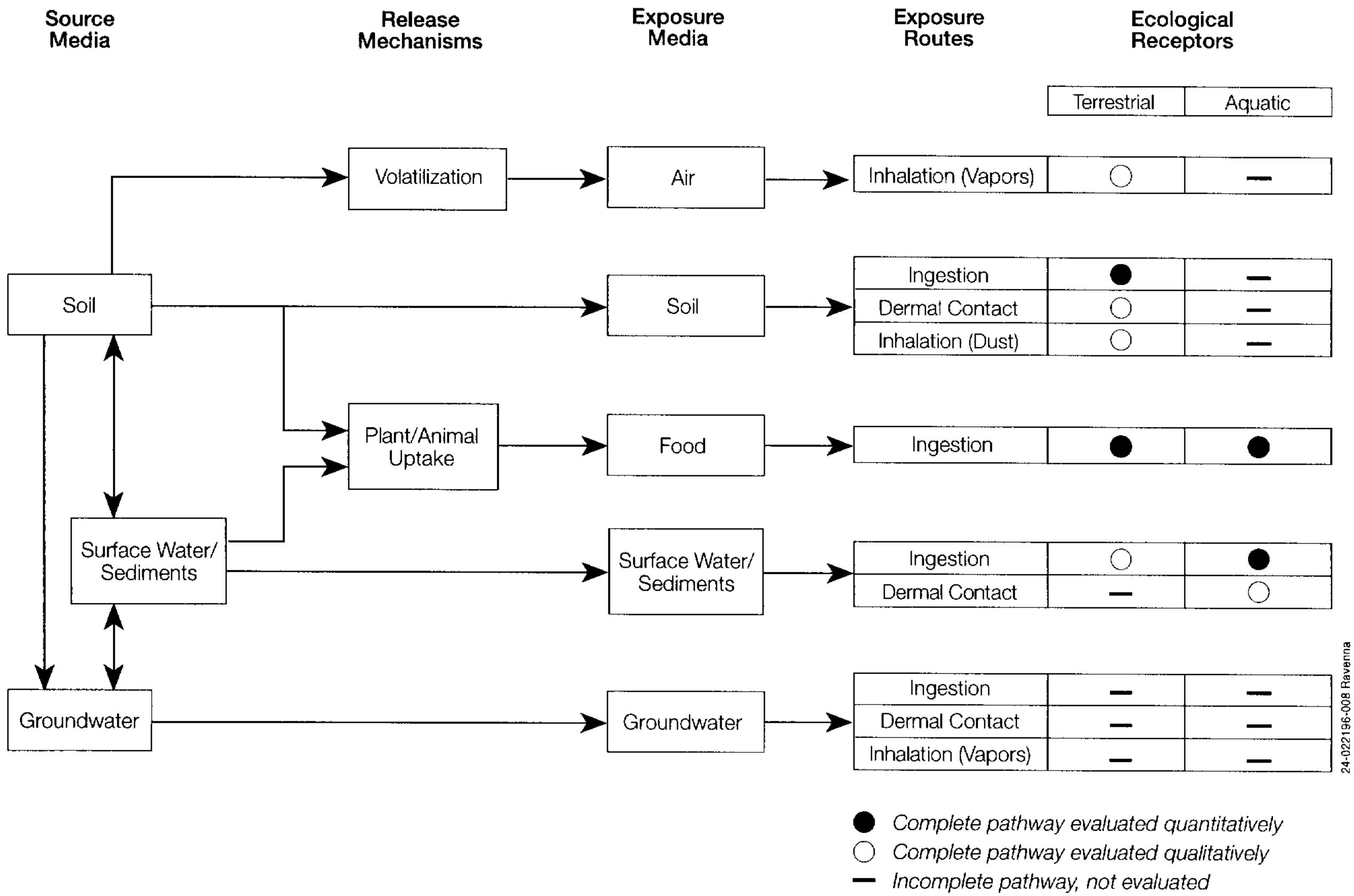


Figure 7-2. Exposure Pathways for Terrestrial and Aquatic Receptors at RVAAP, Ohio

Surface soil [0 to 0.6 m (0 to 2 ft)] and subsurface soil [0.6 m (2 ft) to much deeper)] are both potential locations for exposure to ecological receptors. The great majority of soil invertebrates and small mammals, small birds, and other ecological receptors use the upper few inches of soil and leaf litter. Active decomposition of dead plant and animal material and many soil and other organisms complete all or part of their life cycle (Suter, Luxmore, and Smith 1993). This is mentioned in the uncertainty section (Section 7.7).

Surface water and sediment are also present in the small ditches, creek, and nearby pond. Groundwater is not considered an exposure medium because ecological receptors are unlikely to contact groundwater at its depth of greater than 5 ft bgs. Air is not considered an exposure medium because potential volatile organics are believed to have dissipated. Thus, surface soil, sediment and surface water, and biota (e.g., food chain) were retained as the exposure media for this ERA.

7.3.1.4 Exposure Routes

A principal exposure route is contact of biota with soils at WBG. Animals also are exposed through ingestion of contaminated vegetation and prey species. Plants are exposed by root uptake from soil at the WBG and serve as throughputs to animals. Terrestrial animals may potentially 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 the two principal exposure routes evaluated quantitatively for terrestrial animals. The exposure of animals to constituents in soil by dermal contact and inhalation are likely to be a small fraction of the direct exposure to constituents in soil by incidental ingestion and the indirect exposure by ingestion of contaminated biota. Furthermore, the available toxicity data are almost exclusively for the ingestion pathway (e.g., Opresko, Sample, and Suter 1996). By contrast, direct exposure to constituents in sediment and surface water are principal pathways for sediment-dwelling organisms and fish. The exposure pathways are evaluated quantitatively using site measurements and published exposure parameters.

7.3.1.5 Ecological Receptors

Terrestrial and aquatic animal receptors are recognized in the conceptual site model (**Figure 7-2**) and are presented and discussed in Section 7.4.1.

7.3.2 Identification of Constituents of Potential Ecological Concern

The results of analysis of environmental media samples were organized and evaluated. Constituents that were not detected (i.e., were less than analytical blank concentrations and/or method detection limits) were dropped. Project quantitation levels were compared to 67 available ecotox thresholds (EPA Region V 1996). For sediment there was only one analyte, phenanthrene, whose quantitation level was higher than the ecotox threshold. For surface water there were 11 such conditions: xylenes (total), fluorene, 4-bromophenyl-phenylether, pentachlorophenol, phenanthrene, fluoranthene, cadmium, cobalt, copper, lead, and vanadium. There are no accepted soil ecotox thresholds so this comparison was not made. The implications of these findings are briefly discussed in the uncertainty section (Section 7.7). Also, constituents were dropped when present at concentrations less than or equal to background criteria (see Section 4.1). Inorganic constituents that were considered essential nutrients were retained for further assessment. Four constituents (calcium, magnesium, potassium, and sodium) are considered to be biologically necessary components of ecological systems and biological organisms. These were considered to be COPECs regardless of their low potentials for producing adverse effects. The input data (detected concentrations), including background are presented in Appendix Table L-1 for site-wide soil, Appendix Table L-2 for pad-by-pad soil, Appendix Tables L-569 and L-570 for sediment, and Appendix Table L-575 for surface water. These tables are rather large and, therefore, provided in the appendix. The values shown are the maximum detected environmental point concentration or EPC depending on the sample size of each constituent within the corresponding medium on a pad-by-pad basis, in the small ditches, and creek near WBG. Analytical results for surface soil and sediment are presented as mg/kg of medium; those for surface water are presented as µg/L of water.

7.3.3 Ecological Surveys and Description of Habitats and Populations

This section provides a description of the ecological resources at WBG. This characterization is supported by data collected during a field investigation conducted by SAIC during the summer of 1998. The ecological studies directed by the Ohio National Guard have also provided or are providing valuable information (e.g., definition of ecological receptors). For example, the 1993 inventory on species and plant communities (ODNR 1993) has been used. Also, five studies in 1999 are being used:

- small mammals (Carroll 1999);
- bats (Tawse 1999);
- plants (Gardner 1999);
- macroinvertebrates (Tertuliani 1999); and
- wetlands (Schalk, Tertuliani, and Darner 1999).

The vegetation maps from these studies help to define the homes of the various ecological receptors. In addition, any field-observed effects (e.g., denuded areas, stunted growth, low populations) will help to "ground-truth" the risk predictions.

Plants are discussed in Section 7.3.3.1; fauna is discussed in Section 7.3.3.2; aquatic habitats are discussed in Section 7.3.3.3; and protected species are discussed in Section 7.3.3.4.

7.3.3.1 Plant Communities and Habitats

This section summarizes the natural plant communities and habitats found at WBG. **Table 7-1** provides a list of the flora and **Figure 7-3** shows a habitat map of the area. WBG is located near the center of RVAAP and consists of approximately 80.9 ha (200 acres). Prior to 1941, WBG was predominantly open farmland. Installation-related activities also have physically disturbed areas of surface soil in the area, combining with past agricultural practices to create the variety of habitats and vegetation types that exist today.

The WBG is primarily old farm fields. While under cultivation, the land was tilled and grazed with little regard for soil or erosion management, leaving the topsoil in a depleted condition. After the Army developed the WGB, the fields were mowed regularly to reduce the growth of woody brush and the fire hazard associated with the explosives burning operations. Once mowing was discontinued, species such as black locust, aspen, and red maple pioneered the site. These species are the current dominant woody vegetation, with some cottonwood and black willow occurring along drainage areas. These successional fields provide an abundance of ecotonal edge habitat throughout the burning pad areas. Flora found in the fields contain several grasses, forbs, and small shrubs. Some of the more common herbaceous vegetation observed included strawberries (*Fragaria virginiana*), dandelions (*Taraxacum officinale*), violets (*Viola* spp.), mustards (*Brassica* spp.), buttercups (*Ranunculus* spp.), and mints (Family: *Labiatae*). Big-tooth (*Populus grandidentata*) and quaking aspen (*P. tremuloides*) occur in small stands at former burn areas. Additionally, downy serviceberry (*Amelanchier arborea*), crab apple (*Malus* spp.), witchhazel (*Hamamelis virginiana*), and willow (*Salix* spp.) are abundant edge habitat species. Eastern cottonwood (*Populus deltoides)* occasionally occurs along drainage ways.

Table 7-1. Listing of Vascular Plant Species Noted During Field Investigations at WBG

Scientific Name	Common Name
Herbaceous Plants	
Arisaema spp.	Jack-in-the-Pulpit
Brassica spp.	Mustards
Erigeron philadelphicus	Philadelphia fleabane
Family: *Labiatae*	Mints
Fragaria virginiana	Strawberry
Podophyllum peltatum	May-apple
Ranunculus spp.	Buttercup
Symplocarpus foetidus	Skunk cabbage
Taraxacum officinale	Dandelion
Typha spp.	Cattail
Viola spp.	Violet
Woody Plants	
Acer rubrum	Red maple
A. saccarinum	Silver maple
A. saccarum	Sugar maple
Carya spp.	Hickory
Fraxinus spp.	Ash
Hamamelis virginiana	Witchhazel
Mallus spp.	Crab apple
Populus deltoides	Eastern cottonwood
Prunus spp.	Cherry
Prunus spp.	Plum
Quercus alba	White oak
Q. palustris	Pin oak
Q. rubra	Red oak
Rhus spp.	Sumac
Salix spp.	Willow

Sources: Wildflowers of Northeastern/Northcentral North America, Peterson Field Guides, 1968.
Guide to Southern Trees, Harlow and Harrar, 1969.

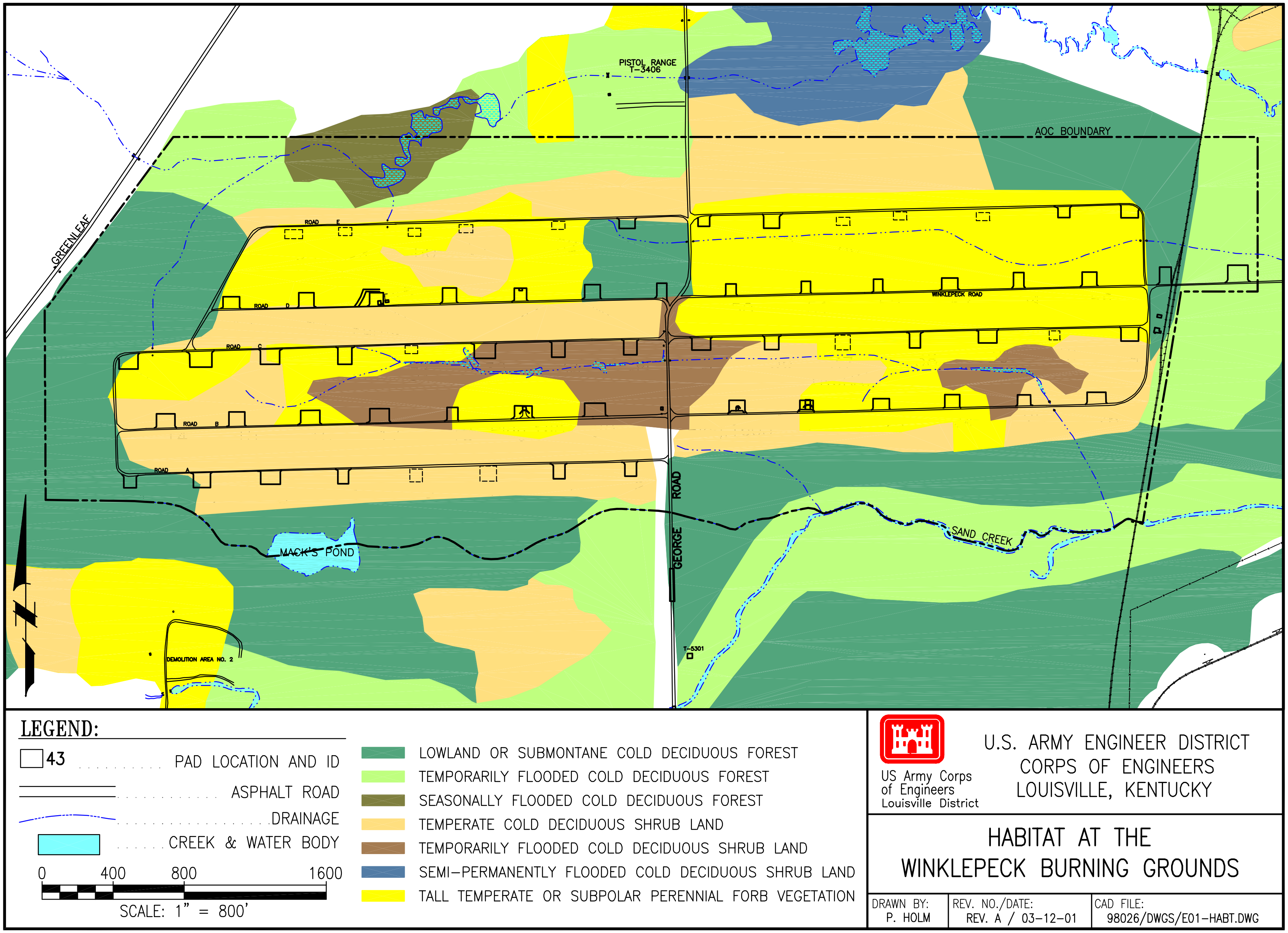


Figure 7-3. Habitat Types at Winklepeck Burning Grounds

The remaining habitat surrounding the burning grounds consists primarily of lowland or submontane cold deciduous forest, temporarily flooded cold deciduous forest, and seasonally flooded cold deciduous forest (**Figure 7-3**). North of WBG, east of George Road, there is an area of temperate and semi-permanently flooded cold deciduous shrub land. Sugar maple (*Acer saccarum*) and northern red oak (*Quercus rubra*) are the most abundant species. The forest habitat surrounding WBG is mature and diverse.

7.3.3.2 Terrestrial Fauna

WBG harbors a wide variety of avian, mammalian, reptilian, amphibian, and aquatic fauna. **Table 7-2** provides a list of the observed fauna. The burning pad areas are abundant with meadow voles (*Microtus pennsylvanicus*). Tunnels of these small mammals occur throughout the area, and numerous individuals were observed during the collection of surface soil samples. Soils of the pad areas are also abundant with earthworms (> 1 per 3-in. auger bucket, 0 to 1 ft bgs, at every pad). Cottontail rabbits (*Sylvagus floridanus*) were observed on numerous occasions along the ecotonal areas of WBG. Red fox (*Vulpes vulpes*) and coyote (*Canis latrans*) scat were observed on a few occasions. Evidence of beaver activity was observed around Mack's Pond.

Numerous songbirds also occupied these areas as well as reptiles and amphibians in that most of these areas were associated with some sort of surface water feature. Red-tailed hawks (*Buteo jamaicensis*) were observed daily roosting on tree limbs in the edge habitats and appear to be the top predator. An osprey (*Pandion haliaetus*) was observed at Cobb's Pond east of the WBG on two occasions.

7.3.3.3 Aquatic Habitats

WBG is dominated by terrestrial habitats. There are permanent water bodies inside WBG: Mack's Pond and part of Sand Creek. There are ephemeral water bodies of two types: water and sediment in man-made ditches (referred to as dry sediment) and water and sediment in a creek and beaver-dam impoundment (referred to as wet sediment).

Small aquatic habitats consist mainly of small intermittently flowing streams with moist edges draining the burning pad areas. Mack's Pond is the only large surface water body located within the WBG area. This man-made pond is on a tributary of Sand Creek. Marshy areas are located at the headwaters of this pond. Willow is the predominant flora of the marshy areas, while cattails (*Typha* spp.), rushes, grasses, and sycamore (*Platanus occidentalis*) are somewhat sporadic in occurrence.

Aquatic fauna were observed in the areas of WBG that contained water. Amphibians included green frogs, chorus frogs, and the American toad. Green sunfish (*Lepomis cyanellus*) were stocked in the pond years ago (Morgan 1999). Other aquatic biota included crayfish, water striders, mosquito larvae, aquatic coleoptera, and other dipteran larvae.

7.3.3.4 Protected Species

A number of rare species are found at the RVAAP, several of which are of federal and state interest (ODNR 1993). These species of concern, excluding the common barn owl, which is known to be on the RVAAP, will be handled qualitatively in the screening ERA. The barn owl will be handled quantitatively in the screening ERA. These species are discussed below. Additional information and complete species lists for the RVAAP are contained in Appendix K.

Table 7-2. Listing of Fauna Species Noted During Field Investigations at WBG

Scientific Name	Common Name
Avian	
Accipiter cooperii	Cooper's Hawk
Agelaius phoeniceus	Red-winged blackbird
Branta canadensis	Canada goose
Buteo jamaicensis	Red-tailed hawk
Cardinalis cardinalis	Cardinal
Cathartes aura	Turkey vulture
Charadrius vociferus	Killdeer
Colaptes auratus	Common flicker
Corvus brachyrhyncos	American crow
Cyanocitta cristata	Bluejay
Passer domesticus	House sparrow
Quiscalus auiscula	Grackle
Sialia sialis	Eastern bluebird
Sturnus vulgaris	European starling
Subfamily: Emberizinae	Various sparrows
Turdus migratorius	American robin
Zenaida macroura	Mourning dove
Mammals	
Canis latrans	Coyote
Castor canadensis	Beaver
Clethrionomys gapperi	Southern red-back vole
Didelphis virginiana	Opossum
Marmota monax	Groundhog
Microtus pennsylvanicus	Meadow vole
Odocoileus virginianus	White-tailed deer
Procyon lotor	Raccoon
Sylvagus floridanus	Eastern cottontail rabbit
Vulpes vulpes	Red fox
Herptiles	
Bufo americanus	American toad
Pseudacis triseriata	Chorus frog
Rana clamitans melanota	Green frog

Sources: A Field Guide to the Birds East of the Rockies, Peterson Field Guides, 1980.
Note: Observations include tracks and/or scat.

Federal

No known federally listed threatened or endangered species have been documented on the RVAAP. The federal endangered Indiana bat (*Myotis sodalis*) has been documented nearby. A 1998 bat survey at RVAAP found no Indiana bats; this bat is not considered to occur on-site (Morgan 1999).

State

State-listed endangered species include eight birds, a lamprey, a butterfly, and two plants. One state-listed threatened species, a plant, is found on RVAAP. A complete listing of rare species by common and scientific names is provided in Appendix K.

Portage County has more rare species, especially plants, than any other county in Ohio. This is reflected in the number of species occurring on the RVAAP that are listed as State Potentially Threatened. These species include two trees, three woody species, a fern, and ten herbaceous species.

Species that are listed as of State Special Interest [listed either by the Ohio Department of Wildlife (ODOW) or the Heritage Program (Heritage)] include eight birds, three mammals, two amphibians, and one reptile. One of the rare species is the four-toed salamander, a State Special Interest species.

7.3.4 Selection of Exposure Units and Receptor Species

From the ecological assessment viewpoint, an exposure unit is the investigation area and some of the surrounding area where ecological receptors are likely to gather food, seek shelter, reproduce, and move around, and, as a result of these activities, be potentially exposed to WBG constituents. Thus, the exposure unit is defined on the basis of the existing habitat and land use, observed and assumed patterns of behavior of the receptors, and the spatial area of site and WBG habitats relative to the home range and foraging areas of the receptors. The spatial boundaries of the ecological exposure unit are the same as the spatial boundaries of unit defined for the human health risk assessment.

These exposure units are:

- all of WBG (terrestrial),
- each individual pad (terrestrial),
- sediment site in the ditch inside and adjacent to WBG,
- sediment site in the creek inside and adjacent to WBG, and
- surface water site in the pond nearby WBG.

The exposed ecological receptors for the ERA were selected from animal species found in terrestrial/aquatic habitats. Three criteria, listed below, were used to select the ecological receptors (**Table 7-3**):

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

- Susceptibility means that the receptor is known to be present at the site and sensitive to chemicals (e.g., rabbits) and exposed through ingestion or direct contact because food preference is high (e.g., robins and shrews).

Table 7-3. Reasons for Selecting Receptors for Ecological Risk Assessment at WBG

Receptor	Selection Criteria		
	Criterion 1 **Ecological Relevance**	**Criterion 2** **Susceptibility**	**Criterion 3** **Represents Management Goals**[a]
Plants (*various species*)	+++	+	+++
Earthworms (*various species*)	++	++	+
Short-tailed shrew (*Blarina brevicauda*)	++	+++	+
American robin (*Turdus migratorius*)	++	++	+
White-tailed deer (*Odocoileus virginianus*)	+	+	+++
Eastern cottontail (*Sylvilagus floridanus*)	++	++	+
Red-tailed hawk (*Buteo jamaicensis*)	++	+++	++
Aquatic organisms	+++	+++	+++
Sediment-dwelling organisms	+++	+++	++

[a] Includes protection of threatened and endangered or other special status species.
+++ = receptor very strongly meets criterion; ++ = receptor strongly meets criterion; and + = receptor meets criterion.
Source: EPA (1996e).

- Management goals mean the sustaining of ecosystems and ecological processes while maintaining the mission of RVAAP, which is to store bulk explosives and function as a military training site. The large tracts of natural land, needed as safety buffers, provide the natural resource base to be managed. Such management goals, as the following, support the mission and natural resource management plan: erosion control through vegetation; population management through hunting of such animals as deer; and protection of rare, threatened, and endangered species such as the barn owl through ecosystem management.

- Department of the Army personnel at all levels must ensure that they carry out mission requirements in harmony with Federal regulatory requirements, including those within the Endangered Species Act (ESA). All U.S. Army land uses, including military training, testing, timber harvesting, recreation, and grazing are subject to ESA requirements for the protection of listed species and their critical habitat. The key to successfully balancing mission requirements and the conservation of listed species is effective planning and management to prevent conflicts between these competing interests (USACE 1995). Where practicable, the Army extends the same consideration to state-listed rare species.

For WBG, the ecological receptors are terrestrial plants, earthworms, short-tailed shrew, American robins, cottontail rabbit, white-tailed deer, red-tailed hawk, barn owl, and red fox, sediment-dwelling organisms, and aquatic organisms. Risks are quantitatively estimated for each receptor. **Figure 7-4** shows the terrestrial food chain for the terrestrial receptors. **Figure 7-5** shows the aquatic food chain for the aquatic receptors.

7.3.5 Ecological Assessment and Measurement Endpoints

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

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

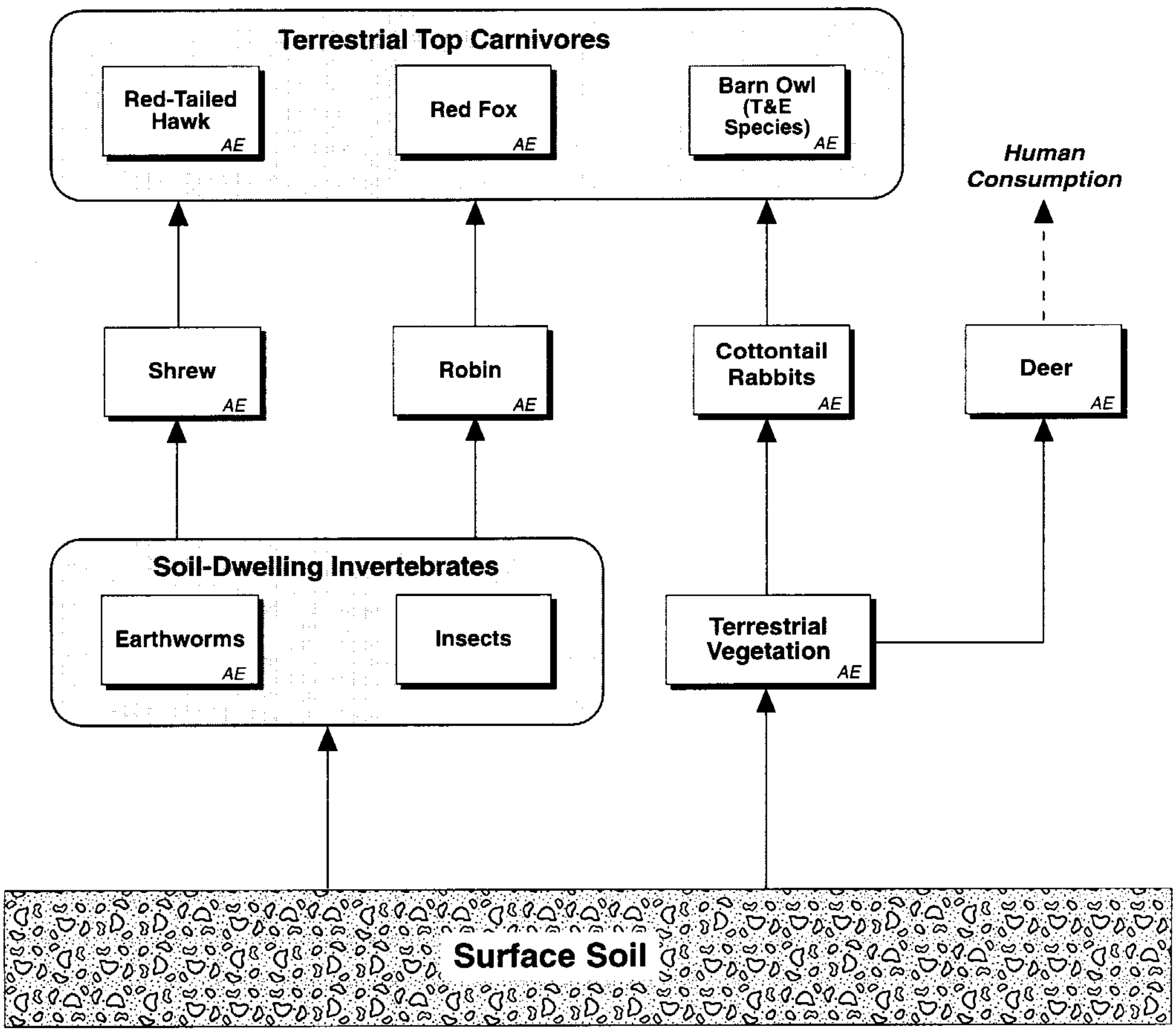
Three policy goals were defined for WBG. Assessment and measurement end points are provided with each policy goal (**Table 7-4**). Policy goals are:

- Policy Goal 1: The preservation and conservation of threatened, endangered, and rare species and their habitats. See Appendix K for an updated list of rare species at Ravenna.

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

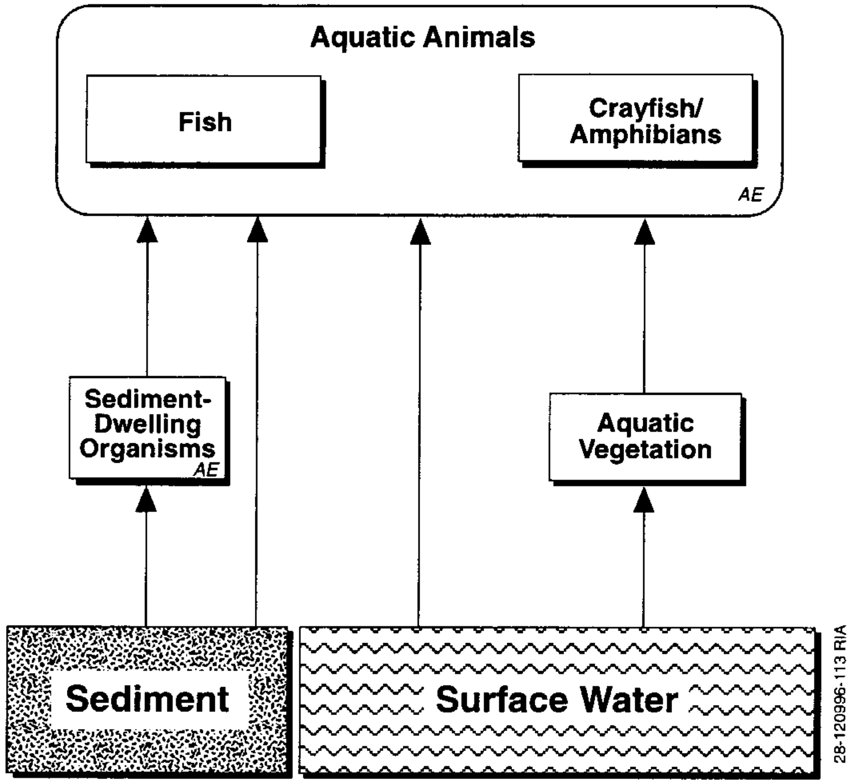
- Policy Goal 3: The maintenance and protection of aquatic populations and communities.

The decision rules associated with the assessment endpoints for the ERA are stated quantitatively in terms of toxicity or risk quotients (Barnthouse et al. 1986). A risk quotient is the ratio of the measured or predicted concentration of an analyte to which receptors are exposed in an environmental medium, and the measured concentration of an analyte that adversely affects an organism (benchmark or toxicity reference value). If the



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

Figure 7-4. Simple Terrestrial Food Web at RVAAP, Ohio for Ecological Risk Assessment



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

Figure 7-5. Simple Aquatic Food Web at RVAAP, Ohio for Ecological Risk Assessment

Table 7-4. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules at WBG

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

Table 7-4. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules at WBG (continued)

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

Table 7-4. Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules at WBG (continued)

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
Policy Goal 3: The maintenance and protection of aquatic populations and ecosystems.	**Assessment Endpoint 7:** Maintenance of sediment-dwelling organisms. Endpoint Species: sediment-dwelling organisms	**Measurement Endpoint 7:** Measured sediment contaminant concentrations.	**Decision Rule for Assessment Endpoint 7:** If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects, and therefore, populations of sediment-dwelling organisms are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.
	Assessment Endpoint 8: Maintenance of aquatic organisms. Endpoint Species: aquatic organisms	**Measurement Endpoint 8:** Measured surface water contaminant concentrations.	**Decision Rule for Assessment Endpoint 8:** If the HQ is <1, then it is indicated that the contaminant alone is unlikely to cause adverse ecological effects, and therefore, populations of aquatic organisms are maintained. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk and the need for any additional measurements or calculations.

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

measured concentration exactly equals or is less than the concentration producing an adverse effect (i.e., the ratio of the two, or the risk or HQ, is less than or equal to 1), the risk is considered acceptable (protective of the ecological receptor). Any risk quotient greater than 1 indicates that the ecological COPC qualifies for further investigation of the actual likelihood of harm, i.e., a baseline risk assessment may be needed. The final COECs are selected only after additional evaluation of the conservatism of exposure assumptions, toxicity thresholds, and uncertainties (e.g., background risk).

From the regulatory viewpoint, any HQ greater than 1 means likely ecological risk and the need to pursue more risk characterization. However, from a technical viewpoint, the higher the HQ, the higher the risk. Regardless, there must be a weight-of-evidence analysis and/or "ground-truthing" of the HQs.

Further thresholds may be needed to make decisions. Accordingly, HQs in the range of 1 to 99 will be designated as low ecological risk, in the range of 100 to 999 as intermediate ecological risk and in excess of 1000 as high ecological risk. The basis for these categories is professional judgment based on tens of ecological risk assessments. The use of such a simple method to organize HQs is designed to help risk management, not supplant this responsibility that is related but different from risk assessment. However, full acknowledgement is given any chemical with an HQ of 1 or higher based on the screening ERA.

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

HQs for assessment endpoints 1 through 6 (**Table 7-4**) were calculated for ecological COPCs in soils. Assessment endpoints 7 and 8 deal with sediment and surface water assessment endpoints, respectively. Assessment endpoint 6 deals specifically with exposure to a raptor and another carnivore species, and assessment endpoint 1 deals with a threatened predator of terrestrial biota. Calculation and evaluation of the HQs for the ecological receptors are discussed below.

7.3.6 Summary of Ecological Constituents of Potential Concern

COPECs are those substances detected at the WBG surface soil [0 to 0.6 m (0 to 2 ft)] that have the potential to pose a hazard or risk to animals. Also, their single or maximum concentrations exceeded the background UTL. Since the toxicity reference values are all less than facility-wide background, all detected/above background soil chemicals automatically became soil COPCs. Maximum concentrations of sediment and surface water analytes were compared to sediment screening values and surface water screening values.

Figure 7-6 provides an overview of this screening process to identify COPECs in the context of analytes and COECs.

7.4 EXPOSURE ASSESSMENT

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

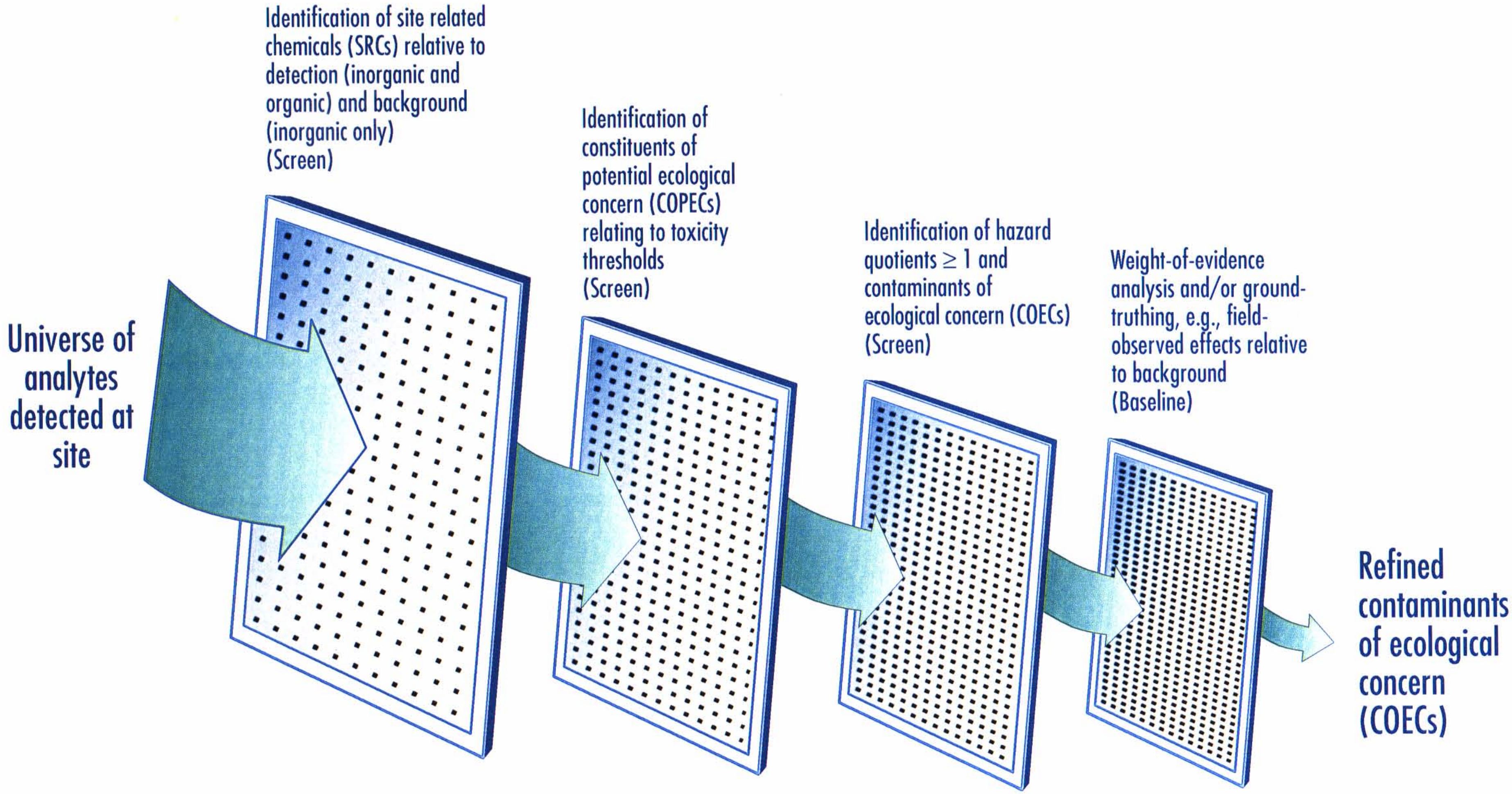


Figure 7-6. Overview of Screening Process for Ecological Risk Assessment

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7.4.1 Ecological Receptors and Their Exposure

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

7.4.1.1 Terrestrial Exposure Classes and Receptors

The terrestrial exposure classes and their ecological receptors for the WBG investigation are:

- Vegetation
  - variety of grasses, forbs, and trees
- Soil-dwelling invertebrates
  - earthworms
- Mammalian herbivores
  - cottontail rabbits
  - white-tailed deer
- Worm-eating and/or insectivorous mammals and birds
  - short-tailed shrews
  - American robins
- Terrestrial top predators
  - red-tailed hawks
  - barn owls (a threatened and endangered species)
  - red foxes

These receptors or their ecological equivalents are present or likely to be present at the WBG and were selected in accordance with the EPA *Framework for Ecological Risk Assessment* (EPA 1992a and EPA 1996a) as explained previously.

Exposure pathways were chosen to provide a range of potential exposures, including high exposures, to receptors under a variety of conditions. For example, earthworms and shrews constitute a pathway where exposure of small mammals from soil constituents would be maximized. Hawks represent the top of the food web where exposures from bioaccumulated materials can be maximal. By contrast, herbivores and plants constitute a pathway of lesser chemical exposure.

Vegetation

Vegetation is composed of grasses, forbs, bushes, and trees of the type growing at WBG. Vegetation converts sunlight to biomass in the form of roots, stems, leaves, and floral parts. In turn, the plant parts are eaten by herbivores.

Soil-dwelling Invertebrates

Earthworms and other soil-dwelling invertebrates (lumbricids) are exposed to soil chemicals in surface soil by ingestion and direct contact. It is assumed that earthworms ingest only soil and are exposed to the full-measured concentrations. As suggested earlier, earthworms have ecological value because of their role in the decomposition of detritus, soil aeration, and soil fertility. Also, earthworms are ingested by worm-eating mammals and birds and, thus, any decrease of earthworm populations would reduce the amount of food going to their predators and, in turn, could affect such predators. In addition, contaminated earthworms—both contaminated soil in their guts and contaminated tissue—can contaminate and affect their mammal and bird predators.

Worm-eating and/or Insectivorous Mammals and Birds

Insectivorous mammals [(e.g., short-tailed shrew, *Blarina brevicauda* (**Table 7-5**), American robin, *Turdus migratorius* (**Table 7-6**)] are primarily exposed by ingestion of potentially contaminated prey (e.g., earthworms, insect larvae, slugs) as well as ingestion of soil. Worm-eating and/or insectivorous mammals and birds may also be exposed to soil constituents by direct contact and inhalation of VOCs and SVOCs and particulates. Dermal exposure is expected to be negligible and skin-associated soil that is ingested is included in the estimated daily soil ingestion rate. For the WBG, the exposure for this class of receptors is the sum of materials absorbed from the soil and from ingested plants and animals. The soil fraction of their diet includes soil from the intestinal tracts of their prey. Exposure by direct contact and inhalation was not evaluated. There are few data on inhalation toxicity or toxicity by direct contact with contaminated soil (or the parameters required to model constituent absorption). Instead, conservative values for soil ingestion and dietary composition were used for shrews and robins. This means that the exposure variables for soil ingestion used 13% for the shrew (**Table 7-5**) and 10.4% for the robin (**Table 7-6**). This means that about $1/10^{th}$ of all ingested material was soil. Both receptors were assumed to eat a lot of earthworms which, in turn, live in the contaminated soil. For shrews, this percent ingestion was 87 percent, and for robins, this percent ingestion was 50 percent. Both values are considered conservative.

Note that in **Tables 7-5, 7-6,** and other receptor parameter tables, ingested food (animal and/or plant) is assumed not to include ingested soil; therefore, plant fraction of diet plus animal fraction of diet = 1.0. The sources of data about ingested animal, plant, and soil rarely reconcile the fractions. Therefore, the conservative route has been adopted to treat soil at its maximum value.

Mammalian Herbivores

Mid-sized and large-sized herbivores [e.g., eastern cottontails, *Sylvilagus floridanus* (**Table 7-7**)], and white-tailed deer, *Odcocoileus virginianus* (**Table 7-8**), are exposed primarily to soil chemicals that are in plant material. Exposure by direct contact with soil is assumed to be limited for cottontails and deer. The exposure for cottontails and deer is the sum of absorption from the soil and ingestion from plants. The estimated exposure for this class does not include exposure by direct contact or inhalation. Few data are available on inhalation toxicity or toxicity by direct contact with contaminated soil (or the parameters required to model constituent absorption).

Terrestrial Top Predators

Top predators are exposed primarily to COPECs that have accumulated in their prey. Terrestrial top predators [e.g., red-tailed hawk, *Buteo jamaicensis* (**Table 7-9**), and barn owl, *Tyto alba* (**Table 7-10**), and red fox, *Vulpes vulpes* (**Table 7-11**)] feed primarily on terrestrial prey. Some terrestrial predators also may incidentally consume soil; hawks and owls do not. Although hawks and other predators are assumed to forage over an area that is larger than the area of the WBG exposure unit and certainly for the area of any pad, there is no adjustment made for the fact that they have home ranges in excess of these locations.

Table 7-5. Receptor Parameters for Short-tailed Shrew

		Receptor:	Short-tailed shrew *(Blarina brevicauda)*
Parameter	**Definition**	**Value**	**Reference / Notes**
BW	Body weight (kg)	0.017	Arithmetic mean of means, both sexes, fall and summer, western Pennsylvania (EPA 1993b)
HR	Home range (ha)	0.36	Maximum, adult female, summer, Michigan (EPA 1993b)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	0.56	Arithmetic mean of adults, both sexes, 25oC, Wisconsin (EPA 1993b)
PF	Plant fraction of diet	0.13	June through October, New York (EPA 1993b); assuming vegetative parts and fungi
AF	Animal fraction of diet	0.87	June through October, New York (EPA 1993b); assuming 100% earthworms
SF	Soil fraction of diet	0.13	Talmage and Walton (1993)
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.223	Adult, both sexes, Illinois, lab (EPA 1993b)

[a] Food ingestion rate (g/g-d) reexpressed as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

Table 7-6. Receptor Parameters for American Robin

		Receptor:	American robin *(Turdus migratorius)*
Parameter	**Definition**	**Value**	**Reference / Notes**
BW	Body weight (kg)	0.08	Adult breeding female, New York (EPA 1993b)
HR	Home range (ha)	0.42	Adult, both sexes, spring, mean, Tennessee (EPA 1993b)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	1.52	Mean, both sexes, free living, Kansas (EPA 1993b)
PF	Plant fraction of diet	0.5	Arithmetic mean, 4 seasons, central U.S., % of stomach contents that is plant material (EPA 1993b); assumed to be plant reproductive tissue
AF	Animal fraction of diet	0.5	Arithmetic mean, 4 seasons, central US, % of stomach contents that is animal material (EPA 1993b); assumed to be earthworm
SF	Soil fraction of diet	0.104	Value for American woodcock (Scolopax minor), estimated percent soil in diet, dry weight (Beyer, Conner, and Gerould 1994)
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.14	Adult, both sexes, estimated (EPA 1993b)

[a] Food ingestion rate (g/g-d) reexpressed as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

Table 7-7. Receptor Parameters for Eastern Cottontail

Parameter	Definition	Receptor:	Eastern cottontail *(Sylvilagus floridanus)*
		Value	Reference / Notes
BW	Body weight (kg)	1.23	Arithmetic mean of 4 seasonal means, adult, both sexes, Georgia, all areas (EPA 1993b)
HR	Home range (ha)	3	Arithmetic mean of winter means, adult, both sexes, Wisconsin (EPA 1993b)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	0.205	Estimated by dividing free-living metabolic rate (203 kcal/kgBW/d) by the product of the energy composition of young grasses (1.3 kcal/g wet wt.) and assimilation efficiency (0.76) per Table 4-7 (EPA 1993b)
PF	Plant fraction of diet	1	EPA (1993b); assumed to be vegetative parts
AF	Animal fraction of diet	0	Not reported in EPA (1993b); assumed to be negligible
SF	Soil fraction of diet	0.063	Value for jackrabbit, estimated percent soil in diet, dry weight (EPA 1993b)
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.097	Adult, both sexes (EPA 1993b)

[a] Food ingestion rate (g/g-d) reexpressed as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

Table 7-8. Receptor Parameters for White-tailed Deer

Parameter	Definition	Receptor:	White-tailed deer *(Odocoileus virginianus)*
		Value	Reference / Notes
BW	Body weight (kg)	56.5	Sample and Suter (1994)
HR	Home range (ha)	175	Geometric mean of minimum (59) and maximum (520) reported in Sample and Suter (1994)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	0.031	1.74 kg/d (Sample and Suter 1994) converted to g/g-d (=kg/kgBW/d) by dividing by body weight of 56.5 kg
PF	Plant fraction of diet	1	Exclusively herbivorous (Sample and Suter 1994); assumed to be vegetative parts
AF	Animal fraction of diet	0	Not reported in Sample and Suter (1994); assumed to be negligible
SF	Soil fraction of diet	0.02	Sample and Suter (1994)
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.065	3.7 L/d (Sample and Suter 1994) converted to g/g-d (= L/kgBW/d) by dividing by body weight of 56.5 kg

[a] Food ingestion rate (g/g-d) reexpresses as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

Table 7-9. Receptor Parameters for Red-tailed Hawk

Parameter	Definition	Receptor:	Red-tailed hawk *(Buteo jamaicensis)*
		Value	Reference / Notes
BW	Body weight (kg)	1.13	Arithmetic mean, female and male, Michigan (EPA 1993b)
HR	Home range (ha)	697	Mean, adults, both sexes, winter, Michigan (EPA 1993b)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	0.11	Adult female, winter, Michigan, captive outdoors (EPA 1993b)
PF	Plant fraction of diet	0	Not stated in EPA (1993b); assumed to be negligible
AF	Animal fraction of diet	1	Prey brought to nests (EPA 1993b)
SF	Soil fraction of diet	0	Not stated in EPA (1993b) and Beyer, Conner, and Gerould (1994); assumed to be negligible.
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.057	Arithmetic mean, both sexes, estimated (EPA 1993b)

[a] Food ingestion rate (g/g/-d) reexpressed as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

Table 7-10. Receptor Parameters for Barn Owl

Parameter	Definition	Receptor:	Barn Owl *(Tyto alba)*
		Value	Reference / Notes
BW	Body weight (kg)	0.466	Mean of male and female (Sample and Suter 1994)
HR	Home range (ha)	250	Approximate area (Sample and Suter 1994)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	0.125	Mean value (Sample and Suter 1994)
PF	Plant fraction of diet	0	(Sample and Suter 1994)
AF	Animal fraction of diet	1	(Sample and Suter 1994)
SF	Soil fraction of diet	0	Assumed negligible (Sample and Suter 1994)
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.035	(Sample and Suter 1994)

[a] Food ingestion rate (g/g-d) reexpressed as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

Table 7-11. Receptor Parameters for Red Fox

Parameter	Definition	Receptor:	Red fox *(Vulpes vulpes)*
		Value	Reference / Notes
BW	Body weight (kg)	4.69	Arithmetic average of means, both sexes, spring, Illinois (EPA 1993b)
HR	Home range (ha)	596	Adult, female, spring, minimum, Minnesota (EPA 1993b)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	0.069	Adult, non-breeding, North Dakota (EPA 1993b)
PF	Plant fraction of diet	0.046	Illinois farm/woods, spring, % wet weight (EPA 1993b); assumed to be reproductive parts
AF	Animal fraction of diet	0.954	Illinois farm/woods, spring, % wet weight, including unspecified/other (EPA 1993b)
SF	Soil fraction of diet	0.028	Estimated percent soil in diet, dry weight (EPA 1993b)
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.085	Arithmetic mean, adult, both sexes (EPA 1993b)

[a] Food ingestion rate (g/g-d) reexpressed as kg/kgBW/d is assumed not to include ingested soil; therefore, PF+AF = 1.0.

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

7.4.1.2 Aquatic Exposure Classes and Receptors

The aquatic exposure classes and their ecological receptors in the small ditches and creek near the WBG are:

- sediment-dwelling organisms, which include crayfish; and
- fish and aquatic animals, which include such organisms as omnivores (caddisflies and may flies, minnows), predators (crayfish), mussels, and sediment-ingesting fish.

Sediment-Dwelling Invertebrates

Sediment-dwelling invertebrates (e.g., crayfish) are assumed to be exposed to sediment and sediment pore water by multiple routes. The toxicity threshold concentrations for COPECs in sediment for the WBG ERA are based on all exposure routes from sediment to sediment-dwelling invertebrates. Thus, the measured COPEC concentrations in sediment are used as the estimated exposure concentrations for sediment-dwelling invertebrates.

Fish and Aquatic Animals

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

The exposures of these receptor classes to analytes are estimated from the measured concentrations in the soil, sediment, or water and adjusted by exposure factors, as described below.

7.4.2 Quantification of Exposure

The exposure of an endpoint receptor to a chemical in surface soil at the WBG is quantified as the average daily dose (ADD) using measured concentrations in the environment and exposure parameters that account for both the transfer of constituents from soil into food and the quantity of food and soil ingested daily. The concentration of constituent used in the exposure calculation was the EPC, provided in Appendix Tables L-1 and L-2 for surface soil and Appendix Tables L-569 and L-570 for sediment and Appendix Table L-575 for surface water. If the sample size for soil and sediment was large enough, an EPC was calculated (i.e., UCL_{95}). Where the sample size consisted of singular datum, the maximum detect is used as the EPC. This is also the case for water where one sample is involved.

Exposure parameters used to derive the ADD for each endpoint receptor for RVAAP are provided in **Tables 7-5 through 7-11**. The quantity of food ingested that is plant matter (I_P), animal matter (I_A), and soil (I_S) is calculated from the total daily rate of food ingestion (IR_F) and the fractions of the diet that are plant matter (PF), animal matter (AF), and soil (SF). Shrews, robins, cottontails, and deer are assumed to ingest plant matter, but hawks, owls, and foxes are assumed to have no plant matter in their diets. Robins are assumed to ingest fruits and berries, whereas shrews and cottontails ingest mainly vegetative parts of plants. The animal matter component of the diets of shrews and robins is assumed to consist of earthworms because earthworms are more directly exposed to soil constituents than most other animals and because soil-to-earthworm uptake factors are available. A fraction of the mass ingested while eating earthworms is soil inside the worm intestine; this amount is included in the amount of soil ingested daily (I_S). Cottontails and deer are assumed to ingest no animal matter, while the hawk's, owl's, and foxes' diet consist entirely of animal prey.

Constituent-specific transfer factors are provided in Appendix Tables L-4 through L-7.

Ecological receptors obtain a fraction of their diet from the WBG exposure unit. Assuming that individuals are distributed randomly and/or forage randomly over their home or foraging ranges, they obtain only a fraction of their diet from an exposure unit that is smaller than their range. The area use factor (AUF) is the ratio of the size of the home or foraging ranges to the size of the exposure unit. AUFs are based on reported foraging or home ranges (**Tables 7-5 through 7-11**). As implied above, AUFs would vary from organism to organism, but AUFs are set at 1.

Exposure equations are presented below. The general equation is:

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

where:

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

For robins,

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

where:

EPC = Exposure point concentration in soil (mg/kg soil),
SP_r = Soil-to-plant (fruiting parts) uptake factor (kg soil/kg plant),
I_P = Ingestion rate of plant matter (kg/kg body wt/d), $IR_F \times PF \times TUF$,

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

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

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

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

where:

EPC = Exposure point concentration in soil (mg/kg soil),
BAF_i = Soil-to-soil-dwelling invertebrates uptake factor (kg soil/kg tissue),
I_A = Ingestion rate of animal matter (kg/kg body wt/d), $IR_F \times AF \times TUF$,
IR_F = Ingestion rate of food (kg/kg body wt/d),
AF = Fraction of animal matter in diet (unitless),
AUF = Area use factor (unitless).

Ingestion of constituents in prey by hawks (proxy for other terrestrial predators) is a special case because uptake by prey from their diets must be accounted for. It is assumed that the diet of hawks is entirely shrews because shrews are highly exposed to soil constituents. Further, it is assumed that the animal portion of the shrew's diet is all earthworms to maximize the exposure route of soil contaminant/earthworm/shrew. Exposure cannot be higher than this; therefore, if the maximum exposure has no ecological risk, the other and lesser exposures (e.g., seeds/white-footed mice, vegetation/voles) would not be expected to show risk. For hawks,

ADD_A = (Concentration in prey, Cs) $\times I_{A(hawk)} \times AUF_{(hawk)}$,
Cs = Prey ADD_{total} x BAF_v / IR_f
Prey ADD_{total} = Prey ADD_P + Prey ADD_A + Prey ADD_S
Prey ADD_P = $EPC \times SP_v \times I_{P\text{-}s} \times AUF_{\text{-}s}$
Prey ADD_A = $EPC \times BAF_i \times I_{A\text{-}s} \times AUF_{\text{-}s}$
Prey ADD_S = $EPC \times I_{S\text{-}s} \times AUF_{\text{-}s}$

where:

$I_{A(hawk)}$ = Ingestion rate of animal matter for hawk (kg/kg body wt/d),
$AUF_{(hawk)}$ = Area use factor for hawk (unitless),
BAF_v = Food-to-tissue uptake factor in shrews (kg shrew's food/kg tissue),
IR_f = Shrew food ingestion rate (kg/kg body wt/d),
EPC = Exposure point concentration (mg/kg),
SP_v = Soil-to-plant (vegetative parts) uptake factor (kg soil/kg plant),
$I_{P\text{-}s}$ = Ingestion rate of plants by shrews (kg/kg body wt/d),
$AUF_{\text{-}s}$ = Shrew area use factor (unitless),
BAF_i = Soil-to-animal bioaccumulation factor for invertebrates (mg/kg wet wt tissue/mg/kg dry wt soil),
$I_{A\text{-}s}$ = Ingestion rate of animal matter for shrews (kg/kg body wt/d),
$I_{S\text{-}s}$ = Ingestion rate of soil for shrews (kg/kg body wt/d).

Ingestion of constituents in soil by all receptors is given by:

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

where:

EPC = Exposure point concentration in soil (mg/kg soil),
I_S = Ingestion rate of soil (kg/kg body wt/d), $IR_F \times SF \times TUF$,
IR_F = Ingestion rate of food (kg/kg body wt/d),
SF = Fraction of soil in diet (unitless),
AUF = Area use factor (unitless).

The fraction of the constituent in ingested soil and tissue that is absorbed is assumed to be 100 percent. Continuous year-round exposure or a temporal use factor (TUF) of 1 is assumed for all receptors.

The constituent-specific values for bioaccumulation for soil-to-plant uptake (SP_v), soil-to-invertebrate uptake (BAF_i), and animal tissue-to-mammal tissue uptake (BAF_v) are detailed in Appendix Tables L-3 and L-4. The bioaccumulation factors (BAFs) for soil-dwelling invertebrate prey ingested by shrews are those reported in *Risk Assessment Methodology for Loring Air Force Base* (HAZWRAP 1994). Note that key parts of this document are included in Appendix K. The BAFs for prey ingested by hawks are those for small mammals (HAZWRAP 1994). Default BAFs for COPECs without published BAF values are 1 for metals and 1 for organics, based on the range of values reported for these two types of constituents (HAZWRAP 1994). Sediment-to-biota BAFs are presented in Appendix Table L-571. Water-to-biota bioconcentration factors (BCFs) are presented in Appendix Table L-576. The next three paragraphs further explain more about the sources and methods for the BAFs.

For inorganic elements, BAFs for plants (SPv for vegetative plant parts and SPr for reproductive plant parts) are empirically-derived ratios of tissue concentration to soil concentrations reported by Baes et al. (1984), converted to a wet weight basis by multiplying by 0.2, assuming that plants are 80 percent water. For organics with log Kow >5 and no available empirical data, plant BAFs are calculated using the following regression equation from Travis and Arms (1988): log BAF = 1.588 – (0.578 × log\Kow). If the log Kow is <5, then the BAF is conservatively assumed to be 0.02, assuming that plants are 80 percent water. This assumption is based on field studies that suggest organic compounds with log Kows <5 do not bioaccumulate in the food chain (Maughan 1993).

The BAFs for soil-dwelling invertebrates are averages or geometric means of published values (e.g., Beyer 1990, Gish 1970, Edwards and Thompson 1973, Diercxsens et al. 1985, and many sources for DDT) of the earthworm tissue to soil concentration ratio, converted to a wet weight basis by multiplying by 0.2, assuming an 80 percent water content. Dry soil concentrations of DDT for calculating BAFs were calculated assuming 10 percent moisture in sandy-loam soils (Donahue, Miller, and Skickluna al. 1977).

For inorganic elements, the BAFs for small mammals and birds are derived from biotransfer factors (BTFs) presented in Baes et al. (1984) for uptake into cattle. Cattle BTFs are converted to generic BAFs by multiplying the BTF by the cattle's food ingestion rate of 50 kg/d wet weight. For organics, BAFs are calculated using the following regression equation from Travis and Arms (1988): log BTF = log Kow – 7.6. The resulting BTF is converted to a BAF by multiplying by an average food ingestion rate of 12 kg/d dry weight and converted to wet weight by dividing by 0.2, assuming food is 80 percent water. The whole-body pheasant BAF for 4,4'-DDT presented in EPA (1985), derived from Kenaga (1973), is used as the surrogate for pesticides for both mammals and birds.

The exposures of endpoint receptors to COPECs in surface soil at WBG and each pad at WBG are estimated by multiplying exposure factors by the EPC, a conservative estimate of the COPEC concentration. The EPCs developed for each COPEC represent a UCL_{95} of the mean or the maximum detected concentration, whichever is smaller. For information about computation of UCL_{95}, see Section 6.3.4 on exposure point concentration where normal and lognormal distributions are also defined.

Chemical concentrations are those measured in soil at depths from 0 to 0.6 m (0 to 2 ft) (Appendix Tables L-1 and L-2). Soil background concentrations also are given in Appendix Table L-1.

The ingestion factors are summarized in **Table 7-12**. The calculated exposure concentrations are provided beginning with Appendix Table L-20, after such inputs as toxicity reference values that are advanced beginning with Appendix Table L-5.

It is assumed that there is no dilution of COPECs for sediment-dwelling and aquatic receptors exposed directly to sediment and surface water. Therefore, exposure factors for these receptors are equal to 1.0. Concentrations are provided on Appendix Tables L-569 and 570 (sediment) and L-575 (water) with background concentrations in the same Appendix Tables.

7.4.3 Summary of Exposure Assessment

The EPCs of COPECs in media at sites at WBG are multiplied by exposure factors to estimate exposure concentrations for each endpoint receptor. Exposure concentrations are the concentrations of COPECs in soil and the prey to which the endpoint receptors are exposed. These average daily doses are an estimate of the exposure of receptors to COPECs on a per-unit-constituent-concentration basis. These EPCs will be compared to published toxicity threshold concentrations (Section 7.5) to characterize the risks to endpoint receptors from direct and indirect exposure to COPECs in soil at the WBG (Section 7.6).

7.5 EFFECTS ASSESSMENT

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

7.5.1 Chemical Toxicity

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

Chronic (long-term) toxicity resulting from chemical constituents is the primary concern at the WBG. VOCs are unlikely to remain at high concentrations because they have volatilized and/or have been transported off-site. Most organisms do not ingest large amounts of soil and sediment, and assuming that the soil is not acutely toxic, these organisms are unlikely to be effected.

Table 7-12. Derivation of Ingestion Rates for Receptors

Receptor	IR_F (kg/kgBW/d)	TUF (unitless)	PF (unitless)	I_P (kg/kgBW/d) IRF × TUF × PF	AF (unitless)	I_A (kg/kgBW/d) IRF × TUF × AF	SF (unitless)	I_S (kg/kgBW/d) IRF × TUF × SF
Short-tailed shrew	0.560	1	0.13	7.28E-02	0.87	4.87E-01	0.13	7.28E-02
American robin	1.520	1	0.50	7.60E-01	0.50	7.60E-01	0.10	1.58E-01
Cottontail rabbit	0.205	1	1.00	2.05E-01	0.00	0.00E+01	0.06	1.29E-02
White-tailed deer	0.031	1	1.00	3.10E-02	0.00	0.00E+01	0.02	6.20E-04
Red-tailed hawk	0.110	1	0.00	0.00E+01	1.00	1.10E-01	0.00	0.00E+01
Barn Owl	0.125	1	0.00	0.00E+01	1.00	1.25E-01	0.00	0.00E+01
Red fox	0.069	1	0.05	3.17E-03	0.95	6.58E-02	0.03	1.93E-03

IR_F = Food ingestion rate; normalized to body weight
TUF = Temporal use factor
PF = Plant fraction
I_P = Plant intake rate
AF = Animal fraction
I_A = Animal intake rate
SF = Soil fraction
I_S = Soil intake rate

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

Toxicity of constituents varies, depending on the receptor species and the attending physical and chemical factors, the presence of complexing agents, or interaction with other chemicals at the site. Plants can be adversely affected by constituents in numerous ways, including seed production, seed germination, growth rate, and plant biomass. Animals can be adversely affected in terms of behavioral and physiological changes including reproductive impairment.

7.5.2 Toxicity Reference Values

Site-specific toxicological studies using the WBG animal populations have not been conducted to determine whether the concentrations of COPECs at the site are toxic. Therefore, this effects assessment uses toxicity data obtained from compiled data bases [e.g., Will and Suter (1996) and Sample, Opresko, and Suter (1996), which utilize U.S. Fish and Wildlife Service and other toxicity studies]. Information on test concentrations, modes of exposure, and effects on similar species from published toxicity studies was used to establish toxicity reference values or thresholds for risk calculations. Examples of the kinds of toxicological data that are used to assess effects of site constituents on ecological receptors are:

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

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

NOAEL-based dietary limits are the preferred toxicity threshold for the WBG ERA and are used in this ERA.

Ecological effects data are available for many ecological COPCs at the WBG. These data encompass effects arising from exposure to ingested matter, including soil and food for animals, and root uptake from soil by plants. Data are available for ecological receptors in all exposure classes for the exposure unit. These data are used in the screening of constituents to identify inorganic and organic COPECs in the soil. Risks are calculated using the toxicity thresholds for COPECs from the soil.

These thresholds are provided in Appendix Tables L-5 (vegetation), L-6 (earthworms), L-7 (birds), L-8 (mammals), L-572 (sediment-dwelling biota), and L-577 (aquatic biota). Two or more thresholds are presented for sediment and water situations. Usually, the lower or lowest value is selected as the final threshold; the footnotes to these tables provide additional details. Additional narrative explains the thought process for obtaining TRVs.

Toxicity reference values (TRVs) for endpoint receptors exposed to ecoCOPCs by ingestion are derived from selected published NOAELs or LOAELS for test species. The published doses for test species are based on laboratory observations of varying effects on organisms exposed to varying concentrations of constituents. The toxicity test data used to derive NOAELs are from those studies compiled and reported in Sample et al. (1996) or published in electronic databases (NLM 1997; NIOSH 1997). If the test duration is long relative to the lifespan of the organism or includes sensitive life stages, the test is considered a chronic test; otherwise, it is considered subchronic. When there is no NOAEL reported, we estimate NOAELs for test species from chronic LOAELs or subchronic values. Following Sample et al. (1996), subchronic values are divided by 10 to estimate the chronic value, and LOAELs are divided by 10 to estimate the test species NOAEL. If there is no LOAEL, it is estimated as the NOAEL × 10.

7.6 RISK CHARACTERIZATION FOR ECOLOGICAL RECEPTORS

The procedures for the fourth step in the EPA ERA process are discussed below. Risk characterization integrates exposure and stressor response on receptor organisms used in the assessment, summarizes risk or the likelihood of harm to animals, and interprets the ecological significance of these findings.

The ecological assessment endpoints depend on this comparison by using HQs for COPECs. The HQs form the quantitative basis of this risk characterization (EPA 1989b).

HQs compare the average daily doses to TRVs. ADDs are derived from measured environmental concentrations, e.g., the larger of the UCL_{95} and maximum, by multiplying the measured concentration by exposure factors. The effects information is expressed as the TRV or the constituent concentration that approximates the area of no response to a small response. This relationship is shown as:

$$\text{Hazard Quotient (HQ)} = \frac{\text{Environmental Exposure Expressed as Total Average Daily Dose}}{\text{Toxicity Reference Value}}$$

Where an HQ could not be calculated because insufficient data were available to establish a toxicity threshold, COPECs were carried through the risk characterization as COPECs of uncertain risk to ecological receptors.

An HQ greater than unity (1.0) indicates that there is a potential for harmful ecological effects and that the COPEC qualifies for further investigation (possibly Phase II or the more definitive baseline risk assessment) into its potential to pose a hazard. Moreover, the risk of potential hazardous effects increases with the magnitude of the ratio. An HQ threshold of 1.0 assumes that the toxicity threshold and exposure concentrations are accurate. In reality, the range of values around 1.0 within which HQs may or may not indicate the existence of risk increases with the uncertainty of the estimated exposure and toxicity threshold concentrations.

7.6.1 Current Preliminary Risk to Ecological Receptors

Risks to ecological receptors under current conditions are estimated by calculating HQs for all terrestrial and aquatic exposure classes, as represented by their ecological receptors. The HQs from all COPECs were summed to show an HI; this is another measure of ecological risk, and any HI greater than 1 is an additional indication of likely ecological risk. The HQs and HIs are reported on a receptor by receptor basis beginning in Appendix Table L-20. Of course, these receptors are those associated with the assessment endpoints. Results of these analyses are as follows:

WBG-Wide for Surface Soil (Appendix Tables L-11 to L-19). The WBG-wide analysis shows nearly every analyte has an HQ of 1 or greater for one or more receptors. For example, antimony has an HQ of 7 for shrews even though HQs were below 1 for other receptors. Regardless and overall, antimony is an COPEC. It was decided that all analytes would proceed to the pad-by-pad analysis.

Pad-by-Pad for Surface Soil (Appendix Tables L-20 to L-568). All pads exhibited some ecological risk (HQs >1). Only one Pad, #4, showed ecological risk of a low nature (range of HQs = 1 to 99). Further, another 46 pads would have exhibited low ecological risk if aluminum were not an COPEC. **Table 7-13** provides these and much more information on a pad-by-pad basis. **Table 7-14** summarized the pad numbers by degree of risk.

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 1	Arsenic (1) vegetation Arsenic (3) cottontail Arsenic (6) shrew Chromium (2) robin Lead (4) fox Zinc (2) owl Zinc (2) robin Zinc (3) hawk	Aluminum (17) robin Aluminum (22) deer Aluminum (54) fox Chromium (13) vegetation Chromium (33) worm Lead (14) robin	Aluminum (202) vegetation Aluminum (497) shrew Aluminum (173) cottontail	
Pad 2	Arsenic (1) fox Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (8) shrew Chromium (2) robin Selenium (1) shrew Selenium (1) vegetation Zinc (1) vegetation Zinc (3) hawk Zinc (3) owl Zinc (3) robin	Aluminum (18) robin Aluminum (56) fox Aluminum (23) deer Chromium (14) vegetation Chromium (36) worm Lead (19) robin	Aluminum (212) vegetation Aluminum (182) cottontail Aluminum (521) shrew	
Pad 3	Arsenic (1) fox Arsenic (2) vegetation Arsenic (5) cottontail Arsenic (9) shrew Chromium (2) robin Zinc (1) vegetation Zinc (3) hawk Zinc (3) owl Zinc (3) robin	Aluminum (15) robin Aluminum (20) deer Aluminum (48) fox Chromium (10) vegetation Lead (16) robin Chromium (26) worm	Aluminum (180) vegetation Aluminum (443) shrew Aluminum (154) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 4	Aluminum (2) robin Aluminum (3) deer Aluminum (8) fox Arsenic (2) fox Arsenic (2) vegetation Arsenic (6) cottontail Chromium (5) vegetation Lead (1) shrew Selenium (1) shrew Selenium (1) vegetation Zinc (2) hawk Zinc (2) owl Zinc (2) robin	Aluminum (28) vegetation Aluminum (69) shrew Aluminum (24) cottontail Arsenic (11) shrew Chromium (14) worm Lead (27) robin		
Pad 5	Arsenic (2) fox Arsenic (2) vegetation Arsenic (6) cottontail Chromium (3) robin Lead (1) shrew Selenium (1) robin Selenium (1) vegetation Selenium (2) shrew Thallium (6) fox Zinc (1) vegetation Zinc (4) hawk Zinc (4) owl Zinc (4) robin	Aluminum (21) robin Aluminum (28) deer Aluminum (67) fox Arsenic (11) shrew Chromium (17) vegetation Chromium (44) worm Lead (26) robin Thallium (12) shrew	Aluminum (252) vegetation Aluminum (620) shrew Aluminum (216) cottontail	
Pad 6	Arsenic (2) vegetation Arsenic (1) fox Arsenic (5) cottontail Arsenic (9) shrew Cadmium (1) robin	Aluminum (21) robin Aluminum (28) deer Aluminum (70) fox Chromium (16) vegetation Chromium (40) worm	Aluminum (252) vegetation Aluminum (620) shrew Aluminum (216) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Cadmium (1) shrew Chromium (2) robin Lead (1) shrew Selenium (1) robin Selenium (1) shrew Selenium (1) vegetation Thallium (6) fox Zinc (1) vegetation Zinc (4) hawk Zinc (4) owl Zinc (4) robin 2,4,6-Trinitrotoulene (3) deer 2,4,6-Trinitrotoulene (4) fox 2,4,6-Trinitrotoulene (7) cottontail 2,4,6-Trinitrotoulene (7) shrew	Lead (25) robin Thallium (11) shrew		
Pad 7	Arsenic (1) fox Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (8) shrew Chromium (1) robin Selenium (1) robin Selenium (1) vegetation Selenium (2) shrew Zinc (3) hawk Zinc (3) owl Zinc (3) robin	Aluminum (13) robin Aluminum (18) deer Aluminum (43) fox Chromium (10) vegetation Chromium (24) worm Lead (18) robin	Aluminum (161) vegetation Aluminum (397) shrew Aluminum (138) cottontail	
Pad 8	Arsenic (1) fox Arsenic (2) vegetation Arsenic (5) cottontail Arsenic (9) shrew Chromium (1) robin	Aluminum (14) robin Aluminum (19) deer Aluminum (45)fox Chromium (10) vegetation Chromium (25) worm	Aluminum (168) vegetation Aluminum (414) shrew Aluminum (144) cottontail Thallium (109) shrew	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Selenium (2) robin Selenium (2) shrew Selenium (2) vegetation Thallium (3) vegetation Thallium (7) cottontail Zinc (2) hawk Zinc (2) owl Zinc (2) robin	Lead (20) robin Thallium (54) fox		
Pad 9	Pad does not exist and no assesement was needed			
Pad 10	Pad does not exist and no assesement was needed			
Pad 11	Pad does not exist and no assesement was needed			
Pad 12	Pad does not exist and no assesement was needed			
Pad 13	Pad does not exist and no assesement was needed			
Pad 14	Arsenic (1) fox Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (7) shrew Chromium (2) robin Selenium (1) robin Selenium (2) shrew Selenium (2) vegetation Zinc (1) vegetation Zinc (3) hawk Zinc (3) owl Zinc (3) robin	Aluminum (16) robin Aluminum (22) deer Aluminum (52) fox Chromium (14) vegetation Chromium (35) worm Lead (17) robin	Aluminum (198) vegetation Aluminum (486) shrew Aluminum (169) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 15	Arsenic (1) fox Arsenic (5) cottontail Arsenic (8) shrew Arsenic (2) vegetation Chromium (2) robin Lead (1) shrew Selenium (1) shrew Selenium (1) vegetation Zinc (2) hawk Zinc (2) owl Zinc (2) robin	Aluminum (15) robin Aluminum (20) deer Aluminum (48) fox Chromium (11) vegetation Chromium (29) worm Lead (23) robin	Aluminum (181) vegetation Aluminum (444) shrew Aluminum (155) cottontail	
Pad 16	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Arsenic (1) fox Chromium (2) robin Lead (1) shrew Selenium (1) vegetation Selenium (1) shrew Zinc (3) robin Zinc (3) hawk Zinc (3) owl Zinc (1) vegetation	Aluminum (19) robin Aluminum (25) deer Aluminum (61) fox Chromium (13) vegetation Chromium (33) worm Lead (22) robin	Aluminum (228) vegetation Aluminum (561) shrew Aluminum (195) cottontail	
Pad 17	Arsenic (6) shrew Arsenic (3) cottontail Arsenic (1) vegetation Chromium (2) robin Zinc (3) hawk Zinc (3) owl Zinc (1) vegetation Zinc (3) robin	Aluminum (23) robin Aluminum (31) deer Aluminum (74) fox Chromium (40) worm Chromium (16) vegetation Lead (20) robin	Aluminum (280) vegetation Aluminum (689) shrew Aluminum (240) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 18	Arsenic (8) shrew Arsenic (4) cottontail Arsenic (2) vegetation Arsenic (1) fox Chromium (2) robin Zinc (3) robin Zinc (3) hawk Zinc (3) owl	Aluminum (17) robin Aluminum (23) deer Aluminum (55) fox Chromium (32) worm Chromium (13) vegetation Lead (20) robin	Aluminum (208) vegetation Aluminum (511) shrew Aluminum (178) cottontail	
Pad 19	Arsenic (6) shrew Arsenic (4) cottontail Arsenic (1) vegetation Chromium (9) vegetation Chromium (1) robin Zinc (2) robin Zinc (2) hawk Zinc (2) owl	Aluminum (14) robin Aluminum (18) deer Aluminum (43) fox Chromium (21) worm Lead (16) robin	Aluminum (162) vegetation Aluminum (398) shrew Aluminum (139) cottontail	
Pad 20	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Arsenic (1) fox Chromium (2) robin Lead (1) shrew Selenium (1) vegetation Selenium (2) shrew Selenium (1) robin Zinc (3) robin Zinc (3) hawk Zinc (3) owl Zinc (1) vegetation	Aluminum (20) robin Aluminum (26) deer Aluminum (63) fox Chromium (37) worm Chromium (15) vegetation Lead (24) robin	Aluminum (236) vegetation Aluminum (580) shrew Aluminum (202) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 21	Pad does not exist and no assesement was needed			
Pad 22	Pad does not exist and no assesement was needed			
Pad 23	Arsenic (6) shrew Arsenic (3) cottontail Arsenic (1) vegetation Cadmium (1) robin Chromium (2) robin Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Alumninum (17) robin Aluminum (23) deer Aluminum (55) fox Chromium (27) worm Chromium (11) vegetation Lead (17) robin	Aluminum (206) vegetation Aluminum (507) shrew Aluminum (177) cottontail	
Pad 24	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Arsenic (1) fox Chromium (2) robin Zinc (3) hawk Zinc (2) owl Zinc (2) robin	Aluminum (19) robin Aluminum (25) deer Aluminum (61) fox Chromium (35) worm Chromium (14) vegetation Lead (15) robin	Aluminum (230) vegetation Aluminum (197) cottontail Aluminum (566) shrew	
Pad 25	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Cadmium (1) robin Chromium (1) robin Zinc (2) robin Zinc (2) hawk Zinc (2) owl	Aluminum (14) robin Aluminum (18) deer Aluminum (44) fox Chromium (26) worm Chromium (10) vegetation Lead (19) robin	Aluminum (165) vegetation Aluminum (406) shrew Aluminum (141) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	**10-99**	**100-999**	**> 1,000**
Pad 26	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Chromium (2) robin Zinc (3) hawk Zinc (2) robin Zinc (2) owl	Aluminum (16) robin Aluninum (21) deer Aluminum (50) fox Chromium (26) worm Chromium (10) vegetation Lead (16) robin	Aluminum (190) vegetation Aluminum (467) shrew Aluminum (163) cottontail	
Pad 27	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Arsenic (1) fox Cadmium (1) vegetation Cadmium (2) shrew Cadmium (2) robin Chromium (2) robin Selenium (2) robin Selenium (2) vegetation Selenium (2) shrew Zinc (3) hawk Zinc (3) owl Zinc (3) robin	Aluminum (19) robin Aluminum (25) deer Aluminum (61) fox Chromium (34) worm Chromium (14) vegetation Lead (16) robin	Aluminum (228) vegetation Aluminum (561) shrew Aluminum (195) cottontail	
Pad 28	Arsenic (8) shrew Arsenic (4) cottontail Arsenic (2) vegetation Arsenic (1) fox Chromium (2) robin Selenium (2) vegetation Selenium (2) shrew Selenium (1) robin Thallium (4) cottontail Thallium (2) vegetation Zinc (3) robin	Aluminum (21) robin Aluminum (28) deer Aluminum (66) fox Chromium (38) worm Chromium (15) vegetation Lead (17) robin Thallium (63) shrew Thallium (31) fox	Aluminum (250) vegetation Aluminum (615) shrew Aluminum (214) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Zinc (3) hawk Zinc (3) owl			
Pad 29	Arsenic (4) shrew Arsenic (2) cottontail Chromium (3) robin Zinc (3) robin Zinc (3) hawk Zinc (3) owl Zinc (1) vegetation	Aluminum (29) robin Aluminum (38) deer Aluminum (92) fox Chromium (46) worm Chromium (18) vegetation Lead (20) robin	Aluminum (348) vegetation Aluminum (856) shrew Aluminum (298) cottontail	
Pad 30	Arsenic (6) cottontail Arsenic (2) vegetation Arsenic (2) fox Chromium (2) robin Zinc (3) robin Zinc (4) hawk Zinc (3) owl Zinc (1) vegetation	Aluminum (14) robin Aluminum (19) deer Aluminum (45) fox Arsenic (10) shrew Chromium (31) worm Chromium (12) vegetation Lead (17) robin	Aluminum (170) vegetation Aluminum (418) shrew Aluminum (146) cottontail	
Pad 31	Arsenic (9) shrew Arsenic (5) cottontail Arsenic (2) vegetation Arsenic (1) fox Chromium (2) robin Lead (1) shrew Selenium (1) shrew Selenium (1) robin Selenium (1) vegetation Zinc (3) robin	Aluminum (20) robin Aluminum (27) deer Aluminum (65) fox Chromium (37) worm Chromium (15) vegetation Lead (23) robin	Aluminum (246) vegetation Aluminum (605) shrew Aluminum (211) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Zinc (3) hawk Zinc (3) owl Zinc (1) vegetation			
Pad 32	Arsenic (5) shrew Arsenic (3) cottontail Barium (2) shrew Barium (2) robin Barium (1) cottontail Chromium (2) robin Lead (3) shrew Lead (1) vegetation Selenium (1) shrew Selenium (1) vegetation Zinc (7) vegetation Zinc (2) fox Zinc (2) worm	Aluminum (34) robin Aluminum (45) deer Cadmium (25) robin Cadmium (22) shrew Cadmium (16) vegetation Chromium (28) worm Chromium (11) vegetation Lead (71) robin Zinc (19) hawk Zinc (17) owl Zinc (17) robin	Aluminum (410) vegetation Aluminum (352) cottontail Aluminum (109) fox	Aluminum (1010) shrew
Pad 33	Arsenic (9) shrew Arsenic (5) cottontail Arsenic (2) vegetation Arsenic (1) fox Cadmium (1) robin Chromium (3) robin Selenium (1) vegetation Selenium (1) shrew Zinc (4) robin Zinc (4) hawk Zinc (4) owl Zinc (1) vegetation	Aluminum (25) robin Aluminum (33) deer Aluminum (79) fox Chromium (45) worm Chromium (18) vegetation Lead (20) robin	Aluminum (298) vegetation Aluminum (733) shrew Aluminum (256) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 34	Arsenic (8) shrew Arsenic (4) cottontail Arsenic (1) fox Arsenic (1) vegetation Cadmium (1) shrew Cadmium (1) robin Chromium (3) robin Lead (1) shrew Zinc (4) robin Zinc (4) hawk Zinc (4) owl Zinc (1) vegetation	Aluminum (22) robin Aluminum (29) deer Aluminum (70) fox Chromium (45) worm Chromium (18) vegetation Lead (23) robin	Aluminum (262) vegetation Aluminum (644) shrew Aluminum (225) cottontail	
Pad 35	Arsenic (6) shrew Arsenic (4) cottontail Arsenic (1) vegetation Chromium (2) robin Lead (1) shrew Zinc (3) robin Zinc (3) hawk Zinc (3) owl	Aluminum (21) robin Aluminum (28) deer Aluminum (68) fox Chromium (38) worm Chromium (15) vegetation Lead (22) robin	Aluminum (256) vegetation Aluminum (629) shrew Aluminum (219) cottontail	
Pad 36	Arsenic (6) shrew Arsenic (3) cottontail Arsenic (1) vegetation Chromium (2) robin Lead (1) shrew Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Aluminum (20) robin Aluminum (27) deer Aluminum (65) fox Chromium (36) worm Chromium (14) vegetation Lead (24) robin	Aluminum (246) vegetation Aluminum (605) shrew Aluminum (211) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 37	Antimony (2) shrew Antimony (1) cottontail Arsenic (8) shrew Arsenic (4) cottontail Arsenic (2) vegetation Arsenic (1) fox Barium (2) cottontail Barium (2) shrew Barium (3) robin Cadmium (1) cottontail Cadmium (1) worm Cadmium (1) fox Chromium (4) robin Copper (1) worm Lead (7) hawk Lead (6) owl Lead (4) cottontail Lead (3) worm Lead (1) fox Selenium (2) shrew Selenium (2) vegetation Selenium (1) robin Thallium (4) cottontail Thallium (2) vegetation Zinc (5) vegetation Zinc (2) fox Zinc (1) worm Bis(2-ethylhexyl)phthalte (5) robin Di-n-butylphthalate (4) hawk Di-n-butylphthalate (3) owl	Aluminum (38) robin Aluminum (50) deer Cadmium (54) vegetation Cadmium (71) shrew Cadmium (81) robin Chromium (28) vegetation Chromium (70) worm Di-n-butylphthalate (82) robin Lead (30) vegetation Lead (92) shrew Thallium (31) fox Thallium (64) shrew Zinc (12) owl Zinc (12) robin Zinc (13) hawk	Aluminum (456) vegetation Aluminum (391) cottontail Aluminum (121) fox	Aluminum (1120) shrew Lead (1890) robin

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 38	Arsenic (9) shrew Arsenic (5) cottontail Arsenic (2) vegetation Arsenic (1) fox Barium (4) shrew Barium (4) robin Barium (3) cottontail Barium (1) vegetation Chromium (4) robin Copper (2) worm Lead (8) vegetation Lead (2) owl Lead (2) hawk Lead (1) cottontail Selenium (5) vegetation Selenium (5) shrew Selenium (4) robin Selenium (2) fox Thallium (6) fox Zinc (6) fox Zinc (4) worm Zinc (3) shrew	Aluminum (37) robin Alumninum (49) deer Cadmium (13) deer Cadmium (44) worm Cadmium (44) cottontail Cadmium (35) fox Cadmium (18) hawk Cadmium (16) owl Chromium (67) worm Chromium (27) vegetation Lead (25) shrew Thallium (12) shrew Zinc (51) hawk Zinc (46) owl Zinc (45) robin Zinc (18) vegetation	Aluminum (444) vegatation Aluminum (381) cottontail Aluminum (118) fox Lead (521) robin	Aluminum (1090) shrew Cadmium (2650) robin Cadmium (2320) shrew Cadmium (1750) vegetation
Pad 39	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Chromium (2) robin Lead (1) shrew Zinc (5) hawk Zinc (4) owl Zinc (4) robin Zinc (2) vegetation	Aluminum (17) robin Aluminum (22) deer Aluminum (54) fox Chromium (29) worm Chromium (12) vegetation Lead (23) robin	Aluminum (204) vegetation Aluminum (175) cottontail Aluminum (502) shrew	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 40	Arsenic (2) deer Arsenic (3) fox Arsenic (4) vegetation Cadmium (1) robin Cadmium (1) shrew Chromium (2) robin Lead (4) vegetation Selenium (1) shrew Selenium (1) vegetation Thallium (6) fox Zinc (6) vegetation Zinc (2) worm Zinc (2) fox	Aluminum (18) robin Aluminum (24) deer Aluminum (58) fox Arsenic (19) shrew Arsenic (11) cottontail Chromium (36) worm Chromium (14) vegetation Lead (12) shrew Thallium (11) shrew Zinc (18) hawk Zinc (17) owl Zinc (16) robin	Aluminum (218) vegetation Aluminum (536) shrew Aluminum (187) cottontail Lead (240) robin	
Pad 41	Arsenic (6) cottontail Arsenic (2) fox Arsenic (2) vegetation Cadmium (1) robin Chromium (2) robin Lead (1) shrew Selenium (2) shrew Selenium (2) vegetation Selenium (1) robin Zinc (3) hawk Zinc (2) robin Zinc (3) owl	Aluminum (15) robin Aluminum (20) deer Aluminum (48) fox Arsenic (11) shrew Chromium (26) worm Chromium (10) vegetation Lead (23) robin	Aluminum (180) vegetation Aluminum (442) shrew Aluminum (154) cottontail	
Pad 42	Pad does not exist and no assesement was needed			
Pad 43	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Arsenic (1) fox	Aluminum (25) robin Aluminum (34) deer Aluminum (81) fox Chromium (43) worm	Aluminum (304) vegetation Aluminum (748) shrew Aluminum (261) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Chromium (2) robin Zinc (4) hawk Zinc (4) owl Zinc (4) robin Zinc (1) vegetation	Chromium (17) vegetation Lead (17) robin		
Pad 44	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Chromium (2) robin Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Aluminum (21) robin Aluminum (27) deer Aluminum (66) fox Chromium (39) worm Chromium (15) vegetation Lead (17) robin	Aluminum (248) vegetation Aluminum (610) shrew Aluminum (213) cottontail	
Pad 45	Arsenic (6) shrew Arsenic (4) cottontail Arsenic (1) vegetation Cadmium (5) robin Cadmium (5) shrew Cadmium (4) vegetation Chromium (7) vegetation Lead (6) vegetation Lead (1) owl Lead (1) hawk Zinc (7) vegetation Zinc (2) worm Zinc (2) fox	Aluminum (17) robin Aluminum (22) deer Aluminum (53) fox Chromium (17) worm Lead (19) shrew Zinc (20) hawk Zinc (18) robin Zinc (18) owl	Aluminum (198) vegetation Aluminum (487) shrew Aluminum (170) cottontail Lead (399) robin	
Pad 46	Arsenic (9) shrew Arsenic (5) cottontail Arsenic (2) vegetation Arsenic (1) fox	Aluminum (14) robin Aluminum (18) deer Aluminum (44) fox Chromium (29) worm	Aluminum (166) vegetation Aluminum (409) shrew Aluminum (143) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Cadmium (1) robin Chromium (2) robin Zinc (3) robin Zinc (3) hawk Zinc (3) owl Zinc (1) vegetation	Chromium (11) vegetation Lead (16) robin		
Pad 47	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Arsenic (1) fox Chromium (2) robin Zinc (5) hawk Zinc (4) robin Zinc (4) owl Zinc (2) vegetation	Aluminum (17) robin Aluminum (22) deer Aluminum (53) fox Cadmium (17) robin Cadmium (15) shrew Cadmium (11) vegetation Chromium (30) worm Chromium (12) vegetation Lead (17) robin	Aluminum (200) vegetation Aluminum (492) shrew Aluminum (171) cottontail	
Pad 48	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) vegetation Arsenic (1) fox Chromium (2) robin Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Aluminum (17) robin Aluminum (22) deer Aluminum (54) fox Chromium (30) worm Chromium (12) vegetation Lead (18) robin	Aluminum (202) vegetation Aluminum (497) shrew Aluminum (173) cottontail	
Pad 49	Arsenic (9) shrew Arsenic (5) cottontail Arsenic (2) vegetation Arsenic (1) fox Cadmium (3) robin Cadmium (2) vegetation	Aluminum (21) robin Aluminum (28) deer Aluminum (67) fox Chromium (39) worm Chromium (15) vegetation Lead (23) robin	Aluminum (252) vegetation Aluminum (620) shrew Aluminum (216) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Cadmium (2) shrew Chromium (2) robin Lead (1) shrew Selenium (1) shrew Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation			
Pad 50	Arsenic (9) shrew Arsenic (5) cottontail Arsenic (2) vegetation Arsenic (1) fox Chromium (2) robin Zinc (4) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Aluminum (21) robin Aluminum (27) deer Aluminum (66) fox Chromium (41) worm Chromium (17) vegetation Lead (18) robin	Aluminum (248) vegetation Aluminum (610 shrew Aluminum (213) cottontail	
Pad 51	Arsenic (8) shrew Arsenic (5) cottontail Arsenic (2) vegetation Arsenic (1) fox Cadmium (1) shrew Cadmium (1) robin Chromium (2) robin Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Aluminum (21) robin Aluminum (28) deer Aluminum (68) fox Chromium (40) worm Chromium (16) vegetation Lead (19) robin	Aluminum (256) vegetation Aluminum (629) shrew Aluminum (219) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 52	Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) fox Arsenic (1) vegetation Chromium (2) robin Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Aluminum (19) robin Aluminum (25) deer Aluminum (60) fox Chromium (34) worm Chromium (13) vegetation Lead (18) robin	Aluminum (226) vegetation Aluminum (556) shrew Aluminum (194) cottontail	
Pad 53	Arsenic (8) shrew Arsenic (4) cottontail Arsenic (1) fox Arsenic (1) vegetation Chromium (2) robin Lead (1) shrew Zinc (4) hawk Zinc (4) owl Zinc (4) robin Zinc (1) vegetation	Aluminum (24) robin Aluminum (32) deer Aluminum (78) fox Cadmium (30) robin Cadmium (27) shrew Cadmium (20) vegetation Chromium (40) worm Chromium (16) vegetation Lead (27) robin	Aluminum (292) vegetation Aluminum (718) shrew Aluminum (250) cottontail	
Pad 54	Arsenic (8) shrew Arsenic (4) cottontail Arsenic (2) vegetation Arsenic (1) fox Cadmium (1) shrew Cadmium (1) robin Chromium (2) robin Lead (2) shrew Zinc (4) hawk Zinc (4) owl Zinc (4) robin Zinc (1) vegetation	Aluminum (19) robin Aluminum (26) deer Aluminum (62) fox Chromium (35) worm Chromium (14) vegetation Lead (41) robin	Aluminum (570) shrew Aluminum (232) vegetation Aluminum (199) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
Pad 55	Arsenic (5) shrew Arsenic (3) cottontail Chromium (1) robin Thallium (3) cottontail Thallium (1) vegetation Zinc (2) robin Zinc (2) hawk Zinc (2) owl	Aluminum (14) robin Aluminum (18) deer Aluminum (44) fox Chromium (25) worm Chromium (10) vegetation Lead (13) robin Thallium (49) shrew Thallium (24) fox	Aluminum (165) vegetation Aluminum (407) shrew Aluminum (142) cottontail	
Pad 56	Arsenic (6) shrew Arsenic (4) cottontail Arsenic (1) vegetation Chromium (2) robin Lead (3) shrew Selenium (1) shrew Selenium (1) vegetation Zinc (3) hawk Zinc (3) owl Zinc (3) robin Zinc (1) vegetation	Aluminum (16) robin Aluminum (21) deer Aluminum (50) fox Chromium (39) worm Chromium (16) vegetation Lead (57) robin	Aluminum (186) vegetation Aluminum (458) shrew Aluminum (160) cottontail	
Pad 57	Pad does not exist and no assessment was needed			
Pad 58	Antimony (9) shrew Antimony (6) cottontail Antimony (3) vegetation Antimony (1) deer Arsenic (6) cottontail Arsenic (2) fox Arsenic (2) vegetation Barium (2) robin Barium (1) shrew Cadmium (4) cottontail	Aluminum (27) robin Aluminum (35) deer Aluminum (85) fox Arsenic (11) shrew Chromium (27) robin Copper (13) worm Lead (63) shrew Lead (20) vegetation Thallium (15) shrew Zinc (44) hawk	Aluminum (322) vegetation Aluminum (791) shrew Aluminum (276) cottontail Cadmium (242) robin Cadmium (212) shrew Cadmium (160) vegetation Chromium (473) worm Chromium (189) vegetation	Lead (1300) robin

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Cadmium (4) worm Cadmium (3) fox Cadmium (2) hawk Cadmium (2) owl Cadmium (1) deer Chromium (2) hawk Chromium (1) owl Copper (7) vegetation Copper (3) robin Copper (3) shrew Copper (2) cottontail Lead (5) hawk Lead (4) owl Lead (3) cottontail Lead (2) worm Mercury (4) vegetation Mercury (3) hawk Mercury (2) owl Nickel (1) vegetation Silver (3) vegetation Thallium (7) fox Thallium (1) cottontail Zinc (5) fox Zinc (4) worm Zinc (2) shrew	Zinc (40) robin Zinc (15) vegetation Zinc (41) owl		
Pad 59	Antimony (6) vegetation Antimony (3) deer Antimony (2) fox Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) fox Arsenic (1) vegetation	Aluminum (24) robin Aluminum (31) deer Aluminum (75) fox Antimony (19) shrew Antimony (12) cottontail Chromium (60) vegetation Lead (54) shrew	Aluminum (284) vegetation Aluminum (698) shrew Aluminum (244) cottontail Chromium (150) worm	Lead (1120) robin

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Cadmium (7) robin Cadmium (6) shrew Cadmium (5) vegetation Chromium (8) robin Copper (1) vegetation Copper (2) worm Lead (4) owl Lead (4) hawk Lead (2) worm Lead (2) cottontail Selenium (1) shrew Selenium (1) vegetation Silver (1) vegetation Thallium (6) fox Zinc (7) fox Zinc (5) worm Zinc (3) shrew	Lead (18) vegetation Thallium (12) shrew Zinc (60) hawk Zinc (55) owl Zinc (54) robin Zinc (21) vegetation		
Pad 60	Antimony (7) cottontail Antimony (4) vegetation Antimony (2) deer Antimony (1) fox Arsenic (7) shrew Arsenic (4) cottontail Arsenic (1) fox Arsenic (1) vegetation Barium (3) robin Barium (3) shrew Barium (2) cottontail Cadmium (2) fox Cadmium (2) cottontail Cadmium (2) worm Chromium (6) robin	Aluminum (54) robin Aluminum (72) deer Antimony (12) shrew Cadmium (86) vegetation Chromium (41) vegetation Copper (82) worm Copper (41) vegetation Copper (20) shrew Copper (17) robin Copper (11) cottontail Lead (43) vegetation Lead (10) hawk Thallium (11) shrew Zinc (72) vegetation Zinc (25) fox	Aluminum (655) vegetation Aluminum (561) cottontail Aluminum (174) fox Cadmium (129) robin Cadmium (113) shrew Chromium (103) worm Lead (132) shrew Zinc (207) hawk Zinc (189) owl Zinc (186) robin	Aluminum (1610) shrew Lead (2730) robin

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Copper (6) fox Copper (3) deer Copper (2) hawk Copper (2) owl Lead (9) owl Lead (5) cottontail Lead (4) worm Lead (2) fox Nickel (1) vegetation Selenium (2) shrew Selenium (2) vegetation Selenium (2) robin Silver (3) vegetation Thallium (6) fox Zinc (2) cottontail	Zinc (18) worm Zinc (10) shrew		
Pad 61	Arsenic (1) fox Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (7) shrew Barium (1) cottontail Barium (2) robin Barium (2) shrew Cadmium (1) hawk Cadmium (2) fox Cadmium (3) cottontail Cadmium (3) worm Chromium (4) robin Copper (1) cottontail Copper (2) robin Copper (2) shrew Copper (5) vegetation Lead (2) hawk	Aluminum (19) robin Aluminum (26) deer Aluminum (62) fox Chromium (29) vegetation Chromium (73) worm Copper (10) worm Lead (24) shrew Thallium (11) shrew Zinc (10) worm Zinc (13) fox Zinc (38) vegetation Zinc (99) robin	Cadmium (105) vegetation Cadmium (139) shrew Aluminum (234) vegetation Aluminum (575) shrew Aluminum (200) cottontail Cadmium (159) robin Lead (499) robin Zinc (101) owl Zinc (111) hawk	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Lead (2) owl Lead (8) vegetation Nickel (3) vegetation Selenium (2) robin Selenium (3) shrew Selenium (2) vegetation Thallium (6) fox Zinc (1) cottontail Zinc (6) shrew			
Pad 62	Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (6) shrew Barium (1) cottontail Barium (2) robin Barium (2) shrew Chromium (3) robin Copper (1) vegetation Copper (3) worm Lead (1) cottontail Lead (2) hawk Lead (2) owl Selenium (1) shrew Selenium (1) vegetation Thallium (6) fox Zinc (3) shrew Zinc (6) worm Zinc (8) fox 2,4,6-Trinitrotoluene (1) vegetation 2,4,6-Trinitrotoluene (2) deer 2,4,6-Trinitrotoluene (3) fox 2,4,6-Trinitrotoluene (6) cottontail 2,4,6-Trinitrotoluene (6) shrew	Aluminum (21) robin Aluminum (27) deer Aluminum (66) fox Cadmium (16) vegetation Cadmium (21) shrew Cadmium (24) robin Chromium (22) vegetation Chromium (55) worm Lead (10) vegetation Lead (30) shrew Thallium (12) shrew Zinc (24) vegetation Zinc (62) owl Zinc (62) robin Zinc (69) hawk RDX (17) cottontail RDX (17) shrew	Aluminum (249) vegetation Aluminum (613) shrew Aluminum (214) cottontail Lead (611) robin	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	HMX (3) deer HMX (4) fox HMX (7) cottontail HMX (7) shrew RDX (2) vegetation RDX (6) deer RDX (9) fox			
Pad 63	Arsenic (1) fox Arsenic (2) vegetation Arsenic (4) cottontail Arsenic (8) shrew Cadmium (1) shrew Cadmium (1) vegetation Cadmium (2) robin Chromium (3) robin Lead (1) vegetation Lead (4) shrew Selenium (1) robin Selenium (2) shrew Selenium (2) vegetation Zinc (1) worm Zinc (2) fox Zinc (6) vegetation	Aluminum (24) robin Aluminum (32) deer Aluminum (76) fox Chromium (20) vegetation Chromium (50) worm Lead (73) robin Zinc (17) hawk Zinc (15) owl Zinc (15) robin	Aluminum (286) vegetation Aluminum (703) shrew Aluminum (245) cottontail	
Pad 64	Arsenic (1) fox Arsenic (2) vegetation Arsenic (4) cottontail Arsenic (8) shrew Barium (1) robin Barium (1) shrew Chromium (2) robin Lead (2) shrew	Aluminum (19) robin Aluminum (25) deer Aluminum (60) fox Chromium (13) vegetation Chromium (33) worm Lead (41) robin Thallium (67) shrew Thallium (33) fox	Aluminum (226) vegetation Aluminum (556) shrew Aluminum (194) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Thallium (2) vegetation Thallium (5) cottontail Zinc (1) vegetation Zinc (4) hawk Zinc (4) owl Zinc (4) robin			
Pad 65	Arsenic (1) fox Arsenic (2) vegetation Arsenic (5) cottontail Arsenic (9) shrew Barium (1) robin Barium (1) shrew Chromium (3) robin Lead (3) shrew Zinc (1) fox Zinc (3) vegetation Zinc (9) owl Zinc (9) robin	Aluminum (29) robin Aluminum (39) deer Aluminum (93) fox Chromium (23) vegetation Chromium (58) worm Lead (63) robin Zinc (10) hawk	Aluminum (350) vegetation Aluminum (861) shrew Aluminum (300) cottontail	
Pad 66	Antimony (1) vegetation Antimony (3) cottontail Antimony (5) shrew Arsenic (1) fox Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (8) shrew Barium (6) fox Barium (8) deer Chromium (3) robin Copper (1) deer Copper (3) fox Copper (5) cottontail	Aluminum (24) robin Aluminum (31) deer Aluminum (75) fox Barium (16) vegetation Barium (38) cottontail Barium (54) shrew Barium (56) robin Cadmium (10) vegetation Cadmium (13) shrew Cadmium (15) robin Chromium (21) vegetation Chromium (53) worm Copper (10) shrew	Aluminum (283) vegetation Aluminum (696) shrew Aluminum (243) cottontail 2,4,6-Trinitrotoluene (127) vegetation 2,4,6-Trinitrotoluene (706) shrew 2,4,6-Trinitrotoluene (709) cottontail 2,4,6-Trinitrotoluene (268) deer 2,4,6-Trinitrotoluene (361) fox	Lead (1280) robin

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Copper (8) robin Lead (2) worm Lead (3) cottontail Lead (4) owl Lead (5) hawk Selenium (1) shrew Selenium (1) vegetation Thallium (1) cottontail Thallium (9) fox Zinc (3) shrew Zinc (5) worm Zinc (7) fox 1,3,5-Trinitrobenzene (3) fox HMX (3) deer HMX (4) fox HMX (8) cottontail RDX (2) deer RDX (3) fox RDX (6) cottontail HMX (8) shrew RDX (6) shrew	Copper (19) vegetation Copper (38) worm Lead (20) vegetation Lead (62) shrew Thallium (18) shrew Zinc (21) vegetation Zinc (54) robin Zinc (55) owl Zinc (60) hawk 1,3-Dinitrobenzene (26) deer 1,3-Dinitrobenzene (35) fox 1,3-Dinitrobenzene (68) cottontail 1,3-Dinitrobenzene (68) shrew 2,4,6-Trinitrotoluene (27) worm		
Pad 67	Antimony (1) shrew Arsenic (1) fox Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (7) shrew Barium (2) deer Barium (2) fox Barium (5) vegetation Cadmium (1) shrew Cadmium (2) robin Chromium (2) robin	Aluminum (21) robin Aluminum (28) deer Aluminum (68) fox Barium (11) cottontail Barium (16) robin Barium (16) shrew Chromium (17) vegetation Chromium (43) worm Lead (52) robin Thallium (12) shrew HMX (78) deer	Aluminum (257) vegetation Aluminum (631) shrew Aluminum (220) cottontail 2,4,6-Trinitrotoluene (113) vegetation 2,4,6-Trinitrotoluene (240) deer 2,4,6-Trinitrotoluene (323) fox 2,4,6-Trinitrotoluene (631) shrew 2,4,6-Trinitrotoluene (634) cottontail HMX (106) fox HMX (207) shrew HMX (208) cottontail	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Copper (1) worm Lead (3) shrew Selenium (1) robin Selenium (1) shrew Selenium (1) vegetation Thallium (6) fox Zinc (7) owl Zinc (7) robin Zinc (8) hawk Zinc (3) vegetation 1,3-Dinitrobenzene (8) deer	RDX (60) vegetation 1,3,5-Trinitrobenzene (15) fox 1,3-Dinitrobenzene (10) fox 1,3-Dinitrobenzene (20) cottontail 1,3-Dinitrobenzene (20) shrew 2,4,6-Trinitrotoluene (24) worm	RDX (229) fox RDX (446) shrew RDX (448) cottontail RDX (169) deer	
Pad 68	Antimony (2) deer Antimony (2) fox Antimony (5) vegetation Arsenic (1) fox Arsenic (2) vegetation Arsenic (5) cottontail Arsenic (9) shrew Barium (8) fox Cadmium (8) vegetation Chromium (4) robin Copper (2) vegetation Copper (4) worm Lead (1) worm Lead (2) cottontail Lead (3) hawk Lead (3) owl Mercury (1) robin Mercury (3) hawk Mercury (3) owl Mercury (4) vegetation Selenium (1) shrew	Aluminum (22) robin Aluminum (29) deer Aluminum (68) fox Antimony (10) cottontail Antimony (16) shrew Barium (11) deer Barium (21) vegetation Barium (51) cottontail Barium (72) shrew Barium (75) robin Cadmium (11) shrew Cadmium (13) robin Chromium (29) vegetation Chromium (72) worm Lead (13) vegetation Lead (39) shrew Thallium (19) fox Thallium (39) shrew Zinc (21) vegetation Zinc (54) robin Zinc (55) owl	Aluminum (259) vegetation Aluminum (636) shrew Aluminum (222) cottontail Lead (813) robin	

Table 7-13. Summary of Surface Soil Ecological COPCs (HQs >1) for WBG (continued)

Location	Range of Hazard Quotients			
	1-9	10-99	100-999	> 1,000
	Selenium (1) vegetation Thallium (1) vegetation Thallium (3) cottontail Zinc (3) shrew Zinc (5) worm Zinc (7) fox 2,4,6-Trinitrotoluene (3) cottontail 2,4,6-Trinitrotoluene (3) shrew 2,4,6-Trinitrotoulene (1) deer 2,4,6-trinitrotoulene (2) fox Tetryl (2) cottontail Tetryl (2) shrew	Zinc (60) hawk		
Pad 69	Arsenic (1) vegetation Arsenic (3) cottontail Arsenic (6) shrew Chromium (1) robin Lead (1) shrew Zinc (1) vegetation Zinc (3) hawk Zinc (3) owl Zinc (3) robin	Aluminum (12) robin Aluminum (16) deer Aluminum (39) fox Chromium (10) vegetation Chromium (26) worm Lead (25) robin	Aluminum (148) vegetation Aluminum (365) shrew Aluminum (127) cottontail	
Pad 70	Arsenic (1) vegetation Arsenic (4) cottontail Arsenic (7) shrew Chromium (3) robin Lead (1) shrew Thallium (2) vegetation Thallium (5) cottontail Zinc (2) vegetation Zinc (4) robin Zinc (5) hawk Zinc (5) owl	Aluminum (23) robin Aluminum (31) deer Aluminum (74) fox Chromium (20) vegetation Chromium (51) worm Lead (29) robin Thallium (33) fox Thallium (67) shrew	Aluminum (280) vegetation Aluminum (689) shrew Aluminum (240) cottontail	

Table 7-14. Overview of Degrees of Ecological Risk at WBG

Degree of ecological risk on a pad basis				
Low (HQ = 1 to 99)	Intermediate (HQ = 100 to 999)			High (HQ = 1000)
	Aluminum driven		Other	
4	1	34	8	32
	2	35	40	37
	3	36	45	38
	5	39	61	58
	6	41	62	59
	7	43	67	60
	14	44	68	66
	15	46		
	16	47		
	17	48		
	18	49		
	19	50		
	20	51		
	23	52		
	24	53		
	25	54		
	26	55		
	27	56		
	28	63		
	29	64		
	30	65		
	31	69		
	33	70		

Pads not assessed, mostly because they do not exist: #9, 10, 11, 12, 13, 21, 22, 42, 57

Another seven pads show intermediate ecological risk (range of HQs = 100 to 1000) (**Table 7-15**). They are Pads #8, 40, 45, 61, 62, 67, and 68. Overall, the inorganic COPECs are aluminum, cadmium, lead, thallium, and zinc. Organic COPECs are 2,4,6-TNT, HMX, and RDX. The following represents ecological COPCs with HQs of 100 to 1000. See Table 7-14 for the COPECs with HQs >1.

- Pad #8 shows aluminum and thallium;
- Pad #40 shows aluminum and lead;
- Pad #45 shows aluminum and lead;
- Pad #61 shows aluminum, cadmium, lead, and zinc;
- Pad #62 shows aluminum and lead;
- Pad #67 shows aluminum, 2,4,6-TNT, HMX and RDX; and
- Pad #68 shows aluminum and lead.

Of the 61 total pads, seven show high ecological risk (range of HQs = 1000 or more) (**Table 7-16**). They are Pads #32, 37, 38, 58, 59, 60, and 66. Overall, the inorganic COPECs are aluminum, cadmium, and lead for HQs >1000. Additional or corroborative inorganic COPECs (range of HQs = 100 to 1000) include chromium and zinc. The additional or corroborative organic COPEC is 2,4,6,-TNT. The following represents COPECs with HQs greater than 1000. See Table 7-14 for the ecological COPCs with HQs >1.

- Pad #32 shows aluminum;
- Pad #37 shows aluminum;
- Pad #38 shows aluminum and cadmium;
- Pad #58 shows lead;
- Pad #59 shows lead;
- Pad #60 shows aluminum and lead; and
- Pad #66 shows lead.

Figure 7-7 provides a visual version of the pad-by-pad findings.

Sediment (Appendix Tables L-569 to L-574). Ecological risk from wet sediment (the creek) is associated with twelve COPECs above an HQ of 1: arsenic (HQ of 2), copper (3), manganese (2), nickel (2), zinc (1), acetone (2), benzo(*a*)anthracene (2), benzo(*a*)pyrene (1), chrysene (2), fluoranthene (2), pyrene (2), and phenanthrene (1). For dry sediment in the ditches, the COPECs are arsenic (HQ of 3), copper (1), manganese (2), and nickel (2). **Table 7-17** summarizes this.

Surface water (Appendix Tables L–575 to L-577). There was no ecological risk in the water at Mack's Pond. **Table 7-17** summarizes this.

7.6.2 Future Preliminary Risk to Ecological Receptors

The HQs for the animals at the WBG are assumed to be the same or similar in the future. True, plant and animal species and densities will change through ecological succession. However, the conservative nature of the screening ERA masks these changes and such distinctions are part of the next stage or baseline ERA. The lack of toxicity thresholds for a few of the organic COPECs contributes to the uncertainty of any assessment of the risk to future animals at the exposure unit. Some organic COPECs would be expected to decrease in concentration through natural degradation processes, although their number and concentration of breakdown products could increase. Regardless, risks in the future are assumed to be the same or similar to risks in the current condition at the WBG. In other words, it is not likely that the conservative-based risk would be any greater, regardless of time frame.

Table 7-15. Overview of Ecological Risk of the Non-Exclusive Aluminum Intermediate Risk at WBG

Intermediate		Intermediate	
PAD	**COPC (HQ) receptor**	**PAD**	**COPC (HQ) receptor**
8	Aluminum (168) vegetation	62	Aluminum (249) vegetation
	Aluminum (414) shrew		Aluminum (613) shrew
	Aluminum (144) cottontail		Aluminum (214) cottontail
	Thallium (109) shrew		Lead (611) robin
40	Aluminum (218) vegetation	67	Aluminum (257) vegetation
	Aluminum (536) shrew		Aluminum (631) shrew
	Aluminum (187) cottontail		Aluminum (220) cottontail
	Lead (240) robin		2,4,6-Trinitrotoluene (113) vegetation
			2,4,6-Trinitrotoluene (240) deer
45	Aluminum (198) vegetation		2,4,6-Trinitrotoluene (323) fox
	Aluminum (487) shrew		2,4,6-Trinitrotoluene (631) shrew
	Aluminum (170) cottontail		2,4,6-Trinitrotoluene (634) cottontail
	Lead (399) robin		HMX (106) fox
			HMX (207) shrew
61	Cadmium (105) vegetation		HMX (208) cottontail
	Cadmium (139) shrew		RDX (229) fox
	Aluminum (234) vegetation		RDX (446) shrew
	Aluminum (575) shrew		RDX (448) cottontail
	Aluminum (200) cottontail		RDX (169) deer
	Cadmium (159) robin		
	Lead (499) robin	68	Aluminum (259) vegetation
	Zinc (101) owl		Aluminum (636) shrew
	Zinc (111) hawk		Aluminum (222) cottontail
			Lead (813) robin

Table 7-16. Overview of Ecological Risk of the Highest Risk Type (HQ>1000) at WBG

Highest HQs (>1000)		Additional or Corroborative HQs (100 to 1000)
Pad	**COPC (HQ) receptor**	**COPC (HQ) receptor**
32	Aluminum (1010) shrew	Aluminum (410) vegetation
		Aluminum (352) cottontail
		Aluminum (109) fox
37	Aluminum (1120) shrew	Aluminum (456) vegetation
	Lead (1890) robin	Aluminum (391) cottontail
		Aluminum (121) fox
38	Aluminum (1090) shrew	Aluminum (444) vegetation
	Cadmium (2650) robin	Aluminum (381) cottontail
	Cadmium (2320) shrew	Aluminum (118) fox
	Cadmium (1750) vegetation	Lead (521) robin
58	Lead (1300) robin	Aluminum (322) vegetation
		Aluminum (791) shrew
		Aluminum (276) cottontail
		Cadmium (242) robin
		Cadmium (212) shrew
		Cadmium (160) vegetation
		Chromium (473) worm
		Chromium (189) vegetation
59	Lead (1120) robin	Aluminum (284) vegetation
		Aluminum (698) shrew
		Aluminum (244) cottontail
		Chromium (150) worm
60	Aluminum (1610) shrew	Aluminum (655) vegetation
	Lead (2730) robin	Aluminum (561) cottontail
		Aluminum (174) fox
		Cadmium (129) robin
		Cadmium (113) shrew
		Chromium (103) worm
		Lead (132) shrew
		Zinc (207) hawk
		Zinc (189) owl
		Zinc (186) robin
66	Lead (1280) robin	Aluminum (283) vegetation
		Aluminum (696) shrew
		Aluminum (243) cottontail
		2,4,6-Trinitrotoluene (127) vegetation
		2,4,6-Trinitrotoluene (706) shrew
		2,4,6-Trinitrotoluene (709) cottontail
		2,4,6-Trinitrotoluene (268) deer
		2,4,6-Trinitrotoluene (361) fox

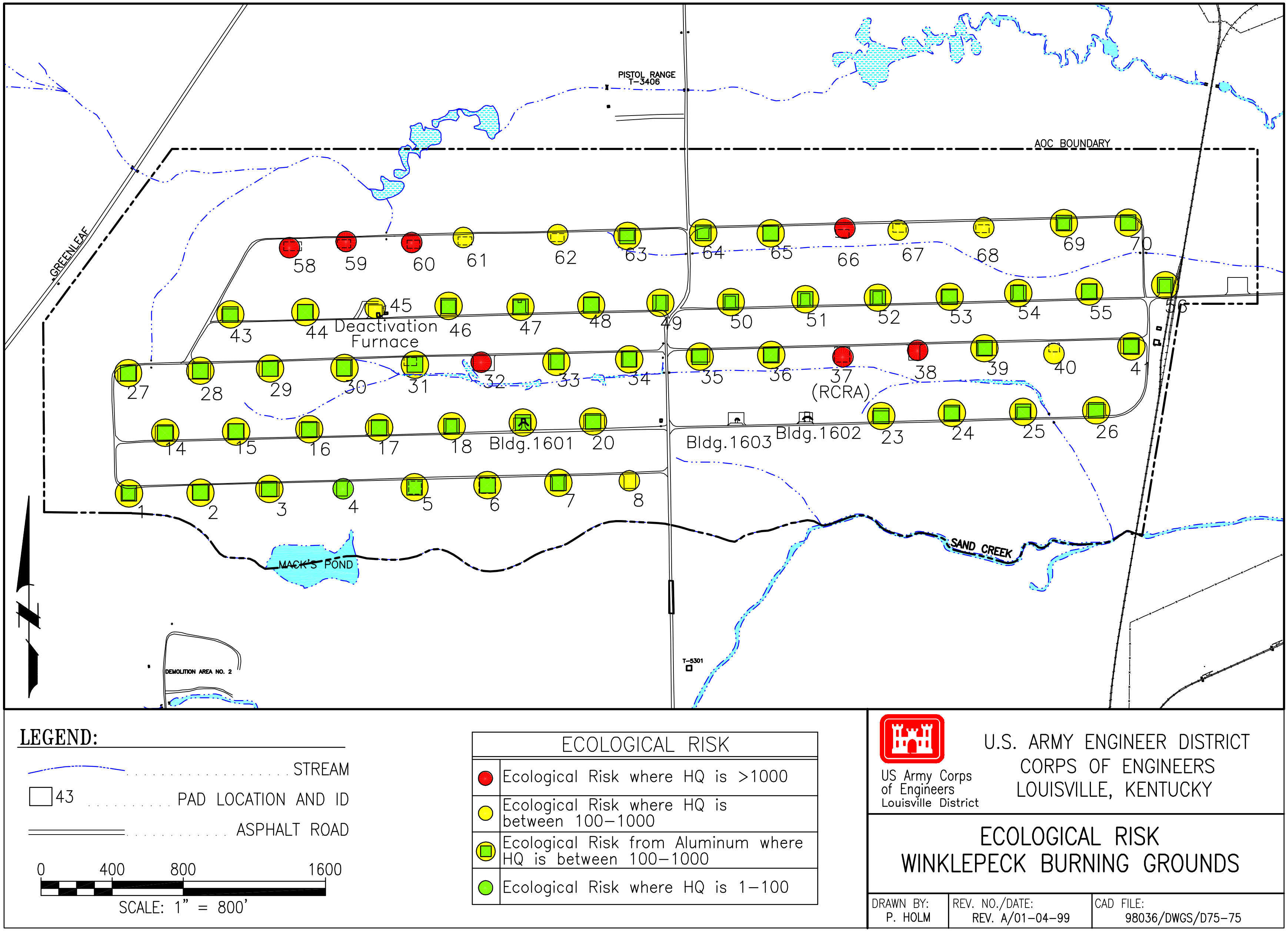

Figure 7-7. Ecological Risk Summary for Winklepeck Burning Grounds

Table 7-17. Summary of Sediment Ecological COPCs (HQ >1) for WBG

Medium	Range of RVAAP Sediment and Surface Water HQs >1			
	1 to 9	**10 to 999**	**100 to 999**	**>1,000**
Sediment Wet	Arsenic (2) Copper (3) Manganese (2) Nickel (2) Zinc (1) Acetone (2) Benzo(a)anthracene (2) Benzo(a)pyrene (1) Chrysene (2) Fluoranthene (2) Phenanthrene (1) Pyrene (2)			
Sediment Dry	Arsenic (3) Copper (1) Manganese (2) Nickel (2)			
Surface Water	None			

In the aquatic habitats, the ecological environment is expected to stay similar from year to year. True, water currents and sedimentation may vary from year to year, but the overall environment, including the low concentrations of COPCs near the burning grounds and low to no ecological risk are expected to characterize future conditions.

7.7 UNCERTAINTIES

Uncertainties in the WBG ERA are discussed in this section by the four interrelated steps of the EPA approach to ERA: problem formulation, exposure assessment, effects assessment, and risk characterization.

7.7.1 Problem Formulation

Environmental concentrations of constituents in the soil, sediment, and surface water at and near the WBG are 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 maximum detected concentration was used as the EPC concentration to calculate HQs, the estimates of risk from ecological COPCs 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.

There was a comparison of project quantitation limits to ecotox thresholds. The project quantitation limits for most of the 67 compared analytes were higher than the ecotox thresholds. For situations where the ecotox thresholds were lower than the project quantitation limits, the one sediment, eleven surface water, and no soil (comparison could not be made) mean that ecological risk could have been slightly greater than projected. Note that most differences were based on an ecotox threshold being about one-half of the project quantitation level.

The distribution and abundance of organisms comprising the ecological receptors at the WBG 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 are found at the WBG. On-site reconnaissance established the nature and quality of habitat and 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.

It is possible that one (or more) unobserved species at the WBG is more sensitive than those ecological receptors for which toxicity data were available for use in setting toxicity thresholds. It does not necessarily follow that these unevaluated species are at significantly greater risk of harmful ecological effects than that estimated in this ERA because exposure concentrations for ecological receptors could be greater than those for more sensitive receptors, and they could be generally overestimated.

7.7.2 Exposure Assessment

The movement of constituents from the WBG constituent source media to ecological receptors was not measured for this ERA. This introduces uncertainties about the actual modes and pathways of exposure and the actual exposure concentrations of these constituents to the ecological receptors. 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. These processes were not evaluated quantitatively in this ERA. Although bioaccumulation was estimated for those receptors ingesting food for which toxicity thresholds were available, it is possible that exposure to top predators is underestimated because the biomagnification of certain constituents in their prey was overlooked.

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

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

Limited biological activity occurs below 0.6 m (2 ft) in the soil. When chemical concentrations in the 0.6 m (2 ft) and lower depths exceed the chemical concentrations in the 0 to 0.6 m (0 to 2 ft) depth (which is not too often), then ecological risk may be underestimated. Finally, the exposure of plants and animals to constituents below detection limits is not considered in the ERA. In addition, the exposure of ecological receptors to tentatively identified compounds is not considered.

7.7.3 Effects Assessment

Toxicity thresholds were based on concentrations reported to have no or little effect on the test organism or were estimated conservatively from published toxicity data as provided in Appendix L. Dietary limits used as threshold levels for soils were derived from NOAELs or LOAELs using factors of 1 or 10 (Opresko, Sample, and Suter 1994) with 10 being the most conventional one. These thresholds would underestimate the risks only to organisms at sites at the WBG that are considerably more sensitive than the study organisms. They are more likely to overestimate the risk to organisms that are equally or less sensitive than the study organisms. The possibility remains that some thresholds were set at levels at or above which some harm would occur to organisms at the WBG.

The calculated risks to the ecological receptors at the WBG are the risks of individual constituents. The risks from exposure to multiple constituents depend on constituent interactions; effects could be greater or lesser than those from a single chemical. This ERA provides findings for COPEC-specific risk estimates. An evaluation of risk from chemical mixtures cannot be conducted without additional data and evaluation of alternative models of constituent interaction.

There are no available TRVs for some compounds, especially organics, for all ecological receptors considered. This, of course, contributes to uncertainty associated with likely underestimates of risk. This lack of data makes a chemical a COPC until it gets the HQ analysis. Then, it is dropped.

Additional uncertainty exists as to the pertinence of individual organism toxicity for characterizing the risk to populations and ecosystems. It is possible that populations may compensate for the loss of large numbers of juveniles or adults with increased survival or birth-rates, and habitats or ecosystems may possess functionally redundant species that are less sensitive to constituents. Although the WBG habitats surely possess these buffering mechanisms, a conservative approach is still justified to risk assessment based on organismal toxicity thresholds (i.e., NOAELs).

7.7.4 Risk Characterization

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

7.7.4.1 Off-site Risk

The risks to off-site receptors cannot be characterized without benefit of clearly identified pathways (especially any surface water pathways) as well as constituent tracer studies and off-site plant and animal and habitat surveys. Off-site receptors can be exposed to constituents via physical and organismal transport processes, but evaluating the magnitude of this exposure would require additional studies. It is unlikely that off-site receptors would have lower toxicity thresholds for constituents than the thresholds used for on-site receptors. In addition, there is little reason to expect that constituents migrating off site would be concentrated above measured concentrations at sites at the WBG unless a constituent bioconcentrates in organisms that move extensively on and off the site. In general, the risk to most off-site receptors is likely to be overestimated rather than underestimated by the risk estimate for on-site receptors.

7.7.4.2 Cumulative Risk

The ERA estimates the risk to populations of ecological receptors from individual constituents. Yet, in nature, receptors are exposed simultaneously to mixtures of chemicals. 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 sites at the WBG may underestimate actual risks to plants and animals from cumulative risks.

7.7.4.3 Future Risk

A third area of uncertainty in the ecological risk characterization is the future risk to the plants and animals from contamination at the WBG. The ERA characterizes the current risk based on chronic exposure to measured concentrations of toxicants with the potential to persist in the environment for extended periods of time. Risk quotients 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, a leaching to surface water or groundwater) or decrease (e.g., enhanced microbial degradation) the risk to future plants and animals at the sites.

7.7.4.4 Background Risk

Another source of uncertainty is ecological risk relative to background conditions. Although only inorganics with concentrations above background were examined in the ecological COPC screening, some ecological COPCs are above background only by a small amount, such that concentrations at a particular exposure location can be actually less than the background concentration. The conservative approach to comparing site concentrations to background likely overestimates the risk from ecological COPCs compared to background.

7.7.5 Summary

The most important uncertainties in the WBG ERA 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 or thresholds). These uncertainties arise from multiple sources, especially from the lack of site-specific data on constituent transport and transformation processes, organismal toxicity, animal behavior and diet, population dynamics, and the response of plant and animal populations to stressors in their environments. Despite these uncertainties, the available site-concentration data and published exposure and effects information allow COPECs (HQs >1) to be identified as risks characterized for each exposure location.

7.8 SUMMARY OF THE SCREENING OR PRELIMINARY ECOLOGICAL RISK ASSESSMENT

A screening ERA was performed in accordance with written guidance from the USACE (Louisville) and OEPA who may confer with EPA Region V. This guidance recognizes step-by-step procedures. The present ERA adheres to an ERA process that includes problem formulation, followed by exposure assessment and effects assessment, and culminating in risk characterization with attention to uncertainties and summarization. The ERA was the screening type.

The WBG covers about 81 ha (200 acres) of mostly natural and a few man-made habitats. Patches of forests and old fields of varying ages occupy the total area. The appearance of the abundant vegetation and various animal life suggest no immediate threat from acute nor chronic exposures. However, appearances are insufficient to identify field-observed effects and ecological risk. Thus, an ecological risk assessment is needed.

A screening step compared the measured maximum concentrations in sediment and surface water to a screening value. Analytes whose maximum concentrations exceeded toxicity values were called ecological COPCs, and there were several metals and a few explosives for soil and a few for sediment and surface water.

The current and future risks to ecological receptors from COPECs at the WBG and nearby aquatic exposure units were characterized by evaluating risk quotients according to ecological assessment endpoints as stated briefly above. Risk quotients are calculated for eleven different receptors for every COPEC for which a TRV or threshold concentration was available from published information. Each risk quotient compares two concentrations: the estimated COPEC concentration (EPC) in soil or other media or dietary dose from soil or other media to which a given receptor is exposed, and the TRV for the COPEC and receptor. The TRV is the dietary limit or other threshold concentration expected to cause no harm to the receptor, minimal harm with no ecological significance, or minimal harm to a community of organisms (i.e., assemblage of species) exposed to the COPEC in that medium. Thus, the TRV is a safe or protective concentration.

Of the many observed plant and animal taxa, five terrestrial classes (vegetation, soil-dwelling invertebrates, worm-eating and/or insectivorous mammals, mammalian herbivores, and terrestrial top predators) were selected for terrestrial receptors. For aquatic classes, sediment-dwelling organisms and aquatic organisms were selected. The studies directed by the Ohio National Guard about plants, small mammals and bats, and macroinvertebrates have contributed to the ability to recognize and use certain ecological receptors.

Risk quotients and HIs were calculated for COPECs at the surface soil and sediment/surface water exposure locations. Then, values (HQs >1) are summarized in **Table 7-13** on a location-by-location basis. Further, **Table 7-14** classifies the pads according to their HQs. **Table 7-15** emphasizes HQs of 100 to 999 on a pad-by-pad basis while **Table 7-16** emphasizes HQs >1000 on a pad-by-pad basis. The following is a summary of the COPCs for surface soil with the HQs >1:

- aluminum,
- arsenic,
- barium,
- cadmium,
- chromium,
- copper,
- lead,
- mercury,
- nickel,
- selenium,
- silver,
- thallium,
- zinc,
- 1,3-Dinitrobenzene,
- 1,3,5-Trinitrobenzene,
- 2,4,6-TNT,
- Di-*n*-butylphthalate,
- HMX,
- RDX, and
- Tetryl,

The COPECs with the highest HQs (up to 2730) were lead and cadmium.

Wet sediment in the small creek at WBG showed a few COPECs with HQs greater than 1 (**Table 7-17**):

- arsenic,
- copper,
- manganese,
- nickel,
- zinc,
- acetone,
- benzo(*a*)anthracene,
- benzo(*a*)pyrene,
- chrysene,
- fluoranthene,
- phenanthrene, and
- pyrene.

The COPEC with the highest HQ is copper (3), which is a rather low HQ.

Dry sediment in the dry ditches at WBG showed four COPECs (**Table 7-17**):

- arsenic,
- copper,
- manganese, and
- nickel.

The COPEC with the highest HQ is arsenic (3), which is a rather low HQ.

Surface water in the pond adjacent to WBG showed no COPECs with HQs >1.

In summary, ecological risk (HQ >1) from the screening ERA is present in surface soil at the site-wide level and at every individual pad. There is no ecological risk in the water sample from the pond. There is small ecological risk in the sediment. Again, the highest ecological risk is found in the surface soil and is associated with 14 of the 61 pads. The highest ecological risk is associated with cadmium and lead for inorganics, and 2,4,6-TNT and RDX for organics; however, screening-level ecological risk is rather extensive and has a number of sources, (i.e., contaminants). There is a need to better define this risk in the next phase — the baseline ERA.

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