FINAL

RVAAP Facility Wide Ecological Risk Work Plan

April 21, 2003

TABLE OF CONTENTS

TABLE OF CONTENTS (*continued*)

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADD	Average Daily Dose
AOC	Area of concern
ARAR	Applicable or relevant and appropriate requirement
AUF	Area Use Factor
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bgs	Below Ground Surface
BHHRA	Baseline Human Health Risk Assessment
BRA	Baseline Risk Assessment
BRACO	Base Realignment and Closure Office
BTF	Biotransfer Factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980.
CMS	Corrective Measures Study
CHPPM	Center for Health Promotion and Preventative Medicine
COEC	Constituent of Ecological Concern
COPC	Chemical of Potential Concern
COPEC	Constituent of Potential Ecological Concern
CRREL	Cold Regions Research and Engineering Laboratory (USACE)
DERR	Division of Emergency Remedial Response
DNT	dinitrotoluene
DOD	Department of Defense
DQO	Data Quality Objective
ECSM	Environmental Conceptual Site Model
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ESA	Endangered Species Act
EU	Exposure Unit
FSAP	Facility-wide Sampling and Analysis Plan
FSHP	Facility-wide Safety and Health Plan
FS	Feasibility Study
GOCO	Government-Owned, Contractor-Operated
GPD	Gallons per day
HEA	Health and Environmental Assessment
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	Hazard Quotient
IAP	Installation Action Plan
IRP	Installation Restoration Program
LL	Load Line
LOAEL	Lowest Observed Adverse Effect Level
LPD	Liters per day
MS	Matrix Spike
MSD	Matrix Spike Duplicate

ABBREVIATIONS (*continued*)

NEPA	National Environmental Policy Act
NFA	No Further Action
NOAEL	No Observed Adverse Effect Level
NWS	National Weather Service
OAC	Ohio Administrative Code
OHARNG	Ohio Army National Guard
ODOW	Ohio Department of Wildlife
OHEPA	Ohio Environmental Protection Agency
OHARNG	Ohio National Guard
OSC	On-Scene Coordinator
OSC	Operations and Support Command
PAS	Preliminary Assessment Screening
PA/SI	Preliminary Assessment/Site Investigation
PETN	Pentaerythrioltetranitrate
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action
RAI	Ravenna Arsenal Inc.
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDX	cyclotrimenthylenetrinitramine
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RMIS	Restoration Management Information System
RPM	Remedial Project Manager
RRSE	Relative Risk Site Evaluation
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SARA	Superfund Authorization
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
T&E	Threatened and Endangered
TNT	2, 4, 6-trinitrotoluene
TRV	Toxicity Reference Value
TUF	Temporal Use Factor
UCL_{95}	Upper 95% Confidence Limit
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEHA	U.S. Army Environmental Health Administration
USATHAMA	U.S Army Toxic and Hazardous Materials Agency

UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WBG	Winklepeck Burning Grounds
WP	Work Plan

1.0 INTRODUCTION

The Ravenna Army Ammunition Plant (RVAAP) has command organization from US Army Materiel Command; Engineering, Housing, Environmental and Installation Logistics, Environmental Quality Division. Additionally the Base Realignment and Closure Office (BRACO) with technical support from Army Environmental Center has authority over RVAAP's environmental restoration program. Said command utilizes an Installation Action Plan (IAP) to cover remedial investigations and clean up needed for closure of RVAAP. The purpose of the IAP is to outline the total multi-year restoration program for an installation. The IAP defines Installation Restoration Program (IRP) requirements and proposes a comprehensive approach and associated costs to conduct future investigations and remedial actions at each Area of Concern (AOC) at the installation and other areas of concern.

The IAP for the RVAAP coordinates planning information between IRP manager, major army commands (MACOMs), installations, executing agencies, regulatory agencies (Ohio EPA), and the public. The IAP is used to track requirements, schedules, and tentative budgets for RVAAP IRP.

Inherent to the IRP is the use of risk assessments as a decision making tool within the CERCLA and RCRA corrective action process. The RCRA and CERCLA ("Superfund") programs use different terminology, but follow parallel procedures in responding to releases. In both, the first step after discovery of a site is an examination of available data to identify releases needing further investigation. This step is called the Preliminary Assessment/Site Investigation in the CERCLA processes and a Preliminary Review (PR)/Visual Site Inspection (VSI) in the RCRA process. Both programs require an in-depth characterization of nature, extent, and rate of contaminant releases as they relate to human health and environmental risks.

> "A risk screening analysis is used during the PA/SI to determine whether a site may be eliminated from further concern or requires further study, which may be focused on specific areas of the site. The screening risk assessment developed during this phase should be conducted using conservative scenarios, as guided by the preliminary Environmental Conceptual Site Model, to ensure that any closeout decision at the PA/SI stage is protective. The PA/SI Ecological Risk Assessment screening study is not to be confused with Preliminary Natural Resource Surveys, which are simple screening studies, conducted by natural resource trustees in conjunction with a Natural Resource Damage Assessment. If release of hazardous substances appears to have resulted in natural resource damage, then Section 122(j) of the amended CERCLA requires Federal natural resource trustees to be notified." [USACE EM 200-1-4, 30 June 1996]

> "Risk assessment has been consistently used as a decision-making tool in one or more steps in the CERCLA and RCRA corrective action processes. A baseline Risk Assessment is conducted in the Remedial Investigation (CERCLA) or RCRA Facility Investigation (RFI) under RCRA. Section 105 of CERCLA/SARA charges the On-Scene Coordinator (OSC) or Remedial Project Manager (RPM) with the responsibilities of

identifying potential impacts on public health, welfare, and the environment, and setting priorities for this protection which is delegated to the Department of Defense (DOD) under Section 115 and Executive Order 12580 for DOD facilities. RCRA Section 3019 requires the facility owner/operator to submit an exposure information report, which provides exposure and health assessment information for certain storage and land disposal waste management units. In the RFI, as required by permit conditions or enforcement actions under RCRA Sections 3008(h), 7003, and/or 3013, health and environmental assessment (HEA) or BRA is used to determine quantitatively if the site or any of its units has exceeded established health criteria. As indicated in the RFI guidance (EPA 1989), a site-specific risk assessment will be performed prior to the CMS to assess potential risk to humans and to determine if no response action is appropriate. Under CERCLA Section 120, risk assessment is one of the primary documents identified for submission to EPA for comment and review in the Federal facility Agreement." [USACE EM 200-1-4, 30 June 1995]

The Preliminary Assessment for RVAAP identified past military/industrial activities including:

- Melt/pour load lines
- Fuze & booster burn pits
- Burning grounds
- Demolition areas
- Quarry landfill
- Sewage treatment plants
- Landfills
- Maintenance areas & waste oil tanks
- Buildings where PCB or pesticide storage occurred
- Buildings with sumps
- Fuze and booster lines
- Scrap areas,
- Ranges (*e.g.*, pistol and 40 mm Ranges)
- Burn pits and burn grounds; and
- Various dump areas.

1.1 FACILITY-WIDE DESCRIPTION

The Ravenna Army Ammunition Plant (RVAAP) is located in the northeastern Ohio within Portage and Trumbull counties, approximately 4.8 km (3 miles) east-northeast of the City of Ravenna and approximately 1.6 km (1 mile) northwest of the town of Newton Falls. The installation consists of 8668.3 ha (21,419 acres) contained in a 17.7-km (11-mile)-long, 5.6-km (3.5-mile)-wide tract bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; State Route 534 on the east; Garrettsville and Berry Roads on the west; and the CONRAIL Railroad on the north. The land use surrounding the installation is primarily rural with country-home residences. The installation is surrounded by several local communities: Windham, which borders on the installation to the north; Garrettsville, located 9.6 km (6 miles) to the northwest; Newton Falls, 1.6 km (1 mile) to the east; Charleston, bordering the southwest; and Wayland, 4.8 km (3 miles) to the southeast.

RVAAP was established on August 26, 1940 for the primary purpose of loading medium- and large-caliber artillery ammunition; bombs, mines; fuze and boosters; primers and percussion elements; and for the storage of finished ammunition components. Originally, the installation was divided into two separate units; one was designated as Portage Ordnance Depot with the primary mission of the depot's storage activity, and the other was designated as the Ravenna Ordnance Plant with the primary mission of the ammunition-loading activities.

Over the years, the Defense Logistics Agency at RVAAP handled and stored strategic and critical materials for various government agencies, whereas RVAAP received, stored, maintained, transported, and demilitarized military ammunition and explosive items. RVAAP maintained the capabilities to load, assemble, and pack military ammunition; however, these operations are inactive. As part of the RVAAP mission, the inactive facilities were maintained in a standby status by keeping equipment in a condition to permit resumption of production within the prescribed time limitations.

RVAAP is a Government-Owned, Contractor-Operated (GOCO) U.S. Army Operations Support Command (OSC) facility. Currently, RVAAP is an inactive facility maintained by a contractor caretaker, Tol-Test, Inc. of Toledo, Ohio. The Atlas Powder Company was the original GOCO manager of the Ravenna Ordnance Depot and operated the plant from 1940-1945; the government operated the Portage Ordnance Depot. The last production for World War II was in August 1945. The government assumed operations of both areas from 1945 to 1951 when Ravenna Arsenal Inc. (RAI), a subsidiary of the Firestone Tire and Rubber Co., Akron, Ohio, was contracted to operate the entire facility. In 1982, Physics International Co., a subsidiary of Rockcor Inc., purchased RAI from Firestone. Olin Corporation purchased Rockcor Inc. in June 1985. In May 1999, the Ohio Army National Guard (OHARNG) assumed administrative control over all but 1,481 acres at RVAAP. These 1,481 acres encompass the Areas of Concern (AOCs) and munitions storage areas and remain under control of the U.S. Army BRACO. A 2001 Memorandum of Agreement (MOA) concerning conditions for transfer of acreage was signed between OHARNG and Department of Army. In March of 2002 Amendment 1 to this MOA was signed by Army and OHARNG thus ratifying the agreement for transfer of remaining property.

A brief overview of the history of RVAAP is provided in a chronological order to provide a summary of the site's history.

Date	Description of Activity/Facility Status
1940	10,117.5 ha (25,000 acres) purchased by the United States Government. Began construction of the plant.
Sept 1940	Operated by Atlas Powder Company
Dec 1941 to	Facility completed and began operations. Primary mission was depot

Date	Description of Activity/Facility Status
Jan 1942	Storage and ammunition loading. Divide installation into two separate units: Portage Ordnance Depot – depot storage of munitions and components; Ravenna Ordnance Plant – loading ammunition
Aug 1943	Designated as the Ravenna Ordnance Center
Nov 1945	Designated as Ravenna Arsenal
1945	Turned over to Ordnance Department
1945-1949	Silas Mason Co. operated the ammonium nitrate line for the production of ammonium nitrate fertilizer.
1950	Plant placed on standby status. Operations limited to renovation, demilitarization, and normal maintenance of equipment and stored ammunition and components.
Apr 1951	RAI contracted to run the facility. Subsidiary of Firestone Tire and Rubber Co.
Jul 1954	Plum Brook Ordnance Works of Sandusky, Ohio, and the Keystone Ordnance Works of Meadville, Pennsylvania, were made satellites of Ravenna.
Aug 1957	All at-plant production ended.
Oct 1957	The installation was placed on standby status.
Mar 1958	Plum Brook Ordnance Works ceased to be under the jurisdiction of Ravenna.
Jul 1959	Keystone Ordnance Works was transferred to General Services Administration.
Oct 1960	Began rehabilitation work to replace facilities in the ammonium nitrate line for the processing and explosive melt-out of bombs.
Jan 1961	Operations began for the processing and explosive melt-out of bombs. Operation of this type was first in the ammunition industry.
Jul 1961	Plant again deactivated.

Date	Description of Activity/Facility Status
Nov 1961	Installation was divided into Ravenna Ordnance Plant and the industrial section. Entire facility was designated as the RVAAP.
May 1968	RVAAP reactivated in support of the Southeast Asian Conflict for loading, assembly, and packing munitions on three load lines and two component lines.
1971	Operations ceased at Load Lines 1,2,3, and 4.
Jun 1973 to Mar 1974	Deactivated major load lines and component line to demilitarization of the M7IA1 90 MM projectile.
Oct 1982	Physics International Company (a subsidiary of Rockcor Inc.) purchased Ravenna Arsenal Inc. from Firestone.
Jun 1985	Rockcor Inc. was purchased by Olin Corporation.
1992	The RVAAP mission was discontinued, placing the installation on the 'Inactive Maintained' status.
Mar 1993	Transfer of RVAAP from 'Inactive Maintained' to 'Inactive Modified-Caretaker' status.
Sept 1993	RVAAP was placed in 'Modified-caretaker' Status.
Sept 1993	Report of Excess determined the load lines and associated real estate as excess to the U.S. Army. The excess area includes approximately 2006.0 ha (4957 acres) and 362 buildings in Load Lines 1 through 12 (excluding 7 and 11), Area 4, and Area 8.
Oct 1993	Mason & Hanger-Silas Mason Co., Inc. took over as the installation's contractor modified caretaker.
Oct 1997	R&R International became the installation's contractor modified caretaker.
1998	Salvage and demolition operations commenced at RVAAP. Removal of the railroad ties and rails, copper wire, and excess metal for salvage was completed. Demolition of Load Lines 1, 2, and 12 commenced with complete or partial removal of transite (friable asbestos and concrete) siding and roofing.

Date	Description of Activity/Facility Status
May 1999	Administrative control of 16,164 acres of RVAAP was transferred to the Ohio Army National Guard for use in training and related activities. These parcels of land are outside any known areas of concern.
Feb 2000	Tol-Test, Inc. replaced R&R International as contractor-modified caretaker.
Dec 2001	MOA between Army and OHARNG developed for land transfer.
March 2002	Amendment 1 to MOA ratifying agreement for transfer of remaining property to OHARNG.

Although currently inactive, RVAAP has historically handled hazardous wastes and operated several waste management units in support of its operations. Materials of potentially hazardous nature were stored, treated, deposited in landfills, or burned at the facility.

The industrial operations at RVAAP consisted of 12 load lines. Load Lines 1 through 4 were used to melt and load trinitrotoluene (TNT) and Composition B into munitions. The operations on the Load Lines 1 through 4 produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floor and the walls would be hosed down with the water and steam cleaned. The liquid, containing TNT and Composition B constituents, would be collected in holding tanks, filtered, and pumped to one of the four settling ponds. Load Lines 5 through 11 were used to manufacture, fuzes, primers, and boosters while Load Line 12 housed the ammonium nitrate plant. Potential contaminants in Lines 5 through 11 included lead azide, lead styphnate, black powder, TNT, Composition B and Pentaerythrioltetranitrate (PETN). Load Line 12 was operated to produce ammonium nitrate for explosives and fertilizers. According to the plant documentation, all residual dust and spills were washed into the storm drainage system.

Landfills at RVAAP were used to bury waste from industrial operations and sanitary sources. In addition, burial sites may also be located on-site based on historical information. Potential contaminants from these areas include, but are not limited to: explosive compounds, explosive wastes, mustard agent, metals, sodium chloride, and calcium chloride.

Settling and retention ponds at the facility collected wastewater from munitions wash down operations at various facilities. Potential contaminants associated with the settling and retention ponds include, but are not limited to, explosive compounds, aluminum chloride, metals, and heavy metals.

RVAAP had several areas associated with the burning, demolition, and testing of various munitions. These burning grounds and demolition areas consisted of large areas of land or abandoned quarries for these activities. Potential contaminants at these sites include, but are not limited to, explosives [cyclonite [hexahydro-1,3,5-trinitro-1,3,5-triazine](RDX), octahydro-

1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), Composition B, TNT, black powder] white phosphorous, antimony sulfide, lead azide, propellant, waste oils, heavy metals, sludge from load lines, various laboratory chemicals, and sanitary waste.

RVAAP has various industrial operations that have been identified as potential sources of contaminants. These operations include sewage treatment, wastewater treatment, vehicle maintenance, storage tanks, waste storage areas, equipment storage areas, furnaces, and evaporation units. Contaminants associated with these operations include, but are not limited to, explosives, lead azide, lead styphnate, metals, heavy metals, polychlorinated biphenyls (PCBs), waste oil, and petroleum.

1.2 ENVIRONMENTAL SETTING

1.2.1 CLIMATIC CONDITIONS

The general climate of the RVAAP area is continental and is characterized by moderately warm and humid summers, reasonably cold and cloudy winters, and wide variations in precipitation from year to year. The following climatological data were obtained from the National Weather Service Office (NWS 1995) at the Youngstown-Warren Regional Airport located in Trumbull County and are based on a 30-year average.

Total annual rainfall in the RVAAP area is approximately 93.25 cm (37.3 inches), with the highest monthly average occurring in July [10.2 cm (4.07 inches)] and the lowest monthly average occurring in February [5.0 cm (2.03 inches)]. Average annual snowfall totals approximately 140.5 cm (56.2 inches) with the highest monthly average occurring in January [32.2 cm (12.9 inches)]. It should be noted that due to the influence of lake-effect snowfall events associated with Lake Erie [located approximately 56.3 km (35 miles) to the northwest of RVAAP], snowfall totals vary widely throughout northeastern Ohio.

The average annual daily temperature in the RVAAP area is 48.3 °F, with an average daily high temperature of 57.7 °F and an average daily low temperature of 38.7 °F. The record high temperature of 100 °F occurred in July 1988, and the record low temperature of -22 °F occurred in January 1994. The prevailing wind direction at RVAAP is from the southwest, with the highest average wind speed occurring in January [18.7 km (11.6 miles) per hour] and the lowest average wind speed occurring in August [11.9 km (7.4 miles) per hour].

Thunderstorms occur on approximately 35 days per year and are most abundant from April through August. The RVAAP area is susceptible to tornadoes; minor structural damage to several buildings on facility property occurred as the result of a tornado in 1985.

1.2.2 GEOLOGIC SETTING

1.2.2.1 Unconsolidated Deposits

Two glacial advances during the Wisconsin Age of the Pleistocene Epoch resulted in the deposition of glacial till over the entire RVAAP installation. The first glacial advance deposited the Lavery Till over the facility. The Lavery Till consists mostly of clay and silt with a few cobbles and sporadic boulders. The second glacial advance deposited the Hiram Till over the eastern two-thirds of the facility only. The Hiram Till consists of 12% sand, 41% silt, and 47% illite and chlorite clay minerals, and ranges in depth from 1.5 to 4.6 m (5 to 15 feet) below ground surface (bgs). The Hiram Till overlies thin beds of sandy outwash material in the far northeastern corner of the facility. Field observations indicate that overall till thickness is less than 0.6 m (2 feet) in some areas of the RVAAP facility. The reduced till thickness may be due to natural erosion or construction grading operations and is not necessarily the result of deposition.

In the central portion of the facility, oriented in a southwest–northeast direction, is located glacial outwash consisting of poorly sorted clay, till, gravel, and silty sand. Depths of unconsolidated sediments range from 30.5 to 61 m (100 to 200 feet) BGS.

1.2.2.2 Bedrock

The bedrock geology of RVAAP consists of Carboniferous Age sedimentary rocks that lie stratigraphically beneath the glacial deposits of the Lavery and Hiram tills. The oldest bedrock within the facility is the Cuyahoga Formation of the Mississippian Age. Three members comprise this formation: (1) the Orangeville Shale, (2) the Sharpsville Sandstone, and (3) the Meadville Shale. The Cuyahoga outcrops in the far northeastern corner of the facility and generally consists of blue-gray silty shale with interbedded sandstone. The regional dip of the Cuyahoga strata is between 1.5 to 3.0 m (5 to 10 feet) per mile to the south.

The remainder of the facility is underlain by bedrock associated with the Pottsville Formation of Pennsylvanian Age. The Pottsville Formation, which lies unconformably on an erosional surface of the Cuyahoga Formation, is divided into four members: (1) the Sharon, (2) the Connoquenessing Sandstone, (3) the Mercer, and (4) the Homewood Sandstone. The Sharon Member consists of two individual units: the Sharon Conglomerate and the Sharon Shale. The Sharon Conglomerate is a second cycle sedimentary rock, and pebbles are comprised of quartzite. The Sharon Conglomerate also has locally occurring thin shale lenses in the upper portion of the unit. Due to the differences in lithology between the Sharon Conglomerate and the underlying shales of the Cuyahoga Formation, the contact between the Pottsville and Cuyahoga Formations usually is quite distinct. The Sharon Shale overlies the Sharon Conglomerate and consists of sandy, gray-black, fissile shale with some plant fragments and thin flagstone beds. Sharon sandstones are exposed on the ground surface at Load Line 1 and the former Ramsdell Quarry.

The Connoquenessing Sandstone member of the Pottsville Formation unconformably overlies the Sharon Member and is a medium- to coarse-grained, gray-white sandstone with more feldspar and clay than the Sharon Conglomerate. Thin interbeds and partings of sandy shale also are common in the Connoquenessing. The Mercer member of Pottsville Formation overlies the Connoquenessing and consists of silty to carbonaceous shale with abundant thin, discontinuous sandstone lenses in the upper portion. Regionally, the Mercer also has been noted to contain interbeds of coal. The Homewood Member of the Pottsville Formation unconformably overlies the Mercer member and consists of coarse-grained crossbedded sandstones that contain discontinuous shale lenses.

The Connoquenessing, Mercer, and Homewood members are present only in the western half of the RVAAP facility. The Sharon Conglomerate unit is the upper bedrock surface in most of the eastern half. The regional dip of the Pottsville Formation strata is between 1.5 and 3.5 m (5 and 10 feet) per 1.6 km (1.0 mile) to the south.

1.2.3 HYDROLOGIC SETTING

1.2.3.1 Unconsolidated Sediments

The largest groundwater supplies within Portage County come from areas that underlie Franklin, Brimfield, and Suffield townships and Streetsboro, Shalersville, and Mantua townships, respectively. The unconsolidated units that consist of sand and gravel are favorably situated to receive recharge from surface streams and surface infiltration. These same areas are used as a source of drinking water for a good percentage of residents in the vicinity of RVAAP.

The water-bearing characteristics for the sand and gravel aquifers in the vicinity of the RVAAP installation are poorly documented. Wells that penetrate these aquifers can yield up to 6080 liters per minute (LPM) [1600 gallons per minute (GPM)]. However, yields from wells penetrating silty or clay till materials are significantly lower. In general, the Kent and Hiram tills are too thin and impermeable to produce useful quantities of water.

1.2.3.2 Bedrock

The most important bedrock sources of groundwater in the vicinity of the RVAAP facility are the sandstone/conglomerate members of the Pottsville Formation. These aquifers, together with two other deeper Mississippian/Devonian sandstone aquifers, represent the most important bedrock sources of groundwater in Northeastern Ohio.

The Sharon Conglomerate is the primary source of groundwater at RVAAP and maintains the most significant well yields of the Pottsville Formation members with hydraulic conductivity values of 19 to 7600 liters per day per meter (LPD/m) [5 to 2,000 gallons per day per foot (GPD/ft)]. Past studies of the Sharon Conglomerate indicate that the highest yields are associated with the true conglomerate phase (coarse-grained sandstone with abundant quartz pebbles) and with joints and fractures in the bedrock; however, there is no facility-specific information available regarding variations in aquifer properties due to these factors. Where present, the overlying Sharon Shale acts as a relatively impermeable confining layer for the Sharon Conglomerate. Several flowing artesian production wells have been noted at the facility.

The Connoquenessing Sandstone and the Homewood Sandstone are the remaining aquifers of the Pottsville Formation and exhibit hydraulic conductivities of 19 to 1140 LPD/m (5 to 300 GPD/ft) and 19 to 760 LPD/m (5 to 200 GPD/ft), respectively. Well yields in the Connoquenessing and

Homewood sandstones, although lower than the Sharon Conglomerate, are high enough to provide significant quantities of water. Several wells at the RVAAP facility have penetrated both the Sharon Conglomerate and the Connoquenessing Sandstone and reportedly produced water from both units.

In general, hydraulic conductivities in the shales of the Sharon and Mercer members of the Pottsville Formation are low and result in insignificant groundwater yields. The primary porosity of the shales is likely secondary, owing to joints and fractures in the bedrock; however, there is no facility-specific information available regarding the occurrence of joints and fractures in these units.

1.2.3.3 Groundwater Utilization

All groundwater utilized at the RVAAP facility during past operations was obtained from on-site production wells, with the large majority of wells screened in the Sharon Conglomerate. Production wells scattered throughout the facility provided necessary sanitary and process water for RVAAP operations. All remaining process production wells were permanently abandoned in 1992. Currently, two groundwater production wells remain in operation. These wells, located in the central portion of the facility, provide sanitary water to the remaining site personnel. Additionally, a production well, not in operation, is located at the former site of Building T-5301. This well will be activated per IRP needs, to include but not limited to, decon, water for bioremediation, and the like.

Residential groundwater use in the surrounding area is similar to that for RVAAP, with the Sharon Conglomerate acting as the major producing aquifer in the area. The Connoquenessing Sandstone and the Homewood Sandstone also provide limited groundwater resources, primarily near the western half of the RVAAP facility.

The *Ground Water Pollution Potential of Portage County* published by the Ohio Department of Natural Resources (1991) provides additional insight into the groundwater characteristics of the RVAAP area. This map indicates the relative vulnerability of groundwater in a specific area to contamination from surface sources. Intended primarily as a groundwater resource management and planning tool, the Ground Water Pollution Potential Map presents index values based on several hydrogeologic criteria including depth to water, hydraulic conductivity, topography, and others. Resulting index values range from a low pollution potential (zero) to a high pollution potential (200+).

Based on this mapping system, the majority of the RVAAP facility has a moderate pollution potential that ranges between 100 and 159, depending on location. In addition, three general hydrogeologic settings are defined for RVAAP and include: (1) glacial till overlying bedded sedimentary rock, (2) glacial till overlying sandstone, (3) and alluvium overlying bedded sedimentary rock. In general, the highest pollution potential values at RVAAP occur in the areas where alluvium overlies bedded sedimentary rock (index range of 140 to 159); however, these areas occur primarily in the northeast portion of the facility. The majority of RVAAP has pollution potential indices that range between 100 and 139.

1.2.3.4 Surface Water

The entire RVAAP facility is situated within the Ohio River Basin, with the West Branch of the Mahoning River representing the major surface stream in the area. The West Branch flows adjacent to the west end of the facility, generally in a north to south direction, before flowing into the M.J. Kirwan Reservoir, which is located to the south of State Route 5. The West Branch flows out of the reservoir along the southern facility boundary before joining the Mahoning River east of RVAAP.

The western and northern portions of the RVAAP facility display low hills and a dendritic surface drainage pattern. The eastern and southern portions are characterized by an undulating to moderately level surface, with less dissection of the surface drainage. The facility is marked with marshy areas and flowing and intermittent streams whose headwaters are located in the facility's hills. Three primary water courses drain RVAAP: (1) the South Fork of Eagle Creek, (2) Sand Creek, and (3) Hinkley Creek. All of these watercourses have many associated tributaries.

Sand Creek, with a drainage area of 36 km^2 (13.9 $miles^2$), flows generally in a northeast direction to its confluence with the South Fork of Eagle Creek. In turn, the South Fork of Eagle Creek then continues in a northerly direction for 4.3 km (2.7 miles) to its confluence with Eagle Creek. The drainage area of the South Fork of Eagle Creek is 67.8 km^2 (26.2 $miles^2$), including the area drained by Sand Creek. Hinkley Creek originates just southeast of the intersection between State Routes 88 and 303 to the north of the facility. Hinkley Creek, with a drainage area of 28.5 km^2 (11.0 $miles^2$), flows in a southerly direction through the installation to its confluence with the West Branch of the Mahoning River south of the facility.

Approximately 50 ponds are scattered throughout the installation. Many were built within natural drainage ways to function as settling ponds or basins for process effluent and runoff. Others are natural in origin, resulting from glacial action or beaver activity. All water bodies at RVAAP could support aquatic vegetation and biota. None of the ponds within the installation is used as a water supply source.

Storm water runoff is controlled primarily by natural drainage except in facility operations areas where an extensive storm sewer network helps to direct runoff to drainage ditches and settling ponds. In addition, the storm sewer system was one of the primary drainage mechanisms for process effluent during the period that production facilities were in operation.

1.2.3.5 Surface Water Utilization

Past and present surface water utilization at RVAAP generally was limited to use by wildlife and recreational users. Although some surface water may have been used intermittently for various facility operations, the vast majority of process water was provided by on-site groundwater production wells. There is no available documentation that indicates any past irrigation or other agricultural use of surface water sources on facility property. It is likely that some agricultural use of surface water was conducted in this area before facility construction due to the presence of homesteads and farms, with the assumption that surface water uses may have included livestock water sources at that time. On-site recreational surface water use was limited to manage fishing programs conducted in the past. Due to access limitations, fishing is not currently prevalent at RVAAP, however, based on the need and availability catch and release fishing may be an option for facility managers. Based on conversations with site personnel, it is likely that some recreational trespasser use of surface water does occur on a limited basis, primarily for fishing.

The major surface water drainages at RVAAP all exit facility property and eventually flow into the Mahoning River to the east. Surface water from Sand Creek, which flows to the northeast across the facility, joins the South Fork of Eagle Creek, which flows to the east inside the northern property boundary. The South Fork of Eagle Creek continues to the east until it eventually discharges to the Mahoning River. It is possible that limited agricultural and recreational use of the South Fork of Eagle Creek does occur off of facility property, although no data are available to allow a more detailed study. Hinkley Creek, which enters facility property from the north and flows to the south across the western portion of RVAAP, eventually discharges to the West Branch of the Mahoning River (and the West Branch Reservoir) south of State Route 5. It is doubtful that the Hinkley Creek is used for any agricultural purposes, although limited recreational use may occur.

1.2.4 Air Quality for Surrounding Area

The RVAAP facility is located in a rural area and has air quality that generally can be described as good. Currently, there are no significant airborne emissions from RVAAP due to its excess status. In addition, there is no operating air monitoring program in place at the facility at this time. There are no significant documented air pollution sources in close proximity to facility property that would affect air quality at RVAAP.

1.2.5 Site Use

Land use within the facility is restricted access industrial. At the present time, RVAAP is an excess status facility maintained by a contracted caretaker, TolTest, Inc. Site workers infrequently visit the AOCs for maintenance purposes, *e.g.*, mowing. The Ohio National Guard (OHARNG) also occupies parts of RVAAP and conducts training exercises. Personnel from OHARNG may occasionally travel through AOCs at RVAAP but generally restrict training to areas outside of AOCs. The land use immediately surrounding the facility is primarily rural. Approximately 55 percent of Portage County is either woodland or farmland (Portage County Soil and Water Conservation District Resources Inventory 1985: U.S. Census Bureau 1992). To the south of the facility is the Michael J. Kirwan Reservoir, which is used for recreational purposes. The reservoir is south of the site, across State Route 5. The reservoir is fed by the West Branch of the Mahoning River, which flows south along the western edge of the installation. Hinkley Creek flows south across the western portion of the facility and eventually flows into the West Branch of the Mahoning River. The major surface drainages at RVAAP-Sand Creek and South Fork Eagle Creek-exit the facility property and eventually flow east to the Mahoning River.

Residential groundwater use occurs outside the facility, with most of the residential wells tapping into either the Sharon Conglomerate or the surficial unconsolidated aquifer. Groundwater from on-site production wells was used during operations at the facility (USACE 1996); however, all but two production wells have been abandoned at the facility. These wells, located in the central portion of the facility, provide sanitary water to the facility. The Sharon Conglomerate is the major producing aquifer at the facility.

Currently surface water is primarily used by only wildlife. Based on conversations with site personnel, it is likely that some recreational trespasser use of the surface water occurs on a limited basis outside of the load lines, primarily associated with fishing. It is unlikely that any fishing occurs now or will in the future at load lines 2 and 3 since the drainage at the site are small and intermittent. Perennial surface water bodies are present at Load Line 4.

Future uses of RVAAP are currently being determined. Potential future uses include:

- Continued storage of bulk explosives (short term);
- Continued use of certain areas for training purposes by the OHARNG;
- Expanded training and occupancy by the OHARNG to encompass the entire facility (long term) >5 years; and
- Recreational use, *e.g.*, hunting, fishing, and hiking.

1.2.6 Ecological Setting

Available estimates indicate that approximately one-third of the RVAAP facility property meets the regulatory definition of a wetland, with the majority of the wetland areas located in the eastern portion of the facility, (OHARNG, 1997). Wetland areas at RVAAP include seasonal wetlands, wet fields, and forested wetlands. Many of the wetland areas are the result of natural drainage or beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas. In the summer of 2000, the OHARNG constructed mitigation wetlands in the western part of RVAAP. There is a potential for chemical releases in wetland areas at RVAAP from past practices of process effluent discharging to settling ponds and the natural drainage of the area in the past.

The flora and fauna present at RVAAP are varied and widespread. A total of 18 plant communities have been identified on facility property, including marsh, swamp, and forest communities (USACE, April 2001).

There are 14 plants and animals listed on the Ohio T & E list that have been identified at RVAAP, including:

- State Endangered
  - Northern harrier
  - Common barn owl
  - Yellow-belly sap sucker
  - Mountain brook lamprey
  - Graceful underwing
  - Ovate spikerush
  - Lurking leskea
  - Northern river otter
  - Little blue heron

  - American bittern
  - Canada warbler
  - Osprey
  - Trumpeter swan

- State Threatened
  - Simple willow-herb

Twelve plant types listed as State Potentially Threatened have been identified at RVAAP including:

- Gray Birch,
- Round-leaved Sundew,
- Closed Gentian,
- Butternut,
- Blunt Mountain-mint,
- Northern Rose Azalea,
- Large Cranberry,
- Hobblebush,
- Water avens
- Weak sedge,
- Shining ladies'-tresses
- Straw sedge
- Swamp oats
- Tall St. Johns Wort
- Woodland Horsetail,
- Long Beech Fern, and

In addition to being listed as a State Potentially Threatened Plant species, the Butternut also is listed as a Federal Candidate (Category 2) species.

A large number of animal species have been identified on facility property, including 26 species of mammals, 143 species of birds, and 41 species of fish. Two animal species identified at RVAAP are listed as Federal Candidate (Category 2) species: the Cerulean Warbler and the Henslow's Sparrow. Animal species listed as Ohio State Endangered (ODNR,1993) include the Northern Harrier, the Common Barn-Owl, the Yellow-bellied Sapsucker, the Mountain Brook Lamprey, and the Graceful Underwing. Several animal species present at RVAAP also are listed as Ohio State Special Concern:

- Woodland Jumping Mouse,
- Solitary Vireo,
- Sharp-shinned Hawk,
- Sora,
- Virginia Rail,

- Four-toed Salamander, and
- Smooth Green Snake.
- Pygmy shrew
- Star-nosed mole
- Red-shouldered hawk
- Henslow's sparrow
- Cerulean Warbler
- Common moorhen
- Eastern box turtle
- *Capperia evansi* (Moth)
- *Zanclognatha Martha* (Moth)
- *Oligia bridghami* (Moth)
- *Sutyna privata* (Moth)
- *Homorthodes frufurana* (Moth)

In addition, databases at ODNR, Division of Wildlife, http://www.ohiodnr.com/wildlife/resources/default.htm, and the Division of Natural Areas and Preserves, http://www.dnr.state.oh.us/dnap/heritage/heritage.html, are to be queried to ensure that the latest special interest species list is used.

There is no documentation available to determine if any of the above animal or plant species have been affected by past facility operations. Future Installation Restoration Program (IRP) activities will require consideration of these species to ensure that detrimental effect on threatened or endangered RVAAP flora and fauna do not occur. There are no federal, state, or local parks or protected areas on RVAAP facility property.

1.3 SUMMARY OF EXISTING SITE DATA

During the last 30 years multiple environmental-related investigations were conducted at RVAAP. A brief summary of these investigations is provided below.

Date	Description of Investigation
1978	U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted an Installation Assessment of RVAAP and concluded that no migration of contamination to groundwater had occurred at the installation (USATHAMA 1978).
1982	Reassessment by USATHAMA also concluded that no migration of contamination to groundwater had occurred (USATHAMA 1982).
1988	The U.S. Army Environmental Hygiene Agency (USAEHA) conducted a groundwater contamination survey and an evaluation of Solid Waste Management Units (SWMUs). Twenty-nine potentially contaminated SWMUs were identified. Further investigation was recommended for 15 of the 29 SWMUs to determine if contaminants had migrated from these units.

1989 The U.S. Environmental Protection Agency (EPA) contracted Jacobs Engineering to perform a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) – Preliminary Review and Visual Site Inspection (USEPA 1989). The report identified 31 SWMUs, 13 of which were recommended for no further action (NFA). These 31 SWMUs are listed as sites in the Restoration Management Information System (RMIS).

1992 USAEHA conducted a hydrogeologic study of the Open Burning/Open Detonation (OB/OD) areas as part of a response to a Notice of Deficiency issued by Ohio EPA regarding the installation's RCRA Part B permit application. Minor amounts of contamination were reported at these areas.

1994 USAEHA performed a Preliminary Assessment Screening (PAS) of the Boundary Load Line areas at RVAAP and provided a Statement of Findings to support a Record of Environmental Considerations along with recommendations for additional activities at these sites.

1996 The U.S. Army Corps of Engineers (USACE) performed a facility-wide preliminary assessment covering all known environmental sites at RVAAP.

1996 USACE developed a Facility-wide Sampling and Analysis Plan (FSAP) and Facility-wide Safety and Health Plan (FSHP) for conducting investigations at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) AOCs at RVAAP.

1996 USACE conducted Phase I Remedial Investigations of 11 areas of concern. These AOCs were Load Lines 1–4, Load Line 12, Winklepeck Burning Grounds (WBG), Landfill North of Winklepeck Burning Grounds, Building 1200, Demolition Area #2, Upper and Lower Cobbs Ponds, and Load Line 12 Pink Wastewater Treatment Plant.

1996 USACHPPM performed Relative Risk Site Evaluations at several known or suspected former areas of concerns: 2, Erie Burning Grounds 3, Open Demolition Area 1,6, C-Block Quarry, 15, Load Line 6, treatment plant, 16, Fuze and Booster Quarry Landfill/Pond, 18, Load Line 12 Pink Waste Water Treatment, 23, Unit Training Site Waste Oil Tank, 24, Reserve Unit Maintenance Area Waste Oil Tank, 25, Bldg 1034 Motor Pool Waste Oil Tank, 26, Fuze and Booster Area Settling Tank, 28, Mustard Agent Burial Site, 30, Load Line 7 Pink Wastewater Treatment Plant, 32, 40/60 mm Firing Range, 33, 40/60 mm Firing Range, 34, Sand Creek Disposal Road Landfill, 35, 1037 Building – Laundry Wastewater Sump, 36, Pistol Range, 37, Pesticide Storage Building – T4452, and 38, NACA Test Area.

1997 USACE conducted a field investigation to support RCRA and other clean closures at the following SWMUs: Building 1601, Open Burning Area (Pad #37 at Winklepeck Burning Grounds), Open Detonation Area (in Demolition Area #2), Deactivation Furnace Area (Pad #45 at WBG), and the Pesticides Building S-4452.

1998	USACE conducted a Phase II Remedial Investigation at Winklepeck Burning Grounds, including Baseline Human Health and Ecological Risk Assessments (BHHRA).
1998	USACE performed a groundwater investigation at Ramsdell Quarry Landfill.
1998	USACHPPM performed Relative Risk Site Evaluations at several known or suspected former waste disposal sites. These included AOCs 39, Load Line 7, 40, Load Line 7 – Booster Line 1, 41, Load Line 8, 42, Load Line 9, 43, Load Line 10, 44, Load Line 11, 45, Wet Storage Area, 46, Building F-15 & F-16, 47, Building T-5301 Decontamination, 48, Anchor Test Area, 49, Central Burn Pits, 50, Atlas Scrap Yard, and 51, Dump along Paris-Windham Road.
1999	USACE performed Phase I Remedial Investigations at Erie Burning Grounds, NACA Test Area, and Demolition Area #1. They also completed the installation of monitoring wells for the Phase II RI at Load Line 1.
2000	U.S. Army OSC performed a Phase I Remedial Investigation at Load Line 11.
2000	U.S. Army OSC performed an Unexploded Ordnance (UXO) Removal and Site Restoration at Demolition Area #2.
2000	USACE performed Phase II Remedial Investigations at Load Line 12 and Load Line 1.
2000	USACE performed a biological assessment at Winklepeck Burning Grounds to support a feasibility study.
2001	U.S. Army OSC performed Phase I Remedial Investigations at Central Burn Pits and Cobbs Pond

2.0 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 includes several activities:
  - Refining preliminary contaminants of ecological concern;
  - Further characterizing ecological effects of contaminants;
  - Reviewing and refining information on contaminant fate and transport, complete exposure pathways, and ecosystems potentially at risk;
  - Selecting assessment endpoints; and
  - Developing a conceptual model with working hypothesis or questions that the site investigation will address.

- **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.

- **Effects Assessment**. Effect 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 individuals or 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 may be used to assess ecological effects.

- **Risk Characterization**. Risk characterization integrates exposure and effects or the response to chemical stressors on receptor populations using hazard quotients (ratios of exposure to effect). The results are used to define the potential for risk from contamination at the exposure unit (EU), , and to assess the potential impact on assessment endpoints at the EU. The associated uncertainties are also included in the risk characterization process (generally in the uncertainty section of the report).

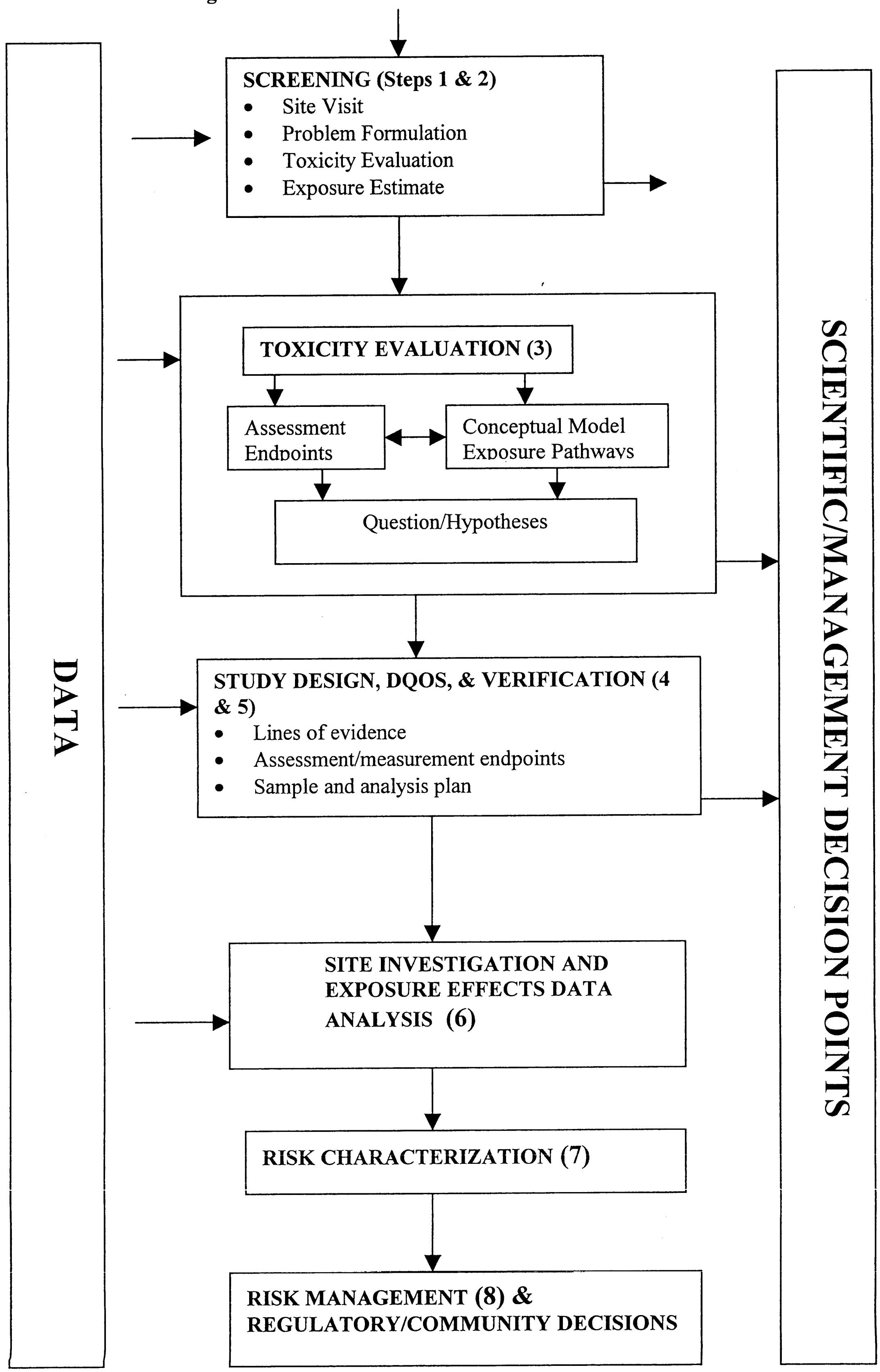
  The four interrelated steps of the EPA framework should organize the discussion of the ERA presented in this report. Detailed technical issues and data evaluation procedures associated with each step should be contained within other Sections of the RI.

<u>Determination of the Scope of the Assessment</u>

The scope of the ecological risk assessment (ERA) is to characterize the risk to individuals or plant and animal populations at the EU and nearby aquatic environment. This is done using both current and modeled concentrations. The ERA assesses the potential hazard to ecological receptors, especially terrestrial and aquatic organisms. Unlike the human health risk assessment, which focuses on individuals, the ERA generally focuses on populations or groups of interbreeding individuals. In the ERA process, individuals are addressed only if they are protected under the state or Federal Threatened and Endangered Species Lists. Chemical constituents are called constituents of potential ecological concern (COPECs). When it has been demonstrated that these COPECs cause potential impact, they are called constituents of ecological concern (COECs). The COECs are associated with the result of the more definitive baseline ERA.

Figure I shows the relationship of screening (Steps 1 and 2) and baseline (Steps 3 through 7) ERAs.

Figure I. Flow Chart for US EPA ERAGS Procedures



Ohio EPA has an ecological risk assessment guidance developed from the US EPA Ecological Risk Assessment Guidance for Superfund (ERAGS) (USEPA, 1998). Figure II shows the relationship of the Ohio Guidance to ERAGS.

To conform to Ohio EPA's Level I assessment for the aforementioned AOCs a property assessment or its equivalent and a site visit/limited field investigation is required. The Level I assessment poses the following questions:

- Are current or past releases at the site suspected?
- Are important ecological resources present at or potentially influenced by the site?

If the answer to both questions is yes, then under Ohio EPA guidance the site is subject to continued ecological investigation by completing a Level II ERA or, a remedial alternative is chosen using background or screening values as remedial objectives. If habitat quality is under question, risk management decisions may be made to continue to Level II or dismiss the site from further ecological assessment.

Specific to terrestrial habitats the ERA under this work plan will parallel the protocol identified under Ohio EPA's guidance as a Level II ERA. Both OEPA and EPA guidance serve to determine first the concentration of the chemicals of interest for the end-point receptors, then hazard quotient(s) (HQs) when the intake of the chemical is screened against the appropriate eco-toxicologically-based screening values. After the HQs are determined a scientific management decision that is defined under Section 4.5, below is made. The scientific management decision is designed to allow those involved with the AOC to make a decision for remedial action in lieu of pursuing further ecological evaluations.

Specific to aquatic habitats, surface water and sediment quality is assessed using the Ohio EPA's chemical specific and biological criteria (OAC 3745) to demonstrate that surface waters have not been impacted by site related contaminants. Biotic and macro-invertebrate communities suspected of being impacted by site related chemicals are scheduled for evaluation under RVAAP Facility-Wide Surface Water Assessment.

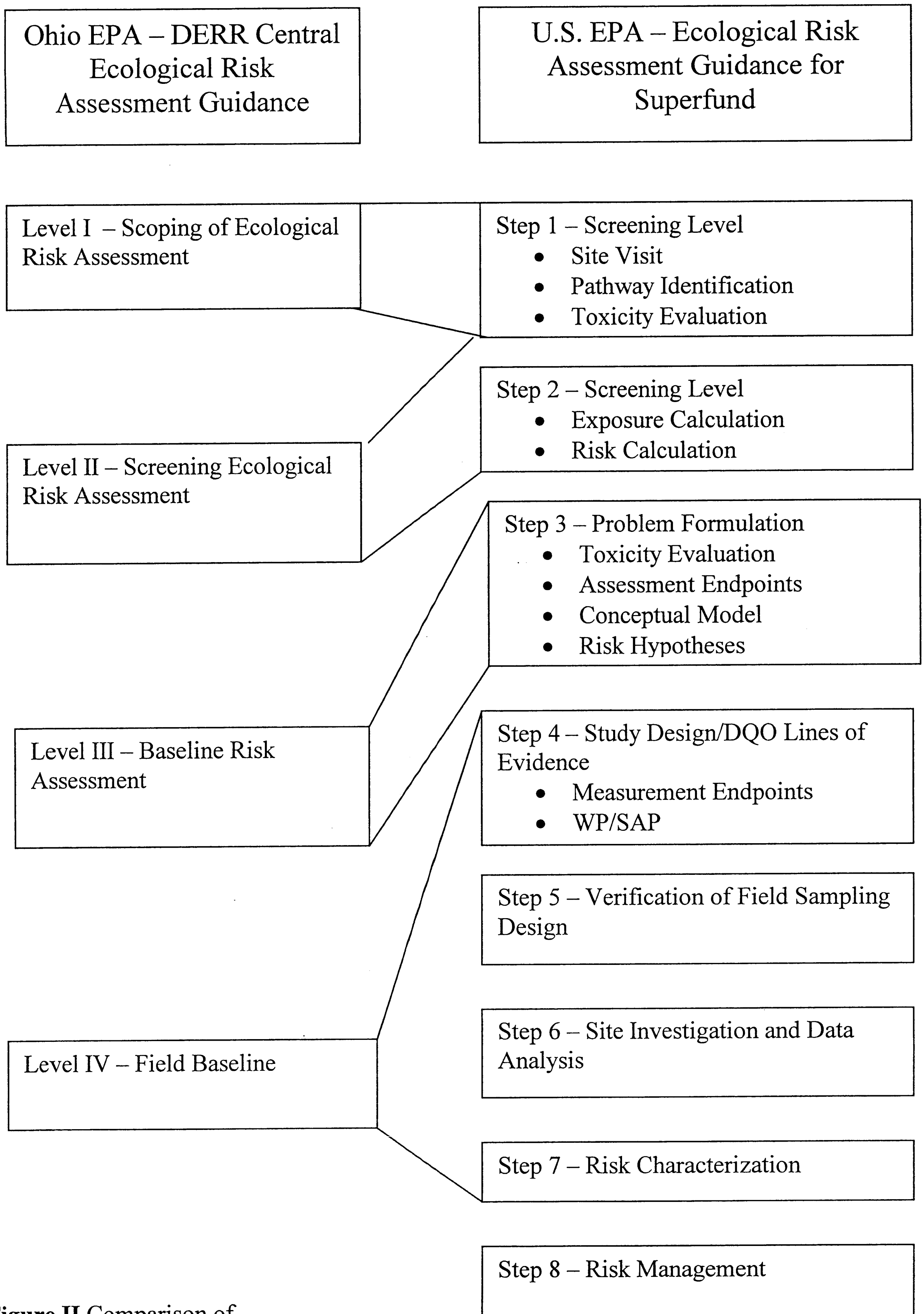


Figure II Comparison of OhioEPA and USEPA Eco-Risk Guidances

3.0 ECOLOGICAL FACILITY-WIDE DATA QUALITY OBJECTIVES

As part of the Facility-wide ecological approach to environmental investigation activities at RVAAP, Facility-wide DQOs have been developed. The DQO process is a tool to guide investigations at CERCLA sites. Although not all AOCs at RVAAP are CERCLA sites, this model still has relevance for decision-makers (USEPA, Sept. 1994). The DQOs serve two major purposes: (1) to present the facility-wide approach to ecological assessment at the installation, and (2) to present the process that will be used to develop data needs and the desired level of effort that is AOC-specific. The stages of the DQO development process are:

- develop the conceptual site model,
- state the problem,
- identify decisions to be made,
- define the study boundaries,
- develop the decision rule (if/then),
- identify inputs to the decision (data uses and data needs),
- specify limits on uncertainty, and
- optimize the sample design.

3.1 CONCEPTUAL SITE MODEL

A conceptual site model is the cornerstone for planning a field sampling effort. It reflects an understanding of the known or expected site conditions and serves as the basis for making decisions about habitat, and locations (*e.g.*, suitable/not suitable), frequencies of detected analytes. A good conceptual model is inclusive of all available information, incorporating the hydrogeologic features and other characteristics of the site that combine to define the problem to be addressed (*e.g.*, location of buried waste, primary contaminants and their properties, contaminant transport pathways, and potential ecological exposure scenarios, etc.). Please refer to Section 4.0, Selection of Exposure Units and Receptor Species, for expanded detail of CSM contents.

A preliminary conceptual model for RVAAP has been developed using available information. Aspects of the conceptual model that are important for contaminant transport pathways are noted below. Perhaps of more importance than what is known, are the uncertainties that must be addressed to determine comparability between areas of ecological concern. Available information indicates:

- Surface geology across the site is highly variable. Glacial overburden ranges in depth from approximately 0.15 m (6 inches) (Hiram Till in the eastern portion of the installation) to 12.2 m (40 feet) (Lavery Till in the western portion). Bedrock outcroppings have been noted in the southeastern portion of the site. The till is reported to be somewhat impermeable, with hydraulic conductivities thought to be greater than 10^{-6} cm/sec.

- An area filled with sand and gravel exists in the central portion of the installation, oriented in a southwest-northeast direction. Depth of the area ranges from 30.5 to 60.7 m (100 to 200 feet).

- The variable nature of the till combined with the topography of the site results in a complex surface water system on the installation.

- The South Fork of Eagle Creek and Sand Creek drain much of the installation. The creeks converge and exit the installation in the northeast. AOCs in the central portion of the site (*e.g.*, Demolition Area #2) and upper and lower Cobbs Ponds feed this drainage system. This system flows east to the West Branch of the Mahoning River.

- Hinkley Creek in the western potion of the site drains due south. The AOC of greatest concern along Hinkley Creek is Demolition Area #1.

- Drainages from load lines 1-4 and 12 appears to flow east and southeast. The southeastern portion of the site is swampy, even in the summer months. Drainages to the south flow into the M.J. Kirwan Reservoir.

- Approximately 50 ponds are scattered throughout the installation. Many of these ponds have acted as settling basins over the years. The ponds could support aquatic vegetation and biota.

- Because of the somewhat impermeable nature of the till, it is suspected that a large percentage of rainfall exits the installation via the surface drainages.

- Information is sparse on the exact nature of the groundwater underlying the AOCs at the installation with the exception of AOCs that have been or are currently being investigated. Groundwater as shallow as 0.61 m (2 feet) bgs may be a possibility at some AOCs at RVAAP.

- The sand and gravel aquifers are a major source of potable water in the local area and can yield up to 6080 liters (1600 gallons) per minute. Little is known about the precise connection between the AOCs at RVAAP and these valleys.

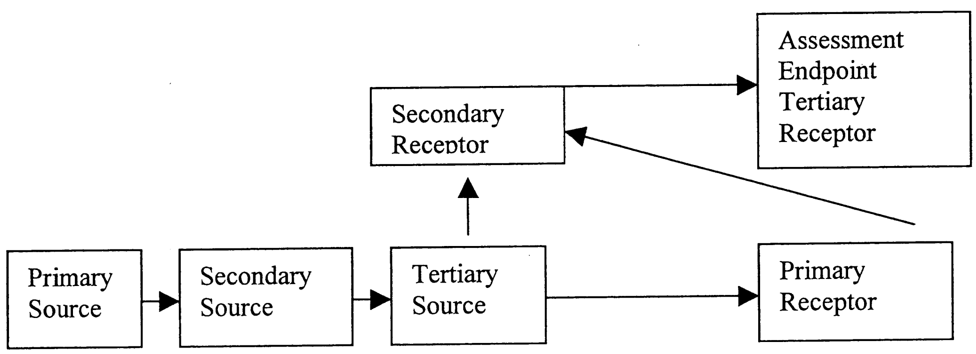
- Bedrock formations in the area are also a source of potable water, with the Pottsville Formation representing the largest bedrock aquifer. Hydraulic conductivities range from 19 to 760 LPD/m (5 to 2000 GPD/ft) in the bedrock aquifers. Sandstone of the Pottsville Formation is exposed at Ramsdell Quarry Landfill and Load Line 1, and underlies much of the eastern and northeastern portion of the facility.

- Major COPCs include, but are not limited to, explosive-related chemicals [TNT, dinitrotoluene (DNT), RDX] and metals (lead, chromium, mercury). Additional chemicals have been identified at some AOCs, including, but not limited to, target analyte list (TAL) metals, semi-volatile organic compounds (SVOCs), and PCBs. Most of the COPCs are relatively insoluble, (*i.e.*, tend to adsorb to soil particles rather than dissolve into water) and are relatively long-lived.

- Currently, access to the facility is controlled and not readily accessible to the public. The Ohio National Guard controls 19,938 acres of the site for training exercises and other purposes. The most likely pathway of exposure to off-site receptors is via chemical migration through the surface water and groundwater systems.

3.2 ECOLOGICAL CONCEPTUAL SITE MODEL (ECSM) FOR NEW EXPOSURE UNIT (EU)

The ECSM is developed and diagrammed by examining the sources of chemicals and possible release mechanisms, based on and understanding of the fate and transport characteristics of chemicals potentially present on site. Below is a generic example of an ECSM.



3.2.1 PRIMARY RELEASE MECHANISMS

Preliminary information suggests the following release mechanism. Chemicals at the EUs may be present in surface soil, sediment, surface water, and groundwater from past chemical releases at RVAAP. Leaching to surface water and to groundwater may be an additional release mechanism and to a lesser extent, volatilization.

3.2.2 EXPOSURE MEDIA

Soil 0 to 1.2m (3.94 feet) is potential exposure media for ecological receptors. However, the majority of soil invertebrates, small mammals, birds, plants and other ecological receptors use the upper few inches of soil and leaf litter. Active decomposition of dead plant and animal material and many soils and other organisms complete all or part of their life cycle.

Surface water and sediment are 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. However, if shallow groundwater were encountered at an investigation site, at a depth of 2 feet or less, it would be evaluated as surface water. Common sense should be applied in that the shallow groundwater may not be a pathway for all receptors and should be evaluated and discussed as such. Air is not considered an exposure medium because most of the potential volatile organics are believed to have dissipated. Due to the lack of inhalation toxicity criteria and receptor-specific inhalation rates exposure via the inhalation pathway is generally not evaluated as part of an ecological risk assessment. All appropriate exposure media will be included in the ecological risk assessment and the exposure media will be determined on a site-specific basis.

3.2.3 EXPOSURE ROUTES

Principal exposure routes are ingestion and absorption of chemicals from soils at RVAAP. Animals are also exposed through ingestion of contaminated vegetation and prey species. Plants are exposed by root uptake from soil at RVAAP and may serve as exposure media 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 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. By contrast, direct exposures 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 (see Tables-1 through 6, below).

3.2.4 ECOLOGICAL RECEPTORS

Vegetation, terrestrial and aquatic receptors are recognized in the conceptual site model. Therefore for each EU list relevant vascular plant, fauna, and aquatic species [reference is to be made, but not limited to the Environmental Baseline Summary Report, Ravenna Army Ammunition Plant, Portage and Trumbull Counties, Ohio. Prepared For the Ohio Army National Guard, by Ogden Environmental and Energy Services. Cincinnati, Ohio. 1999].

3.2.4.1 Protected Species

A number of rare species are found at the RVAAP (Section 1.2.6, above), several of which are of federal and state, interest (ODNR 1993). T & E species will be examined quantitatively in the ERA. These species are discussed below. Additional information and complete species lists for the RVAAP are contained in ODNR, 1993 and 1999. Additional information and updated T & E species list should be included in each ecological risk assessment performed at RVAAP. In addition, databases at both ODNR, Division of Wildlife, http://www.ohiodnr.com/wildlife/resources/default.htm, and the Division of Natural Areas and Preserves, http://www.dnr.state.oh.us/dnap/heritage/heritage.html, are to be queried to ensure that the latest special interest species list is used.

Federal

No known federally listed threatened or endangered species have been documented on the RVAAP, although 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 found on RVAAP 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 of the Phase II Remedial Investigation Report for Winklepeck Burning Grounds at RVAAP. USACE, April 2001.

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.

3.3 DEFINE THE PROBLEM

The problem to be addressed at RVAAP is that:

- Hazardous contaminants from past waste disposal activities may be posing a current or future risk to populations and communities of ecological receptors.

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.

3.4 REMEDIAL ACTION OBJECTIVES

A major goal of implementing the DQO process is to ensure that all data critical for decision-making are collected as part of the field investigations. This should include data necessary for selecting and implementing a cost-effective remedial action if such an action is required. For example, if an impermeable cap is a probable remedial technology, data should be collected to characterize the potential for subsurface lateral groundwater flow. During the planning for investigation of each EU, potential remedies will be identified. This will ensure that all data necessary for a Feasibility Study, should one be necessary, are available.

3.5 IDENTIFY DECISIONS

- *Reduce ecological risks to levels that will result in recovery and maintenance of healthy local populations and communities of biota to levels similar to that of areas not contaminated with the COPECs.*

  Risk assessors and managers are to select assessment endpoints and measures that are:
  - Ecologically relevant to the site (important to sustaining the ecological structure and function of the local populations, communities and habitats present at or near the site; and,
  - Include species that are exposed to and sensitive to site-related contaminants.
  - In addition, if individual threatened or endangered species or critical habitats for such species are present at a site, the Federal Endangered Species Act or a state endangered species act may be an ARAR (Applicable, Relevant or Appropriate Regulations).

3.6 DEFINE STUDY BOUNDARIES

The spatial boundary for initial fieldwork at an AOC is the fence line or other boundary (including railroad tracks, drainage divides, or other defined features) for each individual AOC. The potential for off-site migration will be addressed by sampling at the boundary (*e.g.*, in drainages at the fence line), and as necessary and appropriate at selected locations beyond the boundary.

The spatial boundary for any follow-up field investigation work will be determined based on the results of initial field efforts. If warranted, the spatial boundary for follow-up work may extend to the facility boundary.

The spatial boundaries of the ecological exposure unit may or may not be the same as the spatial boundaries of unit defined for the human health risk assessment.

3.7 IDENTIFY DECISION RULES

The protection of ecological resources, such as the species of plants and animals and habitats described in Section 3.2.4, is required by a variety of legislation and government agency policies (*e.g.*, Comprehensive Environmental Restoration Compensation Liability Act (CERCLA) and Endangered Species Act (ESA)). To determine whether a protection goal has been met, assessment and measurement endpoints were formulated.

Null Hypothesis (H_o):

1. H_o: Site-related contaminants are not present in RVAAP Areas soils, surface waters, or sediments at concentrations that warrant classification as Contaminants of Potential Ecological Concern (COPECs).
2. H_o: If COPECs are present, their concentrations and bioavailability to surrounding biota, populations, communities and ecosystems are not sufficiently elevated to impair or disrupt the viability or recovery of these biotic systems. If COPECs exist, the contractor will address null

hypothesis two (2) by providing a work plan that is designed to determine whether null hypothesis two (2) is to be accepted or rejected.

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* represent those aspects of the ecosystem about which we are concerned. For screening level ecological assessments, assessment endpoints chosen are usually stated in quite general terms such as "protection of a community from changes related to contaminant exposure". A *measurement endpoint* is a measurable biological response that can be used to make inferences related to the chosen assessment endpoint.

Three policy goals should be defined for each EU. Assessment and measurement end points should be provided with each policy goal. Policy goals are:

- Policy Goal 1: The preservation and conservation of threatened, endangered, and rare species and their habitats.
  - Always make sure that the list of rare species at Ravenna is current.

- 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 may be stated quantitatively in terms of toxicity or ecological 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 measured or predicted 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 potential for impact is considered acceptable (protective of the ecological receptor). Any hazard quotients greater than 1 indicates that the ecological COPEC qualifies for further investigation of the actual likelihood of harm. However, the first step could refine exposure assumptions in EPA's step 3a and not move to a baseline evaluation. The final COECs are selected only after additional evaluation of the conservatism of exposure assumptions, toxicity thresholds, and uncertainties.

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 hazard quotients for the assessment endpoints incorporate exposure factors (*e.g.*, dietary soil fractions and bioaccumulation factors). Exposure factors for ecological receptors are discussed in Section 4.1.

HQs for assessment endpoints 1 through 6 (Table 1 below) are to be calculated for ecological COPECs 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.

Table 1 **Policy Goals, Ecological Assessment Endpoints, Measurement Endpoints, and Decision Rules at EU.**

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.	**Measurement Endpoint 1:** Modeled or sampled contaminant concentrations in prey (shrews, robins, and rabbits) and other food based on measured soil concentrations. Some special interest species will be evaluated based solely on media concentrations (*e.g.*, plants, aquatic organisms). Habitat characteristics will be evaluated based on potential use by special interest species likely to be associated with, or adjacent to, the site	**Decision Rule for Assessment Endpoint 1:** If the HQ >1, a weight-of-evidence evaluation, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations or remedial actions.
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.	**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, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations or remedial actions.
	Assessment Endpoint 3: Maintenance of soil-dwelling invertebrate community for nutrient and energy processing.	**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, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations, or remedial actions.
	Assessment Endpoint 4: Maintenance of populations of herbivorous animals.	**Measurement Endpoint 4:** Modeled or sampled 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

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
			maintained. If the HQ >1, a weight-of-evidence evaluation, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations or remedial actions.
	Assessment Endpoint 5: Maintenance of worm-eating and/or insectivorous animals.	**Measurement Endpoint 5:** Modeled or sampled 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, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations, or remedial actions.
	Assessment Endpoint 6: Maintenance of higher terrestrial predators.	**Measurement for Endpoint 6:** Modeled or sampled 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, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations, or remedial actions.

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 aquatic organisms.	**Measurement Endpoint 7:** Measured surface water and sediment contaminant concentrations and biological measurements where appropriate.	**Decision Rule for Assessment Endpoint 7:** . The decision rules and measurement endpoints must include the use of the specific requirements of the State of Ohio surface water standards identified in Section 3745 of the Ohio Administrative Code (OAC) when appropriate. In addition, 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, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations, or remedial actions.
	Assessment Endpoint 8: Maintenance of terrestrial piscivore predators	**Measurement Endpoint 8:** Modeled or sampled food 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 and sediment-dwelling organisms are maintained. If the HQ >1, a weight-of-evidence evaluation, if warranted, will be conducted to determine the potential for ecological risk and the need for any additional measurements, calculations, or remedial actions.

RME = Reasonable maximum Exposure
T&E = Threatened and Endangered
NOAEL = No Observed Adverse Effects Level
HQ = Hazard (risk) Quotient

3.8 IDENTIFY INPUTS TO THE DECISION

"Inputs to the decision of the potential of ecological harm" include results of the field investigation and data analysis, modeling, and hazard estimates or HQs, etc. The data needed to provide decision inputs vary from site to site, depending on the waste type, site setting, and other EU-specific factors, and the data needs will be defined on a EU-specific basis. General factors that need to be considered for the EU are listed below:

- *Coordinate with Federal, Tribal, and State Natural Resource Trustees*
  The protection of ecological resources, such as the species of plants and animals and habitats is mandated by a variety of legislation and government agency policies (*e.g.*, CERCLA, RCRA, and National Environmental Policy Act (NEPA)). Through these laws, protection goals are established by legislation or agency policy.
- *Use site-specific ecological risk assessment data to support cleanup conditions.*
  Site-specific data should be collected and used, wherever practicable, to determine whether or not site releases present unacceptable risks and to develop quantitative cleanup levels that are protective.
- *Characterize site risks*
  When evaluating ecological risks and the potential for response alternatives to achieve acceptable levels of protection, site risks are characterized in terms of:
- Magnitude; (*i.e.*, the degree of the observed or predicted responses of receptors to the range of contaminant levels)
- Severity; (*i.e.*, how many receptors may be affected and to what extent the receptors may be affected)
- Distribution; (*i.e.*, a real extent and duration over which the effects may occur); and,
- Potential for recovery of the affected receptors (including the possibility of development of tolerance).

3.9 SPECIFY LIMITS ON DECISION ERROR

Remedial action decisions may need to be made for RVAAP AOCs based on the results of the data assessment and baseline risk assessment. Controlling the potential for making a wrong decision begins in the DQO process by identifying what types of errors may be introduced during sample collection and data assessment and attempting to limit those errors. Although DQO guidance provides some methods for attempting to limit error by designing statistically based sampling plans (USEPA 1994), most practitioners have found the methods generally account for only single factors (*e.g.*, how a single contaminant is distributed in a single medium), when, in fact, response action decisions are based on understanding multiple factors (*e.g.*, multi-media distribution and partitioning, multiple chemicals of varying degrees of toxicity, and risk modeling output and the various parameter required for that effort).

EPA specifies two types of decision error that should be addressed during DQOs: sampling errors and measurement errors (USEPA 1994). A third type of error, modeling error, is an important consideration when interpreting risk assessment results. Provided below is a summary of errors that may contribute to decision error and ways to minimize the potential for error during sample collection and reporting.

3.9.1 SAMPLING ERRORS

Most sampling plans attempt to avoid the potential of a false positive error (*e.g.*, avoid concluding that wastes do not pose a risk when they actually do). During the planning for each AOC, sample locations and frequencies will be identified using the knowledge of the AOC (conceptual model) and the requirements of the risk assessment. For example, if the conceptual model suggests that surface water is the major contaminant migration pathway for the AOC, more sampling resources will be directed toward characterizing this potential for the pathway to pose a current or future risk. Screening tools (*e.g.*, geophysical surveys, geoprobe sampling, etc.) may also be used to determine optimum sampling locations where analytical data can be collected using definitive sampling methods to define the nature and extent of contamination. Screening tools may be used to define the nature and extent of contamination, and their use may be effective in reducing the number of confirmatory samples collected to characterize an AOC.

3.9.2 MEASUREMENT ERRORS

Measurement errors in laboratory data can be minimized through proper planning, implementation of applicable laboratory QC, and programmatic data verification and validation procedures. Proposed processes and procedures are provided in the Facility-Wide QAPP. A primary focus of the review, verification, and validation process will be to avoid the potential for false positive errors (*e.g.*, avoiding the potential of finding no risk when a risk actually exists). Analytical project-reporting levels established to meet the needs of risk assessment are presented in the Facility-Wide QAPP, Tables 3-3 through 3-9.

Analytical data will be generated using EPA SW-846 Methods, EPA Water and Wastewater Methods, and American Society for Testing and Materials (ASTM) Methods. Analytes with detection limits that exceed screening criteria should be identified in the Site-Specific Sampling and Analysis Plan. The risk team should decide on the further evaluation on an analyte specific basis prior to beginning sampling at the AOC. Alternate or supplemental methods may be added as the need arises through specification in approved FSAP addendum. Analytical data will receive its initial review by the laboratory generating the information prior to the results being reported as definitive data as identified in the Facility-Wide QAPP.

The Contractor will perform verification of the analytical data independently of the analytical laboratory. This verification will ensure that precision, accuracy, sensitivity, and completeness of the analytical data are adequate for their intended use. The greatest uncertainty in a measurement is often a result of the sampling process, the inherent variability of the matrix, or the environmental population. Verification will focus at a level necessary to minimize the potential of using false positive or false negative concentrations in the decision-making process (*i.e.*, first priority will be to assure accurate identification of detected versus non-detected analytes).

Additionally, 10% of the project data will undergo comprehensive data validation through an organization independent of both the laboratory and the Contractor. This review combined with the U.S. Army QA split sample analyses and documentation will form the basis for an overall data quality assessment by the U.S. Army.

Validation will be accomplished by comparing the contents of the data packages and QA/QC results to requirements contained in the requested analytical methods. In general, validation support staff will conduct a systematic review of data for compliance with the established QC criteria based on the following categories:

- sample preparation
- holding times,
- blanks,
- laboratory control samples (LCSs),
- calibration,
- surrogate recovery (organic methods),
- internal standards (primarily organic methods),
- matrix spike/matrix spike duplicate (MS/MSD) and duplicate results,
- sample reanalysis,
- secondary dilutions, and
- laboratory case narrative.

The protocol for analyte data verification and validation is presented in:

- Shell Analytical Chemistry Requirements, version 1.0, 2 November 1998;
- Environmental Data Assurance Guideline, USACE Louisville, May 2000;
- EPA National Functional Guidelines for Organic Data Review (EPA 1994b); and
- EPA National Functional Guidelines for Inorganic Data Review (EPA 1994c).

Consistent with the data quality requirements as defined in the DQOs, all project data and associated QC will be evaluated and qualified as per the outcome of the review.

3.9.3 PURPOSES OF SAMPLING

Sampling and analysis for the RVAAP field investigations will focus on the following:

- determination of the presence of contamination,
- determination of the nature and extent of contamination,
- identification of the connections between contaminant sources and pathway media.

3.9.4 SELECTION OF SAMPLE LOCATIONS

In order to accomplish the purposes described above, process history, topography, geology, and other information specific to an individual AOC will be used to identify locations where residual contamination would most probably remain. Given the non-uniform horizontal distributions of contaminated areas on ammunition plants (*e.g.*, RVAAP's former burning pads separated by apparently unused, uncontaminated land), the investigation of a given AOC may require characterization of the spaces between contaminated areas as well. Several techniques can be employed and must be discussed and accepted by the RVAAP team members prior to the initiation of sample collection. Multi-incremental sampling, random grid sampling, biased sampling are possibilities that must fully be examined for use at any AOC

4.0 SELECTION OF EXPOSURE UNITS AND RECEPTOR SPECIES

From the ecological assessment viewpoint, an exposure unit is the investigative area or an ecologically relevant subdivision of the investigative area. The spatial boundaries of the ecological exposure unit may or may not be the same as the spatial boundaries of unit defined for the human health risk assessment. The spatial boundaries are best determined on a site specific basis with the considerations of habitat and species.

Examples of exposure units are:

- all of AOC (terrestrial),
- each individual EU (for AOCs that have more than one EU) (terrestrial),
- sediment sites in and adjacent to EU (if applicable), and
- surface water inside and adjacent to EU (if applicable).

The exposed ecological receptors for the ERA will be selected from animal species found in terrestrial/aquatic habitats. For example, three criteria, listed below, were used to select the ecological receptors at the WBG (Refer to Table 1 Below):

- 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 or suspected to be 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).

- For the RVAAP, 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.

The EU description of selecting environmental receptors may include: terrestrial plants, terrestrial invertebrates, short-tailed shrew, American robins, meadow vole, red-tailed hawk, barn owl, and red fox, sediment-dwelling organisms, aquatic organisms, and piscivorous organisms. Risks are quantitatively estimated for each applicable receptor. As part of the Conceptual Site Model a figure following the example below will be provided for each EU showing the terrestrial food chain for the terrestrial receptors and aquatic food chain for the aquatic receptors.

Table 1: Reasons for Selecting Receptors for Ecological Risk Assessment at EU

Receptor	***Selection Criteria***		
	Criterion 1 Ecological Relevance	**Criterion 2 Susceptibility**	**Criterion 3 Represents Management Goals[a]**
Plants (*various species*)	+++	+	+++
Terrestrial invertebrates (*various species*)	++	++	+
Mammalian invertivore (*Blarina brevicauda*)	++	+++	+
Avian invertivore (*Turdus migratorius*)	++	++	+
Mammalian herbivore (*Microtus pennsylvanicus*)	++	++	+
Avian carnivore (*Buteo jamaicensis*)	++	+++	++
Aquatic organisms (fish)	+++	+++	+++
Sediment-dwelling organisms (macroinvertebrates)	+++	+++	++
Piscivore(*Mustela vision*)	+++	+++	+++

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

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 physiology.

4.1.1 TERRESTRIAL EXPOSURE CLASSES AND RECEPTORS

The terrestrial exposure classes and their ecological receptors can include those provided for WBG and serve as an example of the type of analysis that is required for each EU of an AOC (see below). Relevant aquatic exposure classes and receptors are presented also for WBG, but may be different at individual EU.

- Vegetation
— variety of grasses, forbs, and trees

- Soil-dwelling invertebrates
— earthworms

- Mammalian herbivores
— meadow vole

- 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 RVAAP and were selected in accordance with the Ohio EPA Ecological Risk Assessment Guidance, http://web.epa.state.oh.us/derr/rules/RR-031.pdf and the EPA *Framework for Ecological Risk Assessment* (EPA 1992a and EPA 1996a).

Ecological receptors were chosen to provide a range of potential exposures, including high exposures, and 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 RVAAP. 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 augmenting soil fertility. Also, worm-eating mammals and birds ingest earthworms and, thus, any decrease of earthworm populations could reduce the amount of food available to predators. In addition, contaminated earthworms—both with contaminated soil in their guts and contaminated tissue—may constitute an exposure pathway for their mammal and bird predators.

Worm-eating and/or Insectivorous Mammals and Birds

Insectivorous mammals and birds [(*e.g.*, short-tailed shrew, *Blarina brevicauda* (Table 2 below), American robin, *Turdus migratorius* (Table 3 below)] 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. The exposure for this class of receptors was 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 (*i.e.*, dermal) 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 2 below) and 5% for the robin (Table 3 below). 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 2 & 3 below 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

The mammalian herbivore [*e.g.*, meadow vole, *Microtus pennsylvanicus* (Table 3 below)] is exposed primarily to soil chemicals that are in plant material. Exposure by direct contact with soil is assumed to be limited for meadow voles. The exposure for meadow voles 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).

Table 2. 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)	0.39	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)

Table 3. Receptor Parameters for American Robin

		Receptor:	American robin *(Turdus migratorius)*
Parameter	**Definition**	**Value**	**Reference / Notes**
BW	Body weight (kg)	0.081	Adult breeding female, New York (EPA 1993b)
HR	Home range (ha)	0.25	Adult, both sexes, spring, mean, Tennessee (EPA 1993b)
TUF	Temporal use factor	1-0.58	Will be 1 unless a specific value exists for a receptor
IRF	Food ingestion rate (g/g-d = kg/kgBW/d)[a]	1. 2	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	0.05	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)

Table 4. Receptor Parameters for Meadow Vole

		Receptor:	Meadow Vole *(Microtus pennsyvanicus)*
Parameter	**Definition**	**Value**	**Reference / Notes**

BW	Body weight (kg)	0.033	Arithmetic mean of means, adult, adult both sexes, all seasons (EPA 1993b)
HR	Home range (ha)	0.027	Arithmetic mean of means, adult both sexes (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]	0.33	(EPA 1993b)
PF	Plant fraction of diet	1	Arithmetic mean of all seasons 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	0.02	Beyer, Connor, and Gerould 1994
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.18	Adult, both sexes (EPA 1993b)

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 5), and barn owl, *Tyto alba* (Table 6), and red fox, *Vulpes vulpes* (Table 7)] 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.

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 are highly exposed to soil. Toxicity information is available. Therefore, earthworms were chosen as the surrogate species to evaluate risks to the soil invertebrate community. Similarly, worm-eating and/or insectivorous mammals are ecologically important because they help to control the size of the terrestrial invertebrate population that might otherwise damage populations of primary producers, especially plants. They 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.

Table 5. 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)

Table 6. 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)

Table 7. 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)

4.1.2 AQUATIC EXPOSURE CLASSES AND RECEPTORS

- The aquatic exposure classes and their ecological receptors in AOC/EU surface water(s) may include: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.
- Some AOCs within RVAAP may have aquatic habitat to support piscivorous mammals and birds, *i.e.* mink (table 8) and Belted Kingfisher (table 9), or Great Blue Heron (table 10).

Sediment dwelling organisms and fish will be evaluated under the RVAAP Facility-Wide Surface Water Work Plan (USACE, March 2003). If persistent, bio-accumulative, and toxic (PBT) compounds exist, then the ecological risk assessment for each AOC with aquatic habitat will be additionally evaluated based on a picivorous species, *i.e.*, mink, belted kingfisher, or great blue heron.

Table 8. Receptor Parameters for Mink

		Receptor:	**Mink** *Mustela vison*
Parameter	**Definition**	**Value**	**Reference / Notes**
BW	Body weight (kg)	1.02	Arithmetic mean, adult both sexes Montana (EPA 1993b)
HR	Home range (km)	2.24	Km of stream mean of means, adults, both sexes, (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]	0.16	Arithmetic mean of means, adult both sexes (EPA 1993b)
PF	Plant fraction of diet	0	Not stated in EPA (1993b); assumed to be negligible
AF	Animal fraction of diet	1	Assumed to be fish (EPA 1993b)
SF	Soil fraction of diet	0	Not stated in EPA (1993b) assumed to be negligible.

IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.079	Arithmetic mean of means, adult both sexes, (EPA 1993b)

Table 9. Receptor Parameters for Belted Kingfisher

Parameter	Definition	Receptor: Value	Belted Kingfisher *Ceryle alcyon* Reference / Notes
BW	Body weight (kg)	0.147	Arithmetic mean of means, adult both sexes (EPA 1993b)
HR	Home range (km shoreline)	1.16	Arithmetic mean of means adults, both sexes, (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]	0.5	Mean of both sexes, adult Michigan (EPA 1993b)
PF	Plant fraction of diet	0	Not stated in EPA (1993b); assumed to be negligible
AF	Animal fraction of diet	1	Assumed to be fish (EPA 1993b)
SF	Soil fraction of diet	0	Not stated in EPA (1993b) assumed to be negligible.
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.11	Estimated, (EPA 1993b)

Table 10. Receptor Parameters for Great Blue heron

Parameter	Definition	Receptor: Value	Great Blue Heron *Ardea herodias* Reference / Notes
BW	Body weight (kg)	2.336	Arithmetic mean of means, adult both sexes (EPA 1993b)
HR	Home range (Ha)	0.6	Size of feeding area only (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]	0.18	Mean of both sexes, adult (EPA 1993b)
PF	Plant fraction of diet	0	Not stated in EPA (1993b); assumed to be negligible
AF	Animal fraction of diet	1	Assumed to be fish (EPA 1993b)
SF	Soil fraction of diet	0	Not stated in EPA (1993b) assumed to be negligible.
IRw	Water ingestion rate (g/g-d = L/kgBW/d)	0.045	Estimated, (EPA 1993b)

4.2 QUANTIFICATION OF EXPOSURE

The exposure of an endpoint receptor to a chemical in surface soil at the AOC/EU is to be 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 should be the EPC, provided in Appendix Tables for surface soil and Appendix Tables for sediment and Appendix Table for surface water (note, Appendix Tables will be numbered specific to EU). 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 a 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 – 2 through -10. 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). Meadow voles represent the organisms that eat only vegetation, shrews and robins are assumed to ingest some amount of 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 meadow voles ingest mainly roots, stems and leaves of plants. The animal matter component of the diets of shrews and robins is assumed to consist of earthworms because earthworms are more directly exposed to soil constituents than most other animals and because soil-to-earthworm uptake factors are available. A fraction of the mass ingested while eating earthworms is soil inside the worm intestine; this amount is included in the amount of soil-ingested daily (I_S).

Constituent-specific transfer factors are provided in Appendix Tables L 1, L4 through L12 in Phase II RI for the WBG at RVAAP, Ravenna, Ohio. Aug 1999. [Tables have been excerpted from the WBG report and provided in Appendix A (tables A1 – A10)]

Ecological receptors obtain a fraction of their diet from the AOC/EU 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 2 through 10). As implied above, AUFs would vary from organism to organism.

Exposure equations are presented below. The general equation is:

Exposure = Total average daily dose = $ADD_P + ADD_A + ADD_S \times AUF \times TUF$,

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),
AUF = Area use factor (unitless), and
TUF = Temporal use factor (unitless).

For Ingestion of Plant Matter (*e.g.*, Meadow vole),

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

where:

EPC = Exposure point concentration in soil (mg/kg soil),
SP_r = Soil-to-plant uptake factor (kg soil/kg plant), The soil to plant uptake factor may be specified to the reproductive or vegetative plant parts depending on the specific receptor.
I_P = Ingestion rate of plant matter (kg/kg body wt/d)
$= IR_F \times PF$,
IR_F = Ingestion rate of food (kg/kg body wt/d),
PF = Fraction of plant matter in diet (unitless),

Ingestion of constituents in Animal Matter (*e.g.* shrews and robins):

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

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)
$= IR_F \times AF$,
IR_F = Ingestion rate of food (kg/kg body wt/d),
AF = Fraction of animal matter in diet (unitless),

Ingestion of constituents in prey by terrestrial carnivores is a special case because uptake by prey from their diets must be accounted for. It is assumed that the diet of hawks is 50% shrews and 50% meadow voles. 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 terrestrial carnivores,

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

Cs $= \text{Prey } ADD_{total} \text{ x } BAF_v / IR_f$
Prey ADD_{total} $= \text{Prey } ADD_P + \text{Prey } ADD_A + \text{Prey } ADD_S$
Prey ADD_P $= EPC \times SP_v \times I_{P\text{-}s} \times AUF \text{ x } TUF$
Prey ADD_A $= EPC \times BAF_i \times I_{A\text{-}s} \times AUF \text{ x } TUF$
Prey ADD_S $= EPC \times I_{S\text{-}s} \times AUF_{\text{-}s} \text{ x } TUF$

where:

$I_{A(hawk)}$	= Ingestion rate of animal matter for hawk,
AUF	= Area use factor for prey (unitless),
TUF	= Temporal use factor for prey (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-s}	= Ingestion rate of plants by shrews (kg/kg body wt/d),
BAF_i	= Soil-to-animal bioaccumulation factor for invertebrates,
I_{A-s}	= Ingestion rate of animal matter for shrews (kg/kg body wt/d),
I_{S-s}	= Ingestion rate of soil for shrews (kg/kg body wt/d).

Ingestion of tissues by piscivorous receptors (avian and aquatic) is assumed to be 100% fish. Fish tissue concentrations measured form the site are preferred as data, however, modeled concentration data can be used. For piscivorous receptors:

$ADD_A = EPC \times I_A \times BAF$ (BAF, BSAF or BCF)

Where:

EPC	= Exposure point concentration in surface water (mg/L) or sediment (mg/kg)
I_A	= Ingestion rate of fish matter ($kg/kg_{bw}^{-1}/d$)
BAF	= surface water to fish (BCF, L/kg) or sediment to fish concentration factor (BAF, BSAF, $L/kg_{fish\ tissue}^{-1}$)

(note if fish tissue data are available the EPC and BAF variables are replaced with fish tissue wet weight COPEC concentration data)

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

$$ADD_S = EPC \times I_S,$$

where:

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

Continuous year-round exposure or a temporal use factor (TUF) of 1 is assumed for most receptors. However, migratory species should be scaled as indicated in the Ohio Ecological Risk Assessment Guidance (February 2003).

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). will be presented in each AOC/EU sampling and analysis plan.

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 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).
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 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 multiplying 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 AOC/EU are estimated by multiplying exposure factors by the EPC, a conservative estimate of the COPEC concentration. Two EPCs (95% UCL and mean) are developed for each AOC/EU for each COPEC.

Approved background soil concentrations and exposure factors specific to the algorithms are available in several final ecological risk assessment documents; *e.g.* Phase II RI for the WBG (Appendix L). Background and exposure factors should be specified in each AOC/EU sampling and analysis plan. Some of these tables have been excerpted from the Phase II RI report for WBG and placed in Appendix A of this work plan. It should be noted that the most current TRV information should be employed in the sampling and analysis plan for future AOC investigations.

4.3 SUMMARY OF EXPOSURE ASSESSMENT

The EPCs of COPECs in media at sites at EUs will be 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 to characterize the risks to endpoint receptors from direct and indirect exposure to COPECs.

4.4 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 stressors at the EU 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 chemical stressors at concentrations or doses (or other units of stress) to which they are exposed.

4.4.1 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.

Chronic (long-term) toxicity resulting from chemical constituents will be the primary concern at the EU. VOCs are unlikely to remain at high concentrations based on the physical/chemical properties of which can be found in general chemistry references. 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 affected.

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 planned for the EUs.

Explosive compounds have varied uptake in plants based on the plant physiology. Many plants can use the explosives compounds as nutrient sources at relatively low levels. These plants seem to accumulate the highest levels of explosives in and around the root matter. Based on the on site studies at WBG, explosives can be toxic to many plant species. Explosives also have been shown, in the peer reviewed scientific literature, to be toxic to animals. Animals have not been shown to accumulate measureable amounts of explosives in the tissue. For the remaining EUs at RVAAP, no further studies are planned to investigate the effects of explosive on plants and animals.

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. Constituents in numerous ways can adversely affect plants, 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.

4.4.2 Toxicity Reference Values

This effects assessment will use 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.

Ecological effects data are available for many ecological COPECs at the RVAAP. 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. Hazards or HQs are calculated using the toxicity thresholds for COPECs from the soil.

Toxicity reference values (TRVs) for endpoint receptors exposed to COPECs 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 sub chronic values. Following Ohio EPA DERR Level III Draft Ecological Risk Assessment Guidance (February 2003), Figure C-1.

4.5 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 potential for 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 smaller of the UCL_{95} and maximum; For informational purposes OHEPA permits the use of the mean in addition to the use of the lower of the maximum value or the 95% UCL] 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:

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

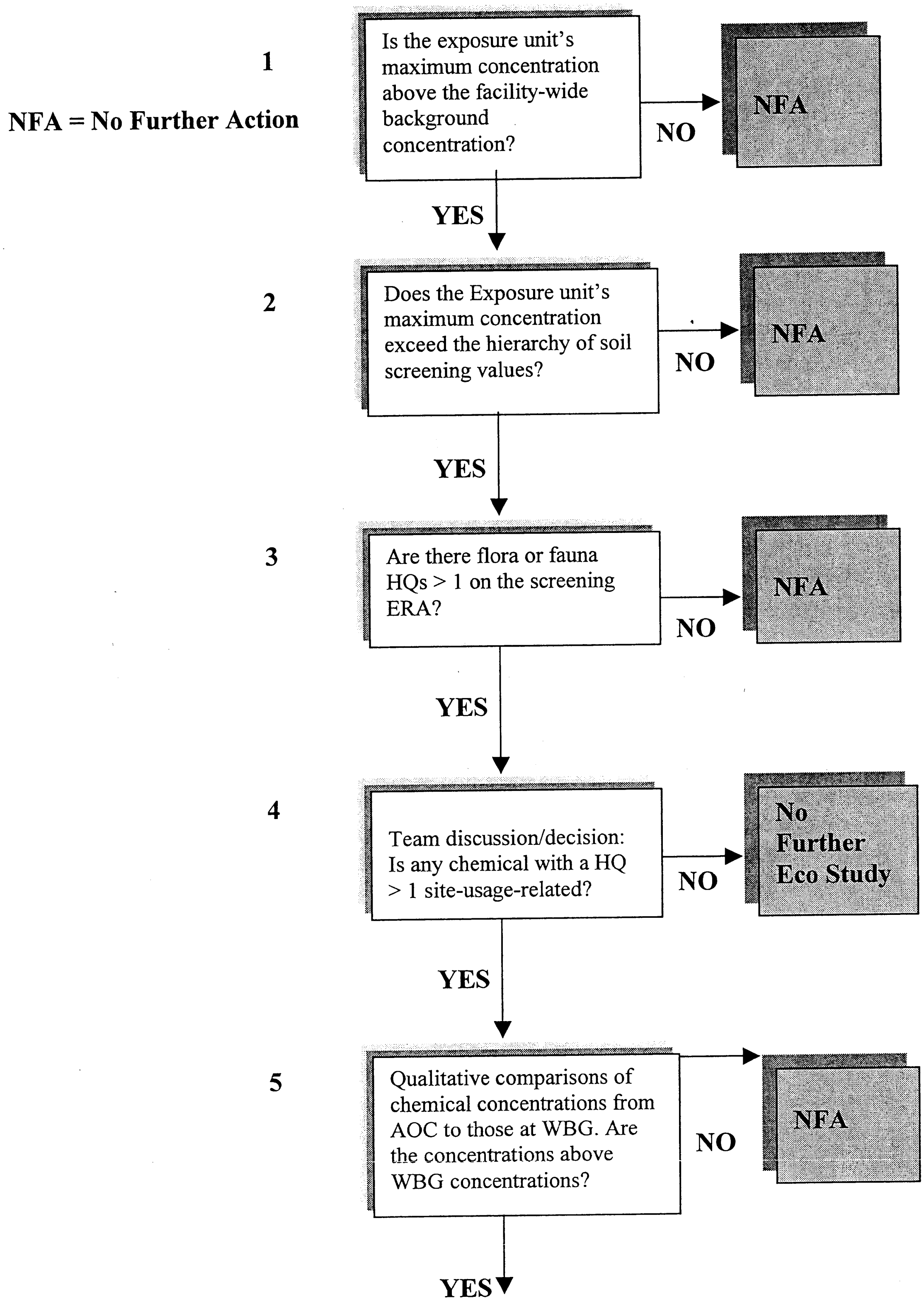
Where an HQ could not be calculated because insufficient data were available to establish a toxicity threshold, COPECs were carried through the risk characterization as COPECs of uncertain risk to ecological receptors.

An HQ greater than unity (1; rounded to one significant figure) 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 assumes that the toxicity threshold and exposure concentrations are accurate. In reality, the range of values around 1 within which HQs may or may not indicate the existence of risk increases with the uncertainty of the estimated exposure and toxicity threshold concentrations.

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 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), then the concentration is less than that anticipated to cause deleterious ecological effects. Any hazard quotient greater than 1 indicates that the ecological COPC qualifies for further investigation of the actual likelihood of harm, *e.g.*, 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.

From the regulatory viewpoint, any HQ greater than 1 means possible ecological risk and the need to pursue more risk characterization or remedial options. However, from a technical viewpoint, the higher the HQ, the greater the potential hazard to ecological receptors. A weight-of-evidence analysis and/or "ground-truthing" of the HQs may be beneficial in the evaluation of the potential ecological harm. (See Flow Chart)

Figure III. Ecological Risk Assessments For Soil at RVAAP



ECOLOGICAL RISK ASSESSMENTS FOR SOIL at RVAAP

6 Risk Management Analysis – Army & Ohio EPA

4.5.1 Plan for AOCs with Terrestrial habitat and receptors

For those AOCs with comparable soil and topography to that of WBG, the terrestrial ecological risk assessment for the remaining AOCs to be covered by this plan will be based on the integration of Ohio Ecological Risk Guidance and the extrapolations from the field measurements from WBG (SAIC, 2001). The current outline for this process includes 6 analysis steps (Figure 3). The integration and WBG extrapolation is meant to utilize the biological measurements at WBG, to speed the ecological risk process, and to make it less costly. Use of this paradigm allows decisions as to: (1) whether no further ecological studies are required; (2) whether to perform additional ecological studies at a site to determine ecological risk or impact; or (3) whether no further cleanup action is required because there is no evidence to substantiate the existence of ecological risk or impact.

Within the AOC, specific units can be delineated as separate EUs. This allows for analysis within reasonable home range for some of the most exposed biota. Also in this way, separate areas of high contamination, hot spots, will be easier to identify. Exposure unit borders should be drawn such that territory with similar functional or contaminant history can be grouped.

The steps involved in this decision-making flow chart (Figure III) include:

Step 1 – Compare the AOC contaminant concentrations to the facility-wide background concentrations. Based on site-wide inventories of plant and vertebrate biota sponsored by the Ohio Department of Natural Resources (1993), RVAAP in general has a well-balanced and healthy biotic community. Background concentrations that exceed state screening levels are not expected to have ecological impact. If no exceedences are noted, then no further action is required. Contaminant/s that fail the background screen or contaminants without background criteria continue to step 2. It should be noted that background values are only available for inorganic compounds.

Step 2 – For each contaminant, determine the exposure unit's maximum and average concentration and screen it against the soil screening values, except for substances that have a PPL as the PPL then becomes the preferred criteria. Soil screening values are considered to be concentrations for which no ecological impacts are expected. The soil screening value hierarchy is to be used in finding the appropriate screening values for soils, and is to be used in the order given below:

- Preliminary Remediation Goals for Ecological Endpoints, Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones, August 1997, ES/ER/TM-162/R2, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831;
- Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invetebrates and Heterotrophic Process; 1997 Revision, Efroymson, R.A., M.E. Will, and G.W. Suter II, ES/ER/TM-126/R2, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831;
- Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision, Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, ES/ER/TM-85/R3, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831;

- Ecological data Quality Levels (EDQL), U.S. EPA, Region 5, Final Technical Approach for Developing EDQLs for RCRA Appendix IX Constituents and Other Significant Contaminants of Ecological Concern, April 1998.

Use of the maximum EU chemical concentration is a conservative screen, but allows for concentration on those chemicals that are more likely to invoke ecological impacts. If no exceedences are noted, then no further action is required. Contaminant/s that fail the screen (using maximum concentration values) continue to step 3. The average concentration screen can be used by the risk managers to assess the necessity of continuing ecological risk assessment for the site.

Step 3 – A screening level ERA with realistic exposure factors instead of conservative assumptions is performed (Step 2) for relevant flora and fauna for contaminants remaining from the first two screening steps. If the HQ/HI values developed are less than 1, then no further action is required. If the HQ/HI values are greater than 1, then the contaminant/s continue to step 4.

Step 4 – The RVAAP risk management/assessor team should discuss and decide if a contaminant in some way correlates to site usage or suspected usage. There are currently no acceptable organics in RVAAP background, and yet it is possible that some organics are ubiquitous. This step is designed such that if it can be shown that the chemical has no possible link to site activity, no further action may be considered by the risk managers. If the contaminants pass the usage screen, decision-makers will proceed to step 5.

Step 5 – The biological walk over survey (to include such items as topography, history, geology, hydrology, and the like) will determine comparability between WBG and the new AOC/EU. Any comparable EU with chemicals remaining at this point in the decision process is compared qualitatively against field-collected data from WBG. Respective constituents between the EU and the WBG will have their "mean" concentrations compared. The comparison of ecological criteria for soil at WBG to reference areas showed no impact; thus, it has been extrapolated that the chemical concentrations at WBG are not at levels great enough to invoke impact to the most exposed biota (*i.e.* plants and small mammals). If the qualitative means comparison shows no difference or exceedance of WBG concentrations by the EU, it can then be determined that impacts to plant receptors is unlikely and no further action for the evaluation of plant receptors is recommended. If the qualitative means comparison shows that EU- concentrations exceed the WBG,or if animal receptors are identified to be at potential risk, then the chemical moves forward in the analysis step. The results of this qualitative evaluation is to be used in step six below.

Step 6 – Allows the Army and Ohio EPA to determine if there is still a significant ecological effect based on existing weight of evidence. Respective to bare areas it is understood that these areas may or may not represent a large enough proportion of the total system and may or may not result in a loss or disruption of ecosystem function to the point the system is impaired. For example, soil compaction, gravel and cinders can also alter the measured floristic parameters. While it may be true that contamination is the cause of the observed floristic community differences, the physical disturbance of the soil can be equally responsible for these differences. Further, can Ohio National Guard studies, other published literature, or other weight-of-evidence for specific receptors and for ecological COCs demonstrate an absence of ecological effects in the habitable area? If so, no further action is required. If the weight-of-evidence does not clearly support evidence of ecological impact then the decision-makers evaluate cost. The costs of further ecological studies are evaluated against the costs of remediation. If the cost effectiveness of a study that could resolve the concern over the presence or absence of ecological effects is greater than the cost of remediation, the management option selected would be to remediate even though ecological effects remain questionable. However, if the effective costs of remediation are greater than the cost of the study that could demonstrate no ecological effect, additional study would be the logical step.

At some of the AOC exposure units, there will likely be chemicals identified in soil that do not correlate with those identified at WBG. These chemicals will follow the first 4 steps of the decision flow chart described above. Chemicals that remain, as chemicals of potential concern (COPCs) at this point must be further investigated based on properties of fate and transport, bioaccumulation, and toxicity to relevant receptors. The decision-makers must use professional judgement to determine remediation goals for these chemicals based on the properties described above and the relevant receptor groups. Tools available to allow such decisions include, review of current scientific literature or site-specific ecological inventories, use of baseline risk assessment equations, and performance of small-scale ecological survey studies.

A similar strategy should be employed for any non-aquatic AOC or EU that is not considered comparable to WBG (*e.g.* forest area). As described above, steps 1-4 should be followed as listed. It is very important that the appropriate ecological receptors should be considered for this type of habitat. Professional judgement will again guide the selection of remedial goal determination or the necessity for further study using the tools described above.

UXO may be an issue at some AOC locations. The risk management team should evaluate the risk assessment results in conjunction with the planed action for UXO for the AOC.

4.5.2 PLAN FOR AOCS WITH AQUATIC HABITAT AND RECEPTORS

Most of the surface waters of the facility will be investigated in the RVAAP facility wide surface water study; however, some water bodies within the boundaries of the AOC may be investigated as part of the RI. The aquatic habitats at RVAAP will directly follow the Ohio EPA Ecological Risk Assessment Guidance Document (February 2003) with secondary consideration to the following documents.

1. Biological Criteria for the Protection of Aquatic Life, Volume I: The Role of Biological Data in Water Quality Assessment, 24 July 1987 *(updated 02/15/88)*, Ohio Environmental Protection Agency.

2. Biological Criteria for the Protection of Aquatic Life, Volume II: User's Manual for Biological Field Assessment of Ohio Surface Waters, 30 October 1987 *(updated 01/01/88)*, Ohio Environmental Protection Agency.

3. Biological Criteria for the Protection of Aquatic Life, Volume III: Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities *(First Update 09/30/89)*, Ohio Environmental Protection Agency.

4. The Qualitative Habitat Evaluation Index [QHEI]: Rationale, Methods, and Application *(11/06/89),* Ohio Environmental Protection Agency.

5. The Ohio Rapid Assessment for Wetlands [ORAM ver 5.0] *(02/01/01),* Ohio EPA, Division of Surface Water.

Within each AOC, the ephemeral streams (*i.e.* ditch lines) should be grouped as a single EU wherever there is a single point of origin. Ditch lines, streams, ponds, and wetlands may extend across or into more than one AOC. This must be addressed in the assessment for such AOCs.

4.5.2.1 Surface Water Evaluation

Surface water concentrations of all water bodies are to be compared to the Ohio EPA Chemical Specific Water Quality Criteria found in 3745 of the OAC. If all surface water chemicals detected in surface waters on-site are below their appropriate chemical criteria and chemical criteria exist for all detected compounds, then surface water can be eliminated as an exposure medium. If surface water chemicals exceed their Chemical Criteria, no chemical criteria are available, or Persistent, or Bioaccumulative Toxicants are present in the surface water, then they are to be retained as surface water COPECs (see Ohio Ecological Risk Assessment Guidance for a list of PBT).

Habitat Evaluation - Lotic

To evaluate stream habitat quality, a Qualitative Habitat Evaluation Index (QHEI) score is calculated. The QHEI, developed by Ohio EPA, is a physical habitat index, which provides a quantified evaluation of the lotic macrohabitat characteristics important to fish communities. The QHEI is calculated by assigning scores for each of the following six metrics:

1. Quality of Substrate
2. Type of In-Stream Cover
3. Channel Morphology
4. Riparian Zone and Bank Erosion
5. Pool/Glide and Riffle/Run Quality
6. Gradient

The sum of the scores from these metrics yields a total score that numerically rates the habitat of a particular stream reach. The highest score represents a high quality, undisturbed habitat. Scores from 60-100 are expected to sustain fish and macroinvertebrate populations indicative of warm water habitat. A score between 45 and 60 allows for best professional judgement by the senior field biologist.

Habitat Evaluation- Lentic

This evaluation must be performed by a certified wetland biologist as per the protocols of the Ohio EPA wetland designations.

4.5.2.2 Fish (Lotic and Lentic*)*

For those aquatic areas that would be considered as possible habitat for fish, the Index of Biotic Integrity (IBI) and the Modified Index of Well Being (MIWB) are the indices for evaluation. In lentic systems the IBI will be used qualitatively and comparisons will be made against reference ponds.

The IBI is a multi-metric index originally described by Karr (1981) and Fausch et al. (1984) and further developed by the Ohio EPA. Each of the twelve metrics is scored as one, three, or five with a maximum additive score of 60. A higher metric score is considered more favorable and the sum of the metrics becomes the IBI score. The overall IBI score is compared to narrative ranges developed by the Ohio EPA for the eco-region.

The twelve IBI metrics for wading sites (greater than 20 mi^2 drainage areas) are as follows:

1. Total Number of Indigenous Fish Species
2. Number of Darter Species
3. Number of Sunfish Species
4. Number of Sucker Species
5. Number of Intolerant Species
6. Percent Abundance of Tolerant Species
7. Percent Omnivores
8. Proportion as Insectivores
9. Percent Top Carnivores
10. Number of Individuals
11. Proportion of Individuals as Simple Lithophilic Spawners
12. Percent DELT Anomalies

The MIWB is also used to evaluate fish populations. The MIWB incorporates four measures of fish communities: numbers of individuals, fish biomass, and the Shannon Diversity Index based on both numbers and weights (Ohio EPA, 1987). All relative numbers and relative weights are adjusted to represent a 0.3 km sampling reach at non-headwater sampling sites. The MIWB is based on a scoring range of 1 to 10 with 1 being "very poor" and 10 being "exceptional" quality.

4.5.2.3 Benthic Macroinvertebrates (Lotic and Lentic)

The Ohio EPA uses a combination of quantitative and qualitative sampling methods to collect data on benthic diversity, relative abundances, and distribution. The principle measure of overall macroinvertebrate community condition is the Invertebrate Community Index (ICI; Ohio EPA, 1987). The ICI is a modification of the IBI described above and consists of the ten structural community metrics:

1. Total Number of Taxa
2. Total Number of Mayfly Taxa
3. Total Number of Caddisfly Taxa
4. Total Number of Dipteran Taxa
5. Percent Mayfly Composition
6. Percent Caddisfly Composition
7. Percent Tribe Tanytarsini Midge Composition
8. Percent Other Dipteran and Non-insect Composition
9. Percent Tolerant Organisms
10. Total Number of Qualitative Ephemeroptera/Plecoptera/Trichoperta (EPT) Taxa

Metrics 1-9 are generated from artificial substrate data while metric 10 uses only qualitative data. The point system associated with each metric is based on drainage area and allows a sample to be evaluated against a database of 247 relatively undisturbed reference sites throughout Ohio. Points are assigned based comparability to exceptional, good, and slight deviation from good. Zero points are assigned for major deviation from good values. The maximum additive ICI score possible is 60 with higher scores being indicative of a healthier benthic community. The sum of the individual metric scores is the overall ICI score, which is then compared to Ohio EPA criteria.

4.5.3 Overall Evaluation

The results of the IBI, MIWB, and ICI are compared against the Narrative ranges of Huron/Erie Lake Plain (Ohio, 1987). Ohio EPA has set an overall goal of "marginally good" to be in full attainment of the warm water habitat (WWH). Partial attainment of WWH is achieved if any of the three scores are in the "marginally good" range with the remaining indices scoring in the 'fair' category. If any of the index scores are in the 'poor' or 'very poor' range, the site will be considered in non-attainment, thus requiring some remedial action. If the stream is in partial attainment a determination must be made as to the cause of impact, *i.e.*, physical or chemical. Partial attainment due to chemical impacts may require some remedial action.

5.0 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 the COPECs are to be summed to show 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 should be reported on a receptor-by-receptor basis and tabulated.

6.0 UNCERTAINTIES

In this Section the four inter-related steps of the EPA approach to ERA should discuss uncetainties for the EU: problem formulation, exposure assessment, effects assessment, and risk characterization. The uncertainty section is the location where various information can be weighed and evaluated outside the rigid bounds of the HQ process. In addition, the uncertainty section gives some estimates of the ranges of "risks" posed to ecological receptors based on the uncertainties in the various sections of the risk assessments. Information that the author of the assessments thinks is important for the risk managers and for the decision makers should be introduced and discussed thoroughly in the uncertainty section.

7.0 EXAMPLES OF GUIDANCE

The following documents are provided for reference. Additional documentation may be used as required.

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