Palmerton Zinc Pile Superfund Site
Natural Resource Damage Assessment Plan

Prepared by

The Palmerton Natural Resource Trustee Council

Commonwealth of Pennsylvania
Department of Environmental Protection
Department of Conservation and Natural Resources
Fish and Boat Commission
Game Commission

U.S. Department of Commerce
National Oceanic and Atmospheric Administration

U.S. Department of the Interior
National Park Service
Fish and Wildlife Service

February 2006

This Page Intentionally Left Blank

EXECUTIVE SUMMARY

Three Federal and four State agencies responsible for managing natural resources on behalf of the public are jointly conducting a natural resource damage assessment (NRDA) of resources in the vicinity of the Palmerton Zinc Pile Superfund Site, Carbon County, Pennsylvania that have been impacted by the release of metals from this site. This Natural Resource Damage Assessment Plan provides information on planned and ongoing studies designed to evaluate past, current, and future impacts to these resources and the services they provide. In addition, the Plan outlines how information gathered from these studies will be used to determine how much restoration is needed to address these impacts.

The multi-agency group, known as the Palmerton Natural Resource Trustee Council, will evaluate environmental impacts from historical zinc smelting and waste handling operations, which have resulted in extensive deforestation and soil loss in the area of the Lehigh Gap. Habitat impacts have affected the diversity and abundance of plants and animals. Aquashicola Creek and the Lehigh River have received contaminated runoff at levels that have impacted aquatic life. The U.S. Environmental Protection Agency is in charge of clean-up at the Palmerton Zinc Pile Site under the Federal Superfund Program, but clean-up activities will not compensate the public for losses associated with injuries to natural resources. Parties liable for Site cleanup under Superfund law are also held responsible for natural resource injuries and will be asked to compensate the public for such losses by funding assessment studies and restoring or acquiring equivalent resources.

Natural resources in and around the Superfund Site include: National Park Service land along the Appalachian Trail; State Game Lands on Blue Mountain; Aquashicola Creek and the Lehigh River; upland habitat on Stony Ridge; wetlands; migratory birds, threatened and endangered species, wildlife, reptiles, amphibians, fish, and their supporting habitat; and groundwater and surface waters. Impacts to human services provided by these resources such as fishing, hunting, hiking, wildlife viewing, resource management, and timber production will also be evaluated. The agencies represented by the Natural Resource Trustee Council include the U.S. Fish and Wildlife Service, National Park Service, National Oceanic and Atmospheric Administration, Pennsylvania Game Commission, Pennsylvania Fish and Boat Commission, Pennsylvania Department of Environmental Protection and the Pennsylvania Department of Conservation and Natural Resources.

The council intends to follow U.S. Department of Interior guidelines for NRDA as described in Code of Federal Regulations at Title 43 Part 11. This process includes steps to: screen resources to determine if injury connected to releases of hazardous substances from the Superfund Site has occurred; quantify injury to plants, animals, soils, sediment, and water affected by the contamination in terms of service losses; and determine the types and quantity of restoration required to compensate for all these losses. The council intends to involve the public throughout the natural resource damage assessment process to exchange information and focus assessment and restoration activities. The council will

also work with the U.S. Environmental Protection Agency and parties involved in clean-up to achieve the most successful result.

LIST OF EXHIBITS

LIST OF ACRONYMS

As	arsenic
AT	Appalachian National Scenic Trail
AWQC	ambient water quality criteria
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cd	cadmium
CFR	Code of Federal Regulations
COPC	contaminants of potential concern
Cr	chromium
Cr(VI)	hexavalent chromium
Cu	copper
CWA	Clean Water Act
DOI	U.S. Department of the Interior
FS	feasibility study
GIS	geographic information systems
GPD	gallons per day
HEA	habitat equivalency analysis
MCL	maximum contaminant level
metals	arsenic, cadmium, chromium, copper, lead, manganese, and zinc
Mn	manganese
MOA	Memorandum of Agreement
ND	below detection limit
NDVI	normalized difference vegetation index
NOAEL	no observed adverse effects levels
NPS	National Park Service
NRDA	natural resource damage assessment
NOAA	National Oceanic and Atmaospheric Administration
OU#	operable unit
Pb	lead
PDCNR	Pennsylvania Department of Conservation and Natural Resources
PDEP	Pennsylvania Department of Environmental Protection
PENNVEST	Pennsylvania Infrastructure Investment Authority
PFBC	Pennsylvania Fish and Boat Commission
PGC	Pennsylvania Game Commission
PNHP	Pennsylvania Natural Heritage Program
PRP	potentially responsible party
RI	remedial investigation
ROD	Record of Decision
Site	Palmerton Zinc Pile Superfund Site
SGL	State Game Land
SQG	sediment quality guideline
SSL	soil screening levels
SDWA	Safe Drinking Water Act
USEPA	U.S. Environmental Protection Agency

USFWS	U.S. Fish and Wildlife Service
ww	wet weight
Zn	zinc

This Page Intentionally Left Blank

CHAPTER 1: INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) is the lead Agency in charge of cleanup at the Palmerton Zinc Pile Site (Site) under the Federal Superfund Program, but clean-up activities will not compensate the public for losses associated with injuries to natural resources. Parties liable for Site cleanup under Superfund law (potentially responsible parties, PRPs) are also held responsible for natural resource injuries and will be asked to compensate the public for such damages by reimbursing for the costs of assessment studies and funding projects to restore or acquire equivalent resources.

Natural resources in and around the Site include, but are not limited to: National Park Service land along the Appalachian Trail; State Game Lands on Blue Mountain; Aquashicola Creek and the Lehigh River; upland habitat along Stony Ridge; wetlands, migratory birds, threatened and endangered species, reptiles, amphibians, other wildlife, fish, and their supporting habitat; soils and sediments; and groundwater and surface waters. Impacts to human services provided by these resources such as fishing, hunting, hiking, wildlife viewing, resource management, and timber production will also be evaluated.

State and Federal agencies are working together as natural resource Trustees to assess the full extent of injuries to natural resources and to develop a restoration plan. The agencies represented by the Natural Resource Trustee Council include the U. S. Fish and Wildlife Service (USFWS), National Park Service (NPS), National Oceanic and Atmospheric Administration (NOAA), Pennsylvania Game Commission (PGC), Pennsylvania Fish and Boat Commission (PFBC), Pennsylvania Department of Environmental Protection (PDEP) and the Pennsylvania Department of Conservation and Natural Resources (PDCNR).

Acting under their authority as natural resource Trustees under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and other Federal and State authorities listed in the Memorandum of Agreement (MOA) between Trustee agencies at this site (Trustees 2003a), the Trustees are conducting a natural resource damage assessment (NRDA). This Assessment Plan (Plan) serves as the guiding document for NRDA activities at the Palmerton Zinc Site.

1.1 Purpose

The purpose of this Plan is to structure the NRDA to ensure that it is performed in a planned and systematic manner and at a reasonable cost. Reasonable cost means that the anticipated cost of the assessment is expected to be less than the anticipated damage amount determined in the assessment. This Plan describes the activities currently proposed by the Trustees. These efforts are designed to provide more information on the nature and extent of the injuries associated with metal contamination around the Palmerton Site. The Trustees also intend for this Plan to communicate proposed assessment methodologies to the public, including the PRPs, so that they can participate in the assessment process.

1.2 Plan Organization

General guidelines for performing a natural resource damage assessment involving hazardous substances such as metals are described in regulations written by the U.S. Department of the Interior (DOI) and appear in the Code of Federal Regulations at Title 43 Part 11. The framework for this plan is consistent with the DOI regulations and provides an effective means of considering the impacts of metal contamination in the environment around Palmerton.

This Plan documents that natural resources around Palmerton have been exposed to contamination by metals. Those natural resources for which exposure to metals has been confirmed are:

- Biological resources, including plants, fish, birds, mammals, amphibians, and invertebrates;
- Surface water resources, including sediments;
- Groundwater resources; and
- Geologic resources, including soils.

This Plan provides information regarding three major steps in the assessment: 1) injury determination, including pathway, 2) injury quantification, and 3) damage determination and restoration.

1.3 Coordination of Trustees

The Trustees signed an MOA which provides a framework for coordination and cooperation among the Trustees (Trustees 2003a). Under the MOA, the Trustees created the Trustee Council for the purpose of coordinating their efforts in order to effectively meet their mutual goal of restoring injured natural resources.

1.4 Modification and Amendments to the Plan

Development of this Plan will be an iterative process. Due to the complex nature of existing data sets, potential breadth of natural resource injuries, and aerial extent of the assessment area, it would be too cumbersome to include all specific study plan components within this document. Instead, specific study plans for each natural resource will be developed as ancillary Plan documents and amended to the Plan following public review. This approach provides flexibility to the Trustees as they evaluate new information and consider funding and workload issues during the course of the injury assessment. The partitioning of injury assessment studies into separate but linked documents also simplifies Trustee activities by creating discrete task sets and facilitates public participation.

This Plan may be modified at any stage of the assessment as new information becomes available and as specific study plans are developed. Significant modifications to the Plan (i.e., resource-specific study plan amendments) will be made available for review by the PRP, any other affected natural resource Trustees, other affected Federal or State agencies, and any other interested members of the public for a period of at least 30 calendar days, with reasonable extensions granted as appropriate. Non-significant modifications may also be made available for review, but implementation of such modifications need not be delayed as a result of the review.

1.5 Public Review and Comment

Copies of the Plan and any modifications or amendments will be made available to the public at the Palmerton Library and on the internet at the following Federal and State websites:

http://www.fws.gov/contaminants/restorationplans/palmerton/palmerton.cfm
http://www.dep.state.pa.us/dep/deputate/airwaste/wm/remserv/nrd/nrdhome.html

Other Trustee documents including the Preliminary Assessment Screen, MOA, Cooperative Funding Agreement and Fact Sheets are also available on these websites. The Trustees encourage active participation of the public in this damage assessment and intend to continue coordination with the general public as this damage assessment proceeds.

A 30 day public comment period was announced in a Notice of Availability, published in the Federal Register (Vol. 70, No. 156 / Monday, August 15, 2005). The Plan has been updated to include the public comments received, Trustee responses and resulting modifications to the plan (Appendix A).

The U. S. Fish and Wildlife Service, acting as Lead Administrative Trustee, is the central contact point for the Trustee Council. Copies of the Plan and other information may be requested in writing or by e-mail to:

Steve Klassen
U.S. Fish and Wildlife Service
Pennsylvania Field Office
315 South Allen Street, Suite 322
State College, PA 16801
e-mail: steve_klassen@fws.gov

The Trustees will also make publicly available subsequent injury study planning documents and/or reports as they are developed.

1.6 Cooperation with Responsible Parties

The NRDA regulations encourage the invitation of PRPs to participate in the assessment process. The Trustee Council has met with a PRP, Viacom International, Inc., and has entered into a cooperative funding agreement designed to provide a framework for a

cooperative NRDA process. This agreement is available for review on the websites listed above.

1.7 Injury Assessment Time Line

The Trustees do not yet have a firm time line for the implementation and completion of the injury assessment phase of this NRDA. A time line may be modified depending on such variables as participation by PRPs in a cooperative assessment, identification of remedial alternatives by the USEPA, public comment on assessment and study plans and environmental conditions (e.g. weather and flooding) that could restrict ancillary study plan(s) implementation. Given these areas of uncertainty, however; the Trustees believe that the bulk of the injury assessment work could be completed within the next two (2) years.

CHAPTER 2: BACKGROUND INFORMATION

The Palmerton Zinc Pile Superfund Site is located in the Ridge and Valley Province of Carbon, Lehigh, and Northampton Counties, Pennsylvania. Facilities at the Site include the East and West Plants of the former New Jersey Zinc Company, a primary zinc smelting facility. This facility discharged metals to the surrounding environment via air emissions and through the release of solid wastes, including the creation of a large waste pile (the "cinder bank"). Hazardous substances released to the environment from these facilities include arsenic, cadmium, chromium, copper, lead, manganese, and zinc (metals).

The Palmerton valley is bordered by Blue Mountain to the south, Stony Ridge to the north, and is cut through by the Lehigh River to the west of the Borough of Palmerton (Figures 1, 2). Aquashicola Creek drains the majority of the site, flowing in a southwest direction through the town of Palmerton and joining the Lehigh River at the Lehigh Gap. Over ninety years of smelting operations emitted large quantities of metals that were wind carried and deposited over surrounding areas. The release of these metals resulted in defoliation of thousands of acres throughout this ridge and valley area of eastern Pennsylvania (USEPA 1987a, USEPA 1987b). The National Park Service owns and maintains approximately 1500 acres of land that has been acquired to protect the Appalachian National Scenic Trail in this area, which winds along the Blue Mountain ridge and through the associated gaps. The Pennsylvania Game Commission also owns several thousand acres of potentially affected State Game Lands on Blue Mountain.

2.1 Natural Resources and the Service They Provide

Blue Mountain, also known as Kittatinny Ridge, is part of a long mountain ridge that runs over 250 miles from Southeastern New York through central Pennsylvania almost to Maryland. This ridge is one of Pennsylvania's most prominent natural features, forming the eastern-most edge of the ridge and valley region. Millions of people and hundreds of communities value the ridge for its scenic beauty, recreational opportunities, wildlife habitat and water supplies (Kittatinny Project 2002). The ridge has national importance as a habitat link in the Appalachian Forest and as a corridor for the Appalachian National Scenic Trail (AT) managed by the National Park Service. The PGC owns thousands of acres of forestland along the ridge, managing and protecting it for wildlife, recreation, and timber production. In addition, Game Lands adjacent to the AT are managed cooperatively with the NPS following principles designed to protect the AT (NPS 1995).

As part of a state-wide effort (Pennsylvania Natural Heritage Program, PNHP) to identify, survey, and map outstanding ecological areas within each county, Blue Mountain was highlighted as the most extensive, relatively contiguous area of natural habitat within Lehigh and Northampton counties (Lehigh Valley Planning Commission 1999). The PNHP data base of Ecological Resources of Special Concern includes endangered, threatened, candidate, rare, and tentatively undetermined species, as well as species of conservation concern that lack a jurisdictional entity in Pennsylvania with authority for listing, exemplary natural communities, and outstanding geologic features. A few of the listed species found around Blue Mountain and associated watersheds

include: bog turtle, Allegheny woodrat, timber rattlesnake, bald eagle, osprey, northeastern bullrush and many other plants. Blue Mountain is one of the major corridors for the movement of biota in eastern Pennsylvania. Blue Mountain is a leading line for the most significant raptor migration flyway in the northeastern US and the forest provides key breeding sites for many interior forest birds (Pennsylvania Audubon 1999, Hawk Mountain 2005).

This area of relatively unfragmented forests and associated watersheds provides important habitat to a great diversity of plants and animals. One of the most comprehensive biological surveys conducted in the area is from Hawk Mountain, located approximately 27 miles west of Lehigh Gap on Blue Mountain (Hawk Mountain Master Biota List 2002). The results of this survey include the identification of: 293 plants, 292 fungi, 17 fish, 35 reptiles and amphibians, 255 birds, 37 mammals and 476 invertebrates. The Hawk Mountain Breeding Bird List (2002) includes 106 species that were found or suspected to be breeding on and around the sanctuary property.

Although Blue Mountain is primarily upland forest, it includes streams, seeps, springs, and vernal pools. These riparian and wetland areas are important habitat for a wide diversity of plant species as well as for many animals, including birds, reptiles, amphibians, odonates (dragonflies and damselflies), and other aquatic insects. The Aquashicola Creek watershed is bordered by Blue Mountain to the south and Stony Ridge to the north. Aquashicola Creek, Buckwha Creek and the Lehigh River are the primary water bodies near the Site. Aquashicola Creek drains into the Lehigh River approximately 6 miles below it's confluence with the Buckwha. Aquashicola Creek and Buckwha Creek are managed by the State as trout stocked cold water fisheries. Aquashicola Creek and Buckwha Creek also support reproducing trout upstream of the mouth of Buckwa Creek. The Lehigh River is managed as a warm water fishery and is a popular river for both fishing and recreational boaters. The Lehigh River is also locally stocked with trout by the Lehigh River Stocking Association, supporting commercial guide services and other anglers in pursuit of trout.

2.2 Description of the Assessment Area

The assessment area is defined in the regulations as the area in which natural resources have been affected by hazardous substances released from the Site. For the purposes of this Plan, the area will include but is not limited to:

- Aquashicola Creek and adjacent wetlands and floodplains from one mile upstream of the confluence of Aquashicola and Buckwha Creeks downstream to the confluence of Aquashicola Creek with the Lehigh River (Exhibit 2-1);

- The Lehigh River and adjacent wetlands and floodplains from the confluence of the Lehigh River and Lizard Creek to downstream of the Cementon Dam in Cementon, PA (Exhibit 2-1);

- Blue Mountain extending from Lehigh Furnace Gap east to Smith Gap including State Game Lands 217 and 168 and National Park Service lands along the AT (Exhibits 2-1);

- Stony Ridge extending from the Lehigh River east to Little Gap (Exhibit 2-1); and

- Groundwater associated with the closed shallow aquifer wells used by the former Palmer Water Company and the deep aquifer wells currently used by the Palmerton Municipal Authority for the public water supply (Exhibit 2-2).

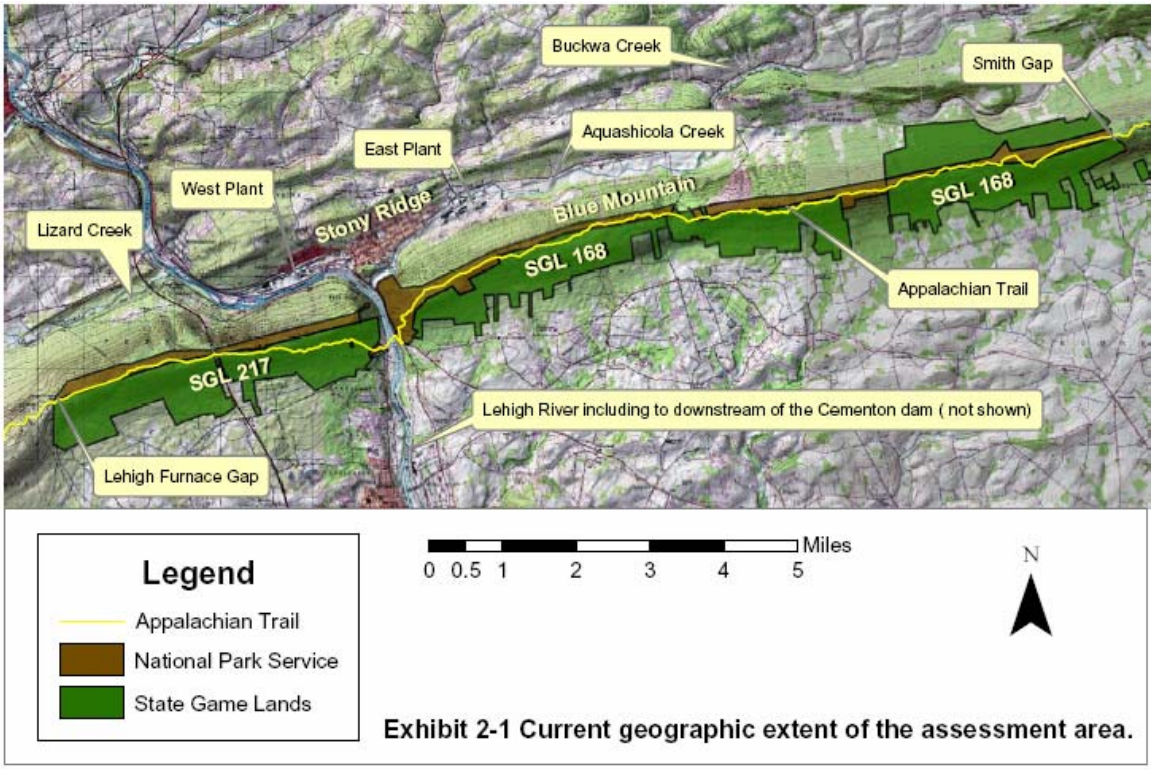

Exhibit 2-1 Current Geographic Scope of the Assessment Area

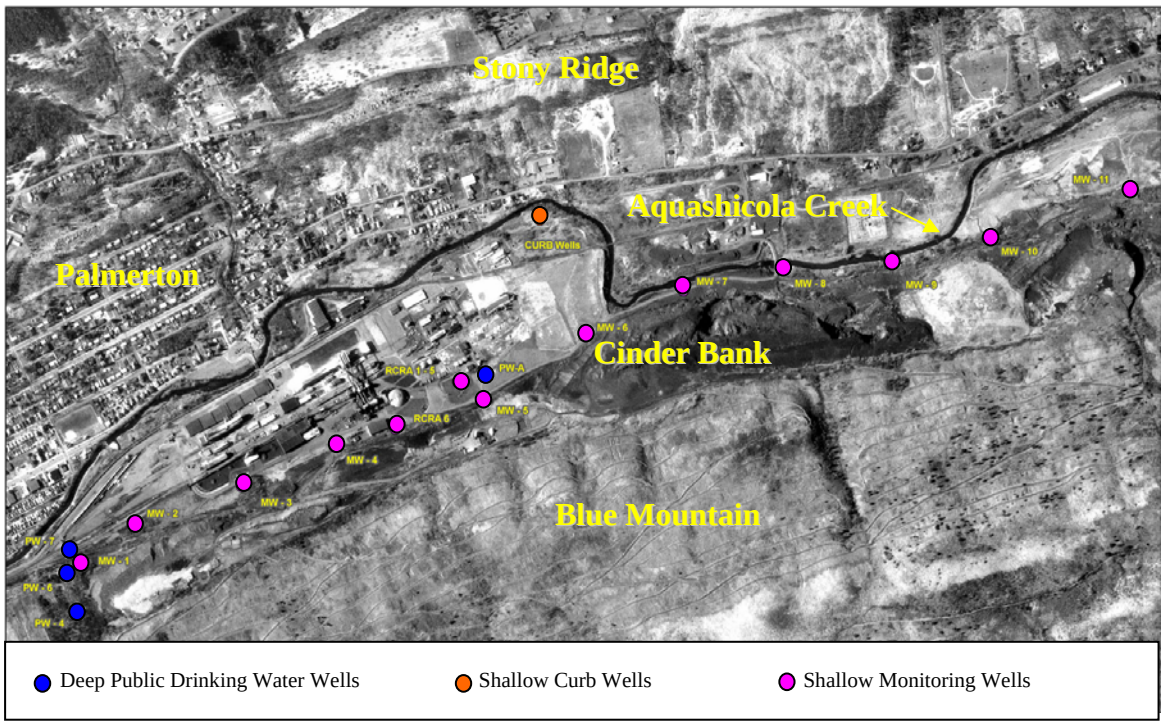

Exhibit 2-2 Shallow and Deep Groundwater Wells

2.3 Historical Industrial and Regulatory Activities at Palmerton

For nearly 70 years, the New Jersey Zinc Company deposited 30 million tons of slag at the Site, creating a cinder bank that extends for 2 ½ miles and measures over 200 feet high and 500 to 1,000 feet wide (USEPA 2005). The smelting operations, which included an East Plant and a West Plant, emitted huge quantities of metals throughout the valley. As a result, approximately 2,000 acres on Blue Mountain, which is adjacent to the former smelters, have been defoliated, leaving the mountain barren. Soil on the defoliated area of the mountain has contaminated the rain water flowing across it. Runoff, erosion, aerial deposition, and contaminated groundwater have deposited contaminants into Aquashicola Creek and the Lehigh River. The Palmerton Water Authority has four production wells at the foot of Blue Mountain that supply water to the Borough of Palmerton (approximately 5,000 people) and the Village of Aquashicola. These deeper bedrock wells have not been affected by contaminants from the Site to date. The USEPA is overseeing the cleanup of the Palmerton Zinc Pile, which is being carried out by Viacom International, Inc. and Horsehead Corporation. The Site is divided into four separate cleanups, known as operable units.

At Operable Unit #1 the USEPA's Record of Decision (ROD), which is a final clean up plan or remedy, requires that the PRPs revegetate about 2,000 acres of Blue Mountain (USEPA 1987a). The vegetation on the mountain was killed by air and soil contamination resulting from the historic smelting operations. So far, Horsehead has revegetated approximately 800 acres of land behind the East Plant. Horsehead utilized the application of a mixture of sewage sludge, fly ash, and limestone called Ecoloam®

with seeding to establish vegetation. Viacom is testing a different approach on the western side of Lehigh Gap that involves land application of compost, fertilizer, and seed, and in very steep areas, the aerial application of seed and fertilizer to grow grasses.

At Operable Unit #2 which is the clean-up of the Cinder Bank, the USEPA completed a ROD in 1988 which was later modified in 2002 (USEPA 1988, USEPA 2002a). Per these agreements, Horsehead built a system to divert surface water around the Cinder Bank and treat contaminated leachate before it is discharged to the nearby Aquashicola Creek and revegetate the non-burning and accessible portion of the Cinder Bank. This work was completed in the fall of 2002. Operations, maintenance, and monitoring of the Cinder Bank and the treatment system are ongoing.

At Operable Unit #3, which is the cleanup of residential soils throughout the Borough of Palmerton, and surrounding areas, the USEPA on October 9, 2001 issued a ROD for the clean-up of the contaminated residential soils (USEPA 2001a). Viacom, working under an USEPA Administrative Order, is completing implementation of the selected remedy. The selected remedy was a voluntary program of soil and interior dust sampling with remediation if concentrations exceeded the levels specified in the ROD.

At Operable Unit #4 which is comprised of Groundwater/Surface Water and Ecological Risks, Viacom is working on a Remedial Investigation (RI). After the RI is completed, a Feasibility Study (FS) will be completed which will evaluate several possible cleanup plans. After the RI/FS reports are completed, the USEPA expects to select a final remedy in a ROD forecast for 2007.

Severe erosion of contaminated soils from Stony Ridge into residential areas caused the initiation of the Stony Ridge Emergency Response Action in 1996. The USEPA's efforts to stabilize a limited area of eroding and contaminated soils on Stony Ridge are completed, although maintenance is conducted on a periodic basis to ensure continued stability of the contaminated hillside. Ongoing surface run-off and erosion associated with the remaining denuded areas along the ridge may result in future remedial actions. Viacom has included Stony Ridge in the current scope of OU4 to address the erosion and sedimentation problems in non-mining areas.

2.4 Temporal Scope

The temporal scope of this assessment is based on determination of injury to natural resources and corresponding damages. Injury has occurred when there is:

> *A measurable adverse change, either long- or short-term, in the chemical or physical quality of the viability of a natural resource resulting either directly or indirectly from exposure to a…release of a hazardous substance (43 CFR Section 11.14 (v)).*

Within the assessment area, natural resource exposure to contaminants of concern and corresponding injury has likely occurred since 1898 and is expected to continue into the future. Damages based on these injuries, that is "*the amount of money sought by the*

natural resource trustee as compensation for injury, destruction, or loss of natural resources" (43 CFR Section 11.14 (l)), are calculated beginning in 1981 (in concordance with the promulgation of CERCLA) continuing at least through the reasonable expected recovery of each resource service. This rate of recovery will be determined based on information regarding remedial and restoration activities, natural attenuation, and resource recoverability.

2.5 Hazardous Substances Released within the Assessment Area

2.5.1 Contaminants of Concern

The Trustees intend to focus on exposure and injuries to natural resources due to the release of seven metals identified by the USEPA as contaminants of concern at the Site: arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), manganese (Mn), lead (Pb) and zinc (Zn). The USEPA described elevated levels of Cd, Pb, and Zn in soils, surface waters, and biota as metals of concern in the 1987 OU1 ROD. Stream sampling in 1984 identified Cd, Pb, and Zn as elevated in fish (USFWS 1986). The USEPA described elevated levels of Cd, Cu, Pb, and Zn in soils, sediments, surface waters, groundwater and biota as metals of concern in the 1988 OU2 ROD. The USEPA listed As, Cd, Pb and Zn as chemicals of potential concern (COPCs) in the 2001 OU3 ROD. All of the above inorganics are listed as hazardous substances in Table 302.4, List of Hazardous Substances and Reportable Quantities under CERCLA (40 CFR Part 302.4(a)), and as toxic pollutants pursuant to 40 CFR Part 401.15, as amended.

Following is a brief overview of each of the contaminants of concern, As, Cd, Cr, Cu, Mn, Pb, and Zn including effects and bioavailability. Note that all of these metals occur naturally, but that exposure to increased concentrations can cause both short term (acute) and long term (chronic) toxic effects to both flora and fauna. In general, these metals tend to be taken up by organisms through: plant uptake; ingestion of contaminated food, soil, sediment or water; inhalation; and dermal contact. Organisms are also capable of eliminating these metals from their systems by excretion as waste, leaf drop, and root death. While these metals can become elevated in an organism and even within specific tissues or organs, the process of elimination is generally sufficient to prevent them from becoming more concentrated as they move up through the food chain. Each of these contaminants is described individually but note that mixtures of these contaminants may cause synergistic or antagonistic effects. Sources for this information include the California Office of Health Hazard Assessment (CA OEHHA 2005), the Agency for Toxic Substance and Disease Registry (ATSDR 2004), the USEPA (USEPA 2001b), and the Handbook of Chemical Risk Assessment (Eisler 2000).

Arsenic: Plant uptake has been known to cause growth reduction, leaf wilting, discoloration, and cell dehydration and shrinkage. Vertebrates exposed to As may experience adverse effects such as decreased birth weight, skin discolorations, skeletal deformities, and impacts on the nervous system. In general, inorganic As is more mobile than organic As, but bioavailability depends on concentration of organic matter and other compounds, sediment characteristics, and pH.

Cadmium: Typical symptoms of Cd toxicity in plants include: growth retardation and root damage; chlorosis of the leaves; discoloration; and inability to form chlorophyll, metabolize nutrients, or photosynthesize. The toxicity of Cd to other biota include: decreased growth and reproductive rates, respiratory disruptions, alteration of life history patterns, negative effects on enzyme systems, and abnormal muscular function. Bioavailability depends on multiple factors, including adsorption and desorption rates of Cd from soil and sediment, pH, and chemical speciation.

Chromium: Symptoms of Cr toxicity in plants include wilting, root injury, and leaf discoloration. Vertebrates are also susceptible to Cr toxicity, especially hexavalent Cr (Cr(VI)). At high concentrations, Cr(VI) is associated with abnormal enzyme activity, altered blood chemistry, lowered resistance to pathogenic organisms, behavioral modifications, and disrupted feeding. Chromium toxicity to aquatic biota is significantly influenced by abiotic variables such as hardness, temperature, pH, and salinity.

Copper: The toxic effects of Cu on plants include tissue and cell damage, inhibitions of photosynthesis and growth, alteration of root permeability, and root malformation. Fauna also experience adverse effects when exposed to high levels of Cu, including behavior, growth, metabolism, and neurological disorders; and immune system suppression. Environmental parameters such as pH, alkalinity, and the presence or absence of other metals affect both the toxicity and the bioavailability of Cu.

Lead: The toxic effects of Pb on plants include reduced growth, photosynthetic activity, mitosis, and water absorption. In aquatic and terrestrial organisms, Pb toxicity can include mortality, reduced growth, reduced reproductive potential, blood chemistry alterations, lesions, and behavioral changes. Toxic in most of its chemical forms, soluble, waterborne Pb is the most toxic form to aquatic biota. The bioavailability of Pb in aquatic systems is a function of temperature, pH, and hardness. In terrestrial systems the bioavailability of Pb is dependent on soil characteristics such as pH, organic content and soil chemistry.

Manganese: Included here as a contaminant of concern in groundwater, Mn has the potential to cause toxic effects such as mental and emotional disturbances, slow and clumsy body movements, decline in motor skills and balance, and respiratory and sexual dysfunction. Exposure to Mn in this case would be through ingestion of contaminated water.

Zinc: Symptoms of Zn toxicity in plants include leaf discoloration, reduced root growth, and reduced plant growth. Examples of toxic effects of Zn in fish include destruction of the gills and tissue hypoxia; effects on mammals include anorexia, diarrhea, decreased milk yield, excessive eating and drinking, convulsions, and death. Zinc in aquatic systems tends to accumulate in sediments, where its bioavailability is dependent on pH, alkalinity, dissolved oxygen, and temperature.

2.5.2 Quantity of released substances

A variety of studies over the last three decades have documented elevated levels of metals in the Palmerton environment. As a result, the USEPA placed the site on the National Priorities List in September 1983. In examining the site, the USEPA has determined that the primary contributors of these metals to the Palmerton landscape were two former ore smelting plants (USEPA 1987b; USEPA 1993), one of which (East Plant) is currently operated as a hazardous waste recycling facility, primarily using electric arc furnace dust (USEPA 2002a). The second (West Plant) is currently shut down and is not included in any of the operable units.

The USEPA has reported that excessive air emissions from the two smelting plants caused the defoliation of the surrounding mountains (USEPA 1987b). Over the years, various sources at the smelters have emitted varying amounts of metals. It has been estimated that total emissions of Cd, Pb, and Zn were 3,740, 7,560, and 286,000 tons, respectively (USEPA 1987b). Using these estimates as a baseline, the USEPA estimated that the average emission rates of Cd, Pb, and Zn for the period of 1900 to 1979 was 47, 95, and 3,575 tons/year, respectively. The time period from 1970 to 1979 was estimated to have the highest emission rates at 105 tons/year of Cd, 322 tons/year of Pb, and 4,800 tons/year of Zn.

Additional ongoing releases contributing contamination to the environment include the cinder bank, Blue Mountain, and drainage ditches emanating from the defunct West Plant (USEPA 2001b), and may also include the existing metals recycling facility (USEPA 1993). There remain significant discharges to surface water and groundwater. In March 1986, runoff samples from seeps, springs, and surface drainages were analyzed and showed levels of Cd, Pb and Zn up to 20 times the USEPA ambient water quality criteria (USEPA 1987b). A study conducted by Horsehead Resource Development Corporation (HRDC 1987) concluded that rainwater infiltration and surface water infiltration were leaching metals from the cinder bank, resulting in a contribution of 80-95 percent of the metals loading to Aquashicola Creek. Runoff from Blue Mountain, combined with ongoing groundwater discharge under the cinder bank, continues to be the source of a significant quantity of metals released to the Aquashicola Creek (USEPA 2001b).

In addition, the metals that have come to be located in the sediments in Aquashicola Creek and the Lehigh River continue to be a source of contamination to the downstream environment. In 1998, sediments were dredged from the lower 4,200 ft of Aquashicola Creek adjacent to the East Plant and deposited on the cinder bank.[1] Post-dredging sediment analysis was not conducted because of a lack of remaining sediment, but water quality analyses indicated that surface water concentrations of Cd and Zn continued to be elevated in lower Aquashicola Creek (USEPA 2001b, Versar 2001). In addition, elevated metal levels have been measured in sediments in ditches draining into the Lehigh River from the west plant, and in sediments in the Lehigh River at the mouth of

[1] The dredging of these sediments was not related to the Superfund Site or associated remedial process, but dredging was sponsored by the U.S. Army Corps of Engineers to prevent flooding in portions of the Borough of Palmerton.

Aquashicola Creek and downstream as far as Cementon (USEPA 2001b). It is possible that metals concentrations are elevated downstream of the Cementon Dam, but available data are insufficient to determine contaminant levels in that reach of the river.

This Page Intentionally Left Blank

CHAPTER 3: NATURAL RESOURCE INJURY DETERMINATION

A wide range of natural resources and natural resource services under Federal or State trusteeship have been injured by the release of metals from the smelting facilities, and continuing releases from the cinder bank, Blue Mountain, and Stony Ridge. Natural resources include surface water, groundwater, sediment, soil, and biota. Each of these natural resources provides a variety of ecological and human services. For example, ecological services include nutrient cycling, food web sustainability, and regulation of water and air quality. Human use services include recreational activities (e.g., fishing, boating, hiking, and hunting) and timber and wildlife management. The following section describes these natural resources and the services they provide, and determines injury for each resource based on the definitions of injury in the DOI regulations (43 CFR Section 11.62).

Determination of injury for resources within the assessment area involves documentation that there is: 1) a viable pathway for the hazardous substance from the point of release to a point at which natural resources are exposed to the hazardous substance, and that 2) injury of site-related resources has occurred as defined in 43 CFR Section 11.62.

3.1 Pathway

Pathway is defined as:

> *The route or medium through which…a hazardous substance is or was transported from the source of the discharge or release to the injured resource (43 CFR Section 11.14 (dd)).*

Although site-specific pathway studies have not been conducted in the assessment area, existing information indicates a pathway of metals from the Site to trust resources. Release of metals from the Site to Aquashicola Creek, the Lehigh River, Blue Mountain, and Stony Ridge has been documented (USEPA 2001b). For example, air emissions containing significant quantities of metals occurred from the Site from the late 1890s through the early 1980s. The metals in these emissions settled on Aquashicola Creek, the Lehigh River, Blue Mountain, and Stony Ridge (USEPA 1987b). The former waste impoundment and process areas around the Acid Plant in the East Plant have also been documented sources for contaminants at the Site (REWAI 1987). Continuing contaminant releases include the cinder bank, contaminated soils on Blue Mountain and Stony Ridge, and surface runoff from the Site (USEPA 1987b). The physical and chemical properties of As, Cd, Cr, Cu, Pb, and Zn, as discussed in USEPA (2001b), allow these metals to be taken up by biota through aquatic and terrestrial food webs. Data showing concentrations of these metals in the surface water, sediments, fish, soils, and soil invertebrates of the Site support this assertion (e.g., USEPA 2001b). Additional detail regarding potential pathways is found in the Preassessment Screen (Trustees 2003b).

3.2 Surface Water Resources: Surface Water

Surface water resources within the assessment area provide ecological services such as habitat for fish and invertebrate species, and feeding, breeding, and nursery functions, as well as human use services such as swimming, boating, and fishing. Aquatic organisms are at risk of metals exposure through their diet, as well as through direct contact with metals in the water column. Although heavy metals are relatively insoluble, and dissolved concentrations in water tend to be low compared to concentrations in sediments, prolonged exposure to relatively low concentrations can lead or add to the accumulation of metals in the food web.

Under the DOI regulations, injury to surface water from release of a hazardous substance has occurred when concentrations and the duration of exposure to substances are:

> *In excess of drinking water standards established by…the SDWA [Safe Drinking Water Act], or by other Federal or State laws or regulations…in surface water that was potable before…the release (43 CFR Section 11.62 (b)(i));*
>
> *In excess of applicable water quality criteria established by…the CWA [Clean Water Act], or by other Federal or State laws or regulations, in surface water that before the…release met the criteria and is a committed use…as a habitat for aquatic life, water supply, or recreation (43 CFR Section 11.62 (b)(iii)).*

Note that "*the most stringent criterion shall apply when surface water is used for more than one of these purposes*" (43 CFR Section 11.62 (b)(iii)).

To determine injury to surface waters within the assessment area, concentrations of As, Cd, Cr, Cu, Pb, and Zn are compared to Federal Ambient Water Quality Criteria (AWQC) for total recoverable metals (adjusted for hardness), and Federal drinking water standards (MCL). Example concentrations of total metals in Aquashicola Creek and the Lehigh River from 1971 to 2001 and corresponding Federal criteria are summarized in Exhibit 3-1. Exceedances of AWQC and MCL for multiple contaminants indicate injury to surface water for Aquashicola Creek and the Lehigh River.

3.3 Surface Water Resources: Sediment

Sediments provide ecological services such as habitat for benthic organisms and substrate for aquatic vegetation, as well as human use services including recreational opportunities (e.g., boating and fishing) and fisheries management (e.g., stocking). Benthic flora and fauna are integral to maintaining the structure and function of the aquatic ecosystem (e.g., function as the base of the aquatic food web), and play an important role in ecosystem energy and nutrient cycling. Sediment can, however, act both as a sink for metals as well as a source of these same metals to the water column and aquatic biota.

Exhibit 3-1 Maximum Metal Concentrations (1971-2001) Compared to Federal Ambient Water Quality Criteria (AWQC) and Drinking Water Standards (MCL) for Total Recoverable Metals in Surface Water

	Aquashicola Creek		Lehigh River		Both waters
Contaminant	**Maximum Concentration (ug/L)**	**AWQC (ug/L)**	**Maximum Concentration (ug/L)**	**AWQC (ug/L)**	**MCL (ug/L)**
Cd	**190**	0.16	**13**	0.10	5
Cr III	*70*	48.8	--	28	100
Cu	*360*	5.2	*70*	2.9	1,300
Pb	**86**	1.3	ND	0.5	15
Zn	**8,620**	66.6	*360*	37.0	5,000

Bold =Concentration exceeds AWQC and MCLs.
Italics = Concentration exceeds only AWQC.
ND = Non-detect.
-- = No data.
Data sources: Wills (2002), USEPA (2001b), RI (1987), Carline and Jobsis (1989), Kime and Moyer (1986).
Federal AWQC (Criterion Continuous Concentrations (CCCs)) for the protection of aquatic life (USEPA 2001b) for metals are hardness dependent, were calculated using an approximate hardness of 50mg/L $CaCO_3$ for Aquashicola Creek and 25 mg/L $CaCO_3$ for the Lehigh River (Kunkle 2005).
Drinking water standards are Maximum Contaminant Levels (MCL; USEPA 2002c).

Injury to sediment is defined as a component of injury to surface water resources, and has occurred when:

> *Concentrations and duration of substances [are] sufficient to have caused injury…to ground water, air, geologic, or biological resources, when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments (43 CFR Section 11.62 (b)(1)(v)).*

Injury to sediment within the assessment area is determined by reviewing site-specific data for Aquashicola Creek and the Lehigh River. Results of laboratory toxicity tests in which the amphipod *Hyalella azteca* was exposed to sediment from the open channel and riparian wetlands of Aquashicola Creek indicate a significant decrease in survival of *H. azteca* as compared to controls (i.e., 12 to 70 percent mortality).[2] This increase in mortality indicates injury to the sediment resources within the assessment area.

3.4 Geologic Resources: Soil

Soil provides ecological services such as habitat for soil organisms (e.g., earthworms and shrews), the nutrients and water holding capacity necessary to sustain vegetative cover, and substrate for litter decomposition. Soils are also essential for the cycling of elements,

[2] Surface water and porewater samples were collected in Aquashicola Creek between the confluence of Aquashicola and Buckwha Creeks and the confluence of Aquashicola Creek with the Lehigh River. Control mortality ranged from zero to 6.2 percent (USEPA 2001b).

minerals, and nutrients through the environment. In addition to these ecological services, soils provide human use services such as management (e.g., timber and wildlife) and recreational opportunities (e.g., hiking and hunting). Soils can, however, serve as both a sink and a source for contaminants such as metals.

Soils are categorized as a geologic resource. Therefore, injury to terrestrial soils has occurred when concentrations of a substance are sufficient to cause:

> *A toxic response to soil invertebrates (43 CFR Section 11.62 (e)(9));*
>
> *A phytotoxic response such as retardation of plant growth (43 CFR Section 11.62 (e)(10)); or*
>
> *Injury…to surface water, ground water, air, or biological resources when exposed to the substances (43 CFR Section 11.62 (e)(11)).*

For this assessment, injury to soil is determined by reviewing the results of site-specific analyses. Soil contamination has been implicated in reductions of abundance of numerous plant and animal species investigated on Blue Mountain (e.g., Beyer 1988, Nash 1975). For example, the earthworm *Eisenia foetida* experienced an average of 55 percent and 100 percent mortality when exposed to soil from Blue Mountain and Stony Ridge, respectively (USEPA 2001b). Woodlice, another species of soil invertebrate, experienced up to 90 percent mortality when exposed to soil litter from the assessment area (Beyer et al. 1984). In addition, an estimated 12 to 24 inches of the original surface soil has eroded from portions of Blue Mountain due to elevated levels of metals, resulting in a barren and devastated landscape (Sopper 1989, Oyler, undated)

Mortality of *E. foetida* and woodlice, loss of surface soil, and adverse effects to other biota exposed to remaining soil contaminated with metals indicate injury to soils on Blue Mountain and Stony Ridge within the assessment area.

3.5 Groundwater Resources

Groundwater resources are an important source of potable water, and provide essential ecological functions such as surface water recharge. Previously, shallow groundwater was used by the Palmer Water Company as a drinking water source. Current water supply wells, however, access a deep aquifer.

An injury to a groundwater resource has resulted from the release of a hazardous substance when concentrations and duration of substances are:

> *In excess of drinking water standards, established by… the SDWA, or by other Federal or State laws or regulation that establish such standards for drinking water, in ground water that was potable before the discharge or release (43 CFR Section 11.62 (c)(i));*

Sampling and analysis of shallow groundwater at the Palmerton Zinc Pile site has documented the release of hazardous substances including Cd, Cu, Pb, Mn, and Zn to this resource (HRDC 1987, USEPA 2001b). The highest concentrations of metals in the groundwater have been measured in shallow groundwater in the vicinity of the cinder bank and the former acid plant lagoon area. The discharge of contaminated shallow groundwater to Aquashicola Creek has been estimated to be the major source of Cd and Zn contamination entering the creek (HRDC 1987, USEPA 2001b).

To determine injury to groundwater in the assessment area, concentrations of Cd, Cu, Pb, Mn, and Zn from the shallow aquifer are compared to Federal drinking water standards (USEPA 2002c). Data on metals concentrations in groundwater and corresponding Federal standards are summarized in Exhibit 3-2 (NJZ 1987). Exceedances of the drinking water standards for Cd, Mn, Pb, and Zn indicate injury to groundwater in the assessment area. Note that the shallow wells are currently closed. Based on the May 1997 sampling event, metal concentrations in deep wells are currently below drinking water standards (USEPA 1997).

Exhibit 3-2 Maximum Dissolved Metals Concentrations in Deep and Shallow Groundwater from the Palmer Water Company Wells Compared to Federal Drinking Water Standards

Contaminant	Deep Wells† (ug/L)	Shallow Wells‡ (ug/L)	Drinking Water Standards†† (ug/L)
Cd	**6**	**2,700**	5
Cu	10	52	1,300
Pb	ND	**1,700**	15
Mn	**590**	**3,500**	50
Zn	1090	**100,000**	5,000

† Deep wells include PW-3, PW-4, PW-6, PW-7, PW-Acid, and PW-East as described in NJZ (1987).
‡ Shallow wells include PW-9, PW-9A, PW-9C, PW-9D, and PW-AGG as described NJZ (1987).
†† Drinking water standards are Maximum Contaminant Levels (MCL; USEPA 2002b).
Bold = exceedance of Federal drinking water standard (MCL).
ND = below detection limit.

3.6 Biological Resources

Biological resources include the flora and fauna of aquatic and terrestrial habitats such as vegetation, fish, reptiles, amphibians, birds, and mammals. These resources, both individually and as a whole, provide ecological and human use services. Examples of ecological services include nutrient cycling, food web sustainability, and the enhancement of air and water quality. Examples of human use services include fishing, hunting, hiking, bird watching, and wildlife and timber management.

An injury to a biological resource has resulted from the release of a hazardous substance if the concentration of the substance is sufficient to:

Cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations (43 CFR Section 11.62 (f)(1)(i)).

Injury to vegetation, fish, birds, mammals, amphibians, terrestrial invertebrates, and other biota is discussed below.

3.6.1 Vegetation

Vegetation in the assessment area such as vascular plants, fungi and lichens provides both ecological (e.g., soil stability) and human use (e.g., wildlife and timber management) services. Injury to vegetation within the assessment area is determined by reviewing site-specific information regarding metal concentrations and corresponding adverse effects such as soil phytotoxicity, soil infertility, reduced rates of nutrient cycling, losses of soil, reduced plant diversity, forest fragmentation, and the potential influx of invasive species. Examples of the metals-induced toxicity of assessment area soils include:

- Vegetation was completely lost on approximately 2000 acres of what would otherwise be eastern hardwood forest (USEPA 1987a, USEPA 1987b);
- Large areas remain almost completely devoid of vegetation (Exhibit 3-3);
- Zinc concentrations in soils from Lehigh Gap have inhibited the elongation of seedling rootlets (Buchaeur 1973);
- Trees in the assessment area have been stunted and killed by emissions of metals (Jordan 1975);
- The structure and function of the litter on Blue Mountain have been altered by metals (Beyer 1988); and
- Fungi, lichen, and moss communities have been severely reduced in both diversity and density as a result of metal toxicity within the assessment area (Beyer and Storm 1995, Beyer 1988, Nash 1975).

These data indicate that injury to vegetation in the assessment area has occurred (43 CFR Section 11.62 (f)(1)(i)).

Exhibit 3-3 Denuded area on top of Blue Mountain

3.6.2 Fish

Assessment area fishery resources provide extensive recreational and ecological value. But for the contamination, the river would provide habitat for recreationally targeted species such as trout. Fishery resources also play an important role in the riverine ecosystem. Fish can be found at almost any trophic level (fish are forage feeders, piscivores, semipiscivores, and omnivores), and therefore function in the cycling of nutrients and energy through the system. In addition, fish serve as an important food source for non-aquatic species, and represent an important pathway for metals to other biological resources including piscivorous birds and mammals.

Injury to fish is determined by reviewing site-specific data. Laboratory toxicity tests exposed fathead minnows (*Pimephales promelas*) to surface water and porewater from Aquashicola Creek. Results indicate significant a decrease in survival of *P. promelas* as compared to controls (i.e., up to 100 percent mortality; USEPA 2001b).[3] Increased mortality of *P. promelas* indicates injury to fish in Aquashicola Creek and the Lehigh River within the assessment area (43 CFR Section 11.62 (f)(1)(i)).

[3] Source: USEPA (2001b). Tests conducted on samples collected in 1997. Percent control mortality = 3.3 percent.

3.6.3 Birds

Birds provide both ecological (e.g., food web sustainability) and human use (e.g., hunting) services within the assessment area. Piscivorous, insectivorous, omnivorous, and carnivorous birds in the assessment area are exposed to metals mainly through their diet. Injury to these birds is determined by reviewing site-specific data. For example, data indicate that on Blue Mountain, body burdens of metals are sufficient to cause 50 percent lethality in multiple species of songbirds (Beyer and Storm 1995). This is supported by results of a feeding study using birds collected from the assessment area, which show that the Pb concentrations detected in some assessment area songbirds were toxic (Beyer et al. 1988 in Beyer 1988). In addition, population reductions have occurred both in the denuded areas and adjacent vegetated areas, presumably due at least in part to habitat destruction resulting from phytotoxic levels of metals (Beyer 1988). These data indicate that injury to assessment area birds has occurred (43 CFR Section 11.62 (f)(1)(i)).

3.6.4 Mammals

Mammals provide both ecological (e.g., food web sustainability) and human use (e.g., hunting) services within the assessment area. Piscivorous, carnivorous, omnivorous, and herbivorous mammals in the assessment area are exposed to metals mainly through their diet. Injury to these mammals is determined by reviewing site-specific data. For example, white-tailed deer and cottontail rabbits accumulated Cd concentrations that have been shown to cause renal damage and lesions (Beyer and Storm 1995, Beyer 1988, Gunson et al. 1982, Sileo and Beyer 1985). Lead concentrations in cottontail rabbits and shrews on Blue Mountain are associated with Pb poisoning (Beyer and Storm 1995, Beyer et al. 1985, Beyer and Storm 1995). In addition, population reductions up to 50 percent in small mammals (e.g., white-footed mice) on Blue Mountain were recorded, presumably due at least in part to habitat destruction resulting from phytotoxic levels of metals (Beyer 1988). These data indicate that injury to assessment area mammals has occurred (43 CFR Section 11.62 (f)(1)(i)).

3.6.5 Amphibians

Amphibians provide both ecological (e.g., food web sustainability) and human use (e.g., wildlife management) services within the assessment area. Amphibians in the assessment area are exposed to metals through ingestion of contaminated food and water, as well as incidental ingestion of contaminated sediment and soil. Injury to amphibians is determined by reviewing site-specific data. Concentrations of Cd, Pb, and Zn were excessively high in green frog tadpoles, red-backed salamanders, and eastern newts found within the assessment area (Storm et al. 1994). Research indicates a complete absence of forest-floor salamanders, and a reduction in populations of ravine salamanders and pond amphibians in much of the assessment area (Beyer 1988, Beyer and Storm 1995, Storm et al. 1994). This lack of amphibians is attributed to the direct toxicity of metals, as well as the indirect effects of metal contamination, such as inadequate soil moisture and soil conditions, lack of forest cover, and lack of prey (Beyer 1988, USEPA 2001b). These data indicate that injury to assessment area amphibians has occurred (43 CFR Section 11.62 (f)(1)(i)).

3.6.6 Other Biota

Aquashicola Creek, the Lehigh River, Blue Mountain, and Stony Ridge provide important habitat to many other species types that may be injured due to exposure to As, Cd, Cr, Cu, Pb, and Zn. For example, reptiles utilize the riverine ecosystems within the assessment area, and insects are an essential component of both riverine and terrestrial ecosystems. Currently, however, there is insufficient data to determine injury to these organisms.

This Page Intentionally Left Blank

CHAPTER 4: INJURY QUANTIFICATION: ECOLOGICAL SERVICES

Once injury to a natural resource is determined, that injury is quantified to establish a basis for scaling restoration and determining damages. This chapter discusses the methodologies proposed to evaluate baseline conditions and quantify injury to aquatic (i.e., riverine and wetland) and terrestrial (i.e., floodplain and upland) ecological resources. This process is summarized in Exhibit 4-1.

The effects of the releases of hazardous substances will be quantified in terms of the reduction from the baseline condition in the quantity and quality of services provided by the injured resources [43 CFR 11.70 (a)]. Injury quantification includes determination of the baseline condition and baseline services of the injured resources, determination of the extent of injury and the reduction in services resulting from injury, and determination of the recoverability of the injured resources [43 CFR 11.70 (c)].

As noted in Chapter 1, this Plan outlines an *initial* quantification of injury. The Trustees' claim for damages will be based on calculation of restoration costs and must include consideration and estimation of losses residual to any remediation or response actions undertaken at the Site by the USEPA, PRPs and other response agencies. Final injury quantification will not be completed until remedial and response actions are determined and their impacts are factored into a restoration plan.

4.1 Interdependent Ecological Services

The injured resources associated with the Site, including surface water, soil and sediment, aquatic and terrestrial biota, and, upland and riparian resources are ecologically interdependent and provide interdependent services. The services provided collectively by these resources are inseparable at the ecosystem level. This section describes services unique to the injured resources, linkages between the injured resources, and services provided by interacting injured resources that may have been impacted by metals released from the Site.

Individually, **ecological services provided by soils and sediments** include habitat for all biological resources that are dependent on upland, riparian, wetland and aquatic habitats. Soils and sediments provide habitat for migratory birds and mammals; habitat for amphibians and reptiles; habitat for soil biota; growth media for plants and invertebrates; primary productivity, carbon storage, nitrogen fixing, decomposition, and nutrient cycling; soil organic matter and energy (food) to streams; hydrograph moderation; and geochemical exchange processes.

Vegetation provides primary and secondary productivity; food and cover (thermal cover, security cover) for fish, migratory birds, mammals, reptiles and amphibians; feeding and resting areas for fish, migratory birds, mammals, reptiles and amphibians; a migration corridor provided by the riparian zone and forest; nesting habitat for migratory birds, habitat for invertebrates; nutrient cycling; soil and bank stabilization and erosion control; and hydrograph moderation.

Surface water provides habitat for migratory birds and their supporting ecosystem; habitat for fish and their supporting ecosystem; habitat for benthic macroinvertebrates and aquatic, semi-aquatic, and amphibious animals; water, nutrients, and sediments for riparian vegetation and its supporting ecosystem; nutrient cycling; geochemical exchange processes; primary and secondary productivity and transport of energy (food) to downstream and downgradient organisms; growth media for aquatic and wetland plants; and a migration corridor.

Bed sediments provide habitat services for all biological resources that are dependent on the aquatic habitat. In addition, bed sediment services contribute to services provided by surface water, including suspended sediment transport processes, security cover for fish and their supporting ecosystems, primary and secondary productivity, geochemical exchange processes, and nutrient cycling and transport.

Wildlife provide prey for carnivorous and omnivorous wildlife, as well as existence values, food, and recreational opportunities for humans.

Migratory birds provide prey for carnivorous and omnivorous wildlife, as well as insect control, existence values, food, and recreational opportunities for humans.

Fish provide food for other biota, as well as existence values and recreational opportunities for humans.

The services listed above are interdependent [43 CFR 11.71 (b)(4)]. For example, soils and vegetation interact to:

- intercept and store energy from solar radiation, provide a growth medium for plants, and provide substrate for nutrient cycling and decomposition;

- support rich assemblages of plant and animal species; diverse habitat for vegetation, fish, migratory birds and mammals; and highly productive ecological communities;

- provide cover and food for aquatic and terrestrial biota, contribute to physical habitat complexity through the production of trees, shrubs and root masses, and regulate the supply of nutrients within the ecosystem;

- provide critical connectivity between upland and aquatic habitats and a corridor for dispersal of plant and animal species;

- provide the capacity to withstand natural disturbances such as fire, drought, herbivory, disease, flooding, and anthropogenic nutrient or other pollutant contamination;

- moderate hydrology and reduce peak flows by slowing runoff; increase interception, infiltration, and evapotranspiration of precipitation; reduce water velocity; and store flood waters;

- stabilize hillsides and stream banks by anchoring the soil by plant root structures and dissipating erosive energy;

- control nonpoint source urban, agricultural, and industrial pollutant discharges to surface waters, and maintain surface and shallow groundwater quality by physical filtering of surface runoff, by plant uptake of nutrients or pollutants, and through biotically controlled reactions in soils that release nutrients as gases to the atmosphere; and

- control sediment delivery rates to downstream aquatic and riparian resources.

The services collectively provided by these resources, plus the wildlife that use the resulting habitats, provide existence values for a wild and functional ecosystem; sustainable interacting hydrological, geomorphological, and ecological processes; and rich biodiversity.

The injuries to natural resources described in previous chapters have likely reduced the services identified above. Together, the injuries have likely caused ecosystem-level service reductions. In addition, many of the services normally provided by the injured resources and reduced by the injuries are secondary service losses (43 CFR Section 11.71 (b)(4). For example, loss of vegetation and the cascading effects of the associated service losses, such as increased erosion and sedimentation and elimination of nutrient and energy regulation, all affect the viability of terrestrial and aquatic resources. The high degree of overlap in injured services results from the fact that contaminated soil, sediment, and surface water resources are now ubiquitous in and around the Site and the services provided by these resources are integral parts of an ecologically interdependent ecosystem.

Therefore, the Trustees propose to focus the quantification of ecological injuries on resources that provide an intrinsic part of the habitat for aquatic biota, wildlife, and vegetation. Additional consideration may be given to the quantification of injuries to individual resources if necessary for evaluating restoration options or supplementing habitat-based injury quantifications.

4.2 Injury Quantification

The Trustees propose to follow the steps to quantify ecological injuries within the assessment area, as described in the DOI regulations:

> *In the quantification phase, the extent of the injury should be measured, the baseline condition of the injured resource shall be estimated, the baseline services shall be identified, the recoverability of the injured*

resource shall be determined, and the reduction in services that resulted from the discharge or release shall be estimated (43 CFR Section 11.70 (c)).

The Trustees will evaluate whether injury can be quantified using existing data, or whether additional, site-specific studies are required. The Trustees will review site-specific contaminant concentrations and toxicity data, as well as toxicological data in the peer-reviewed literature. If these data are insufficient to quantify injury, the Trustees may choose to conduct primary research regarding the incidence and severity of the effects of metals on assessment area resources. For example, existing data regarding the concentration of metals do not cover the geographic and temporal scope of this assessment. Therefore, scoping studies of metal concentrations in assessment area soils and sediments are currently ongoing. Potential additional studies are outlined in Exhibit 4-2. As previously described in the introduction (Section 1.4), specific study plans for each natural resource injury category will be developed as ancillary Plan documents and amended to the Plan following public review.

4.2.1 Baseline

In order to quantify injuries, and therefore calculate damages and scale restoration activities, the baseline conditions (i.e., physical, chemical, and biological conditions) of the affected resources and associated services must be established. Baseline is "*the condition or conditions that would have existed at the assessment area had the…release of the hazardous substance…not occurred*" (43 CFR Section 11.14 (e)). The Trustees propose that ecological injury be quantified based on a reduction in services, as described in the DOI regulations (43 CFR Section 11.72 (a)). Therefore, baseline is considered to be the level of services that would have been provided in the absence of the contamination.

Baseline can be established through review of historical conditions and conditions in reference areas (43 CFR Section 11.72). Examples of baseline parameters that may be evaluated include, but are not limited to: concentrations of contaminants of concern, water quality (e.g., dissolved oxygen), community composition in terrestrial and aquatic ecosystems, and contaminants unrelated to the specific source of concern.

Exhibit 4-1
Injury Quantification Methodology

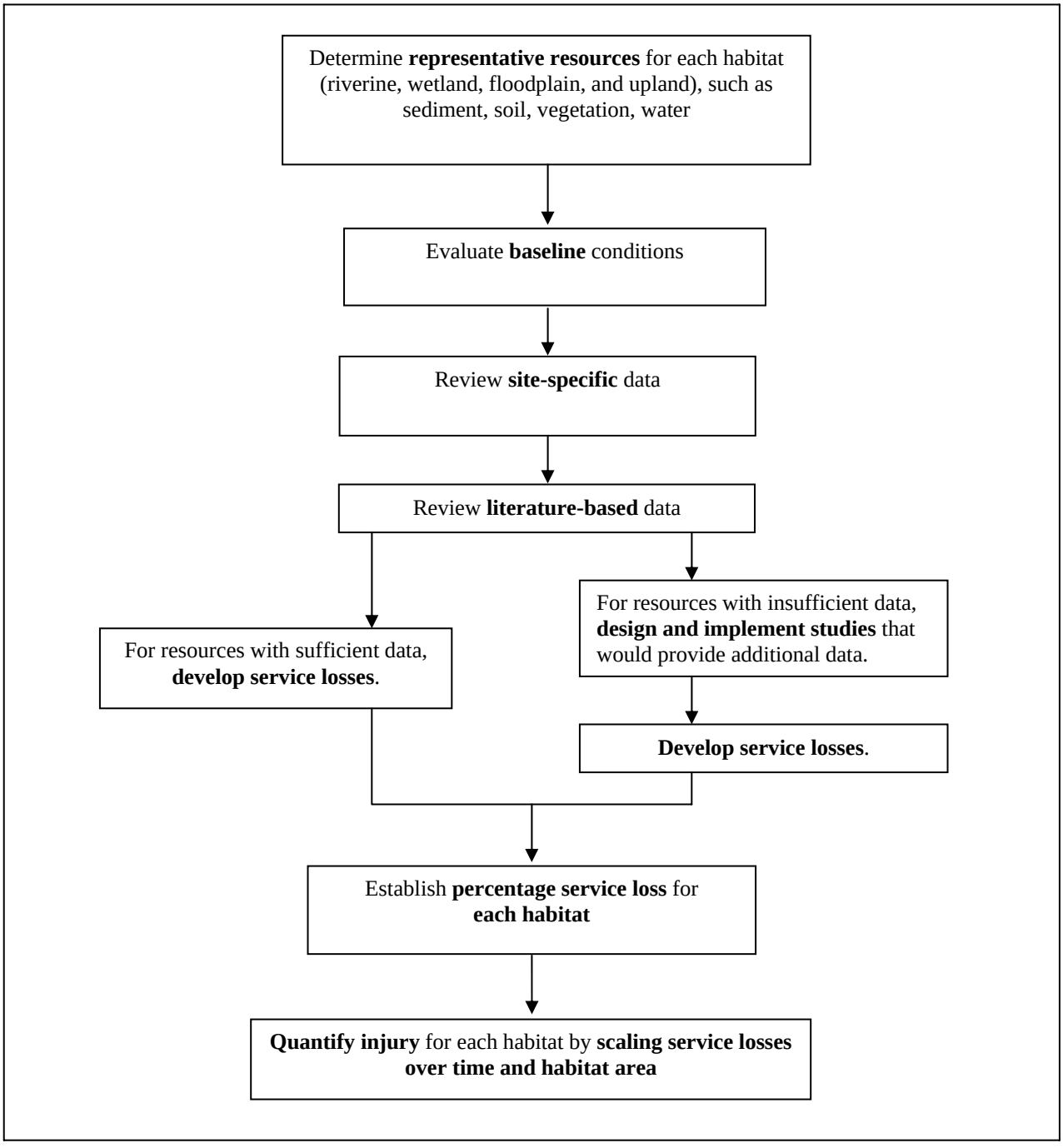

Exhibit 4-2.
Summary of Ecological Studies

Habitat	Study Components	Status	Objectives
Riverine and Wetland	Preliminary Sediment Evaluation	Ongoing	Scoping study to evaluate metal concentrations of sediments and extent of contamination
	Evaluation of existing data on exposure, toxicity, and effects of metals (site specific and literature based)	Ongoing	To evaluate existing information relevant to aquatic injuries at this site
	Biological surveys, exposure and effect studies for aquatic biota such as benthic invertebrates, fish, birds, amphibians and reptiles	Potential	To assess potential adverse effects of metals to biota utilizing riverine and wetland habitat
	Wetlands evaluations	Potential	To assess potential adverse effects of metals to wetlands
Floodplain	Preliminary Floodplain Soils Evaluation	Proposed	Scoping study to evaluate metal concentrations of floodplain soils and extent of contamination
	Evaluation of existing data on exposure, toxicity, and effects of metals (site specific and literature based)	Ongoing	To evaluate existing information relevant to floodplain injuries at this site
	Biological surveys, exposure and effect studies for floodplain biota such as invertebrates, amphibians and reptiles, mammals, birds and vegetation	Potential	To assess potential adverse effects of metals to biota utilizing floodplain habitat
Upland	Preliminary Soils Evaluation	Ongoing	Scoping study to evaluate metal concentrations of soils and extent of contamination
	GIS Analysis	Ongoing	To assess potential adverse effects of metals to upland habitat at the landscape level
	Evaluation of existing data on exposure, toxicity, and effects of metals (site specific and literature based)	Ongoing	To evaluate existing information relevant to upland injuries at this site
	Soil studies to evaluate metal bioavailability, biological activity and soil loss	Proposed	To assess potential adverse effects of metals to soils
	Vegetation studies to evaluate plant growth, phytotoxicity, and forest health	Potential	To assess potential adverse effects of metals to forest health
	Biological surveys, exposure and effect studies for upland biota such as invertebrates, amphibians and reptiles, mammals, birds and vegetation	Potential	To assess potential adverse effects of metals to biota utilizing upland habitat

4.3 Riverine and Wetland Habitat

The Trustees propose to quantify injury to riverine and wetland habitat within relevant areas of Aquashicola Creek and the Lehigh River based on service losses associated with representative resources that are vital to the natural function of the aquatic habitat (Exhibit 4-2). These

representative resources may include, but are not limited to, water, sediment, and plants. Baseline conditions will be established through the use of reference areas and relevant historical data. Additional consideration for this quantification may be provided by evaluating injury to biota including benthic invertebrates, fish, birds, reptiles, and amphibians.

Studies may include, but are not limited to, biota surveys, exposure and effect studies, sediment and water toxicity testing, and modelling of bioaccumulation and dose of metals to potential consumers of contaminated prey (Exhibit 4-2).

4.4 Floodplain Habitat

Stretching along the banks of Aquashicola Creek and the Lehigh River, the floodplain ecosystem forms a bridge between the riverine system and upland habitat. Unique in its ecological composition, the floodplain provides essential habitat for a multitude of species that have adapted to specific environmental and ecological conditions. The Trustees propose to quantify injury to floodplain habitat based on service losses associated with soils and plants. Baseline conditions will be established through the use of reference areas and relevant historical data. Additional consideration for this quantification may be provided by evaluating injury to invertebrates, reptiles, amphibians, birds, and mammals.

Studies may include, but are not limited to, determination of contaminant levels in the floodplain resources of Aquashicola Creek and the Lehigh River, biota surveys, exposure and effect studies, toxicity testing and modelling of bioaccumulation and dose of metals to potential consumers of contaminated prey (Exhibit 4-2).

4.5 Upland Habitat

The Trustees propose to quantify injury to the upland habitat of Blue Mountain and Stony Ridge within the assessment area by reviewing existing data and conducting additional studies when necessary. The Trustees propose to quantify injury to upland habitat based on service losses to representative resources that are vital to the natural function of the upland habitat such as soils and plants. Baseline conditions will be established through the use of reference areas and relevant historical data. Additional consideration for this quantification may be provided by evaluating injury to soil invertebrates, reptiles, amphibians, birds, and mammals.

Studies may include, but are not limited to, determination of contaminant levels in upland resources, GIS analysis of vegetative cover and metals-induced stress, biota surveys, exposure and effect studies, seedling recruitment and tree ring studies, toxicity testing, and modelling of bioaccumulation and dose of metals to potential consumers of contaminated prey (Exhibit 4-2).

This Page Intentionally Left Blank

CHAPTER 5: INJURY QUANTIFICATION: HUMAN USE SERVICES

Blue Mountain, Stony Ridge, Aquashicola Creek, and the Lehigh River are important natural resources, and provide many human use services such as recreational fishing, hiking, hunting, trapping, wildlife viewing, timber and wildlife management, and drinking water. Releases of metals from the Site have impaired the ability of these areas to provide these services. This section discusses the methodologies proposed to quantify injury to these services. The Trustees' general approach to the assessment is to estimate lost use based on existing data and to evaluate the benefit of undertaking additional studies for improving such estimates as outlined in Exhibit 5-1.

5.1 Recreational Fishing

Aquashicola Creek supports a regionally significant recreational cold water fishery (PDER 1988). Fish species include brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), redfin pickerel (*Esox americanus*), pumpkinseed (*Lepomis gibbosus*), white sucker (*Catostomas commersoni*), creek chubsucker (*Erimyzon oblongus*), tesselated darter (*Etheostoma olmstedi*), and migrating American eels (*Angilla rostrata*). Sections of Aquashicola Creek are stocked with legal-sized (i.e., seven-inch) trout.

Metals contamination has likely changed the way that anglers view the river and its fishery. Although a State fish advisory was never issued for Aquashicola Creek and the Lehigh River, the ATSDR, after reviewing the summary findings of the USFWS (1986), recommended that fish from the streams in the immediate area of OU1 should be consumed no more than once per week (HRDC 1987). In addition, due to the contamination, PFBC has not stocked Aquashicola Creek between the entrance to the Palmerton Zinc East Plant and the confluence with the Lehigh River since 1978.

Common responses that anglers have when faced with chemical contamination and any associated advisories or changes in resource management at their preferred fishing location include fishing less frequently or not at all, fishing in less desirable locations, traveling further to fish, converting to catch-and-release angling, or pursuing a different activity altogether. In order to assess these impacts, the Trustees are evaluating stocking data and other statewide fishing data. If existing data are insufficient to quantify injury across the geographic and temporal scope of this assessment the Trustees may implement a survey of recreational anglers to gather additional information regarding lost fishing services.

5.2 Hiking and other Recreational Use

The assessment area contains segments of the Appalachian National Scenic Trail, specifically the Lehigh Furnace Gap to Lehigh Gap and Lehigh Gap to Little Gap sections. A unit of the NPS, the AT is a footpath spanning 2,174 miles along the ridge crests and across the major valleys of the Appalachian Mountains from Springer Mountain in northern Georgia to Mount Katahdin in Maine (NPS 2004). The AT is used by day, weekend, and other short-term hikers; section-hikers; through-hikers; and other recreational users (birding, camping, wildlife viewing). Section hikers hike the entire length of the AT in segments over time, while through-hikers complete the

Exhibit 5-1.
Summary of Human Use Studies

Human Use Service	Study Components	Status	Objectives
Fishing	Estimate lost use based on number of trout anticipated to be stocked using existing information	Ongoing	To evaluate service loss to fishing in Aquashicola Creek
	Fishing survey	Potential	To further evaluate lost fishing use and value
Hiking and other Recreational Use	Estimate lost use and diminished experience based on existing data	Ongoing	To evaluate service loss to hiking, camping, and wildlife viewing on the NPS and Game Lands
	Recreational user surveys	Potential	To further evaluate lost hiking and other recreational use and value
Forest Management	Estimate net revenue of lost timber resources based on existing data	Ongoing	To evaluate service loss to timber production on SGL's 168 and 217
	Tree ring study	Potential	To evaluate growth reductions
	Seedling recruitment study	Potential	To evaluate success of seedling establishment
	Food plot study	Potential	To evaluate success of wildlife food plots
Trail Management	Trail maintenance health and safety evaluation	Proposed	Evaluate increased trail maintenance costs due to health and safety concerns for trail crews
	Rock slide stabilization study	Proposed	Evaluate increased maintenance and management costs associated with rock slide stabilization to ensure health and safety of the general public
	Hiker health and safety evaluation	Proposed	Evaluate increased management costs due to health and safety concerns for trail users
Hunting and Trapping	Estimate lost use based on hunting/trapping and biological data using existing information	Ongoing	To evaluate service loss to hunting and trapping on public lands
	Hunter/Trapper survey	Potential	To further evaluate lost use and value
Drinking Water	Review existing data	Ongoing	To evaluate service loss to drinking water
	Water Supply Evaluation	Potential	To further evaluate service loss to drinking water

entire length of the AT in one season. In addition, the AT winds in and out of State Game Lands within the assessment area. State Game Lands provide the same recreational opportunities found on NPS lands and are cooperatively managed to insure the protection of the AT and associated natural, scenic, and cultural resources (NPS 1995).

Metals contamination has likely changed the way that hikers and other recreational users value and actively use the area. Although the AT within the assessment area has not been closed[4], it is well known that the section of the trail from Furnace Gap to Little Gap is denuded due to metals contamination and other relevant areas, even if they retain some vegetation, are visibly impacted. Both on-site signs and AT hiking guides warn hikers of the contamination along the section of the AT that runs through the assessment area. Since 1990, the NPS has posted this section of trail with "hiker advisory" signs discouraging children from daily recreation in the area and discouraging hikers from consuming water from untested on-site springs (Trustees 2003b). Many of the published trail guides on this section of the AT describe the effects of metals contamination on the trail. Therefore, AT hikers and other recreational users are likely to know of the damage to the assessment area before encountering it.

As a result of contamination, hiker and other recreational user responses likely include making fewer trips to the area or quitting using it at all, diminished experiences, going to less desirable areas, traveling further to go somewhere else, or pursuing other activities.

The Trustees propose to quantify losses to hikers and other recreational use due to the metals contamination and corresponding deforestation by estimating economic welfare losses associated with the diminished value of recreational trips within the assessment area. The Trustees will use existing information to estimate the number of users affected, the degree to which users are affected, and the value of a trip. If existing data are insufficient to quantify injury across the geographic and temporal scope of this assessment, the Trustees may elect to conduct a survey to collect site-specific data regarding the change in user experience, behavior and associated lost value along the affected section of the AT and Game Lands.

5.3 Trail Management

Metals contamination and corresponding deforestation along the AT have impaired the NPS's ability to manage the trail due to health and safety concerns for trail maintenance crews, increased problems with erosion and rock slides, and health and safety concerns for trail users. Health and safety issues associated with trail maintenance have not been thoroughly evaluated but may require hazardous materials training, the use of personal protective equipment and specialized operating procedures to protect workers from metals contamination. Similarly, health and safety concerns for trail users may require the need to construct permanent signs warning users of contaminated water sources, soils and vegetation. Increased erosion and rock slides are a very serious safety concern, especially on the steep slopes of Lehigh Gap, where slides threaten the existing alignment of the trail and

[4] It is the policy of the National Park Service not to close sections of the Appalachian National Scenic Trail (Owen 2004).

particularly the highway below. Stabilization of these slopes will likely require expensive engineering solutions and long-term maintenance.

To quantify the loss to trail management due to metals contamination and deforestation, the Trustees propose to estimate the increased costs associated with health and safety concerns for the general public, maintenance crews, and trail users, including stabilization of rock slides and long term trail maintenance. Three separate types of studies are proposed to evaluate increased trail management costs and determine damages (Exhibit 5-1).

5.4 Forest Management

State Game Lands (SGL) in Pennsylvania are managed and maintained by the PGC for wildlife habitat for outdoor recreation in the form of sport-hunting and trapping, and wildlife protection and management. In accordance with its goals of protecting and perpetuating non-game wildlife species and managing for an annual harvest of all game species, PGC also harvests timber on the SGLs and maintains wildlife food plots.

Upland habitat located on SGLs 168 and 217 has been rendered inoperable for timber and adversely impacted for wildlife habitat management due to metals contamination. The Trustees propose to estimate the annual net revenue of timber that would have been harvested from the inoperable acreage (i.e., inoperable due to contamination) based on the forest characteristics of the surrounding area unaffected by the contamination (Henry 2004). Annual losses would be summed over the relevant time period, and a present value of damages estimated.

Injuries associated with wildlife management will be evaluated in part through ecological studies previously described in chapter 4 and through an assessment of lost hunting and trapping services as described below. If existing data are insufficient to quantify injuries across the geographic and temporal scope of this assessment, the Trustees may elect to conduct additional research such as a tree ring study, seedling establishment study, food plot study, or other forest or wildlife evaluation.

5.5 Hunting and Trapping

The assessment area, including State Game Lands 168 and 217, provides the public with opportunities for hunting and trapping woodland and aquatic/riparian wildlife including deer, bear, turkey, squirrels, rabbit, grouse, raccoon, groundhog, woodcock, fox, weasel, bobcat, coyote, crow, dove, skunk, opossum, muskrat, mink, and waterfowl (PGC 2004, PGC 2003). As discussed earlier, these species utilize or would have utilized habitat within the assessment area but for metal contamination, and may have experienced adverse effects due to exposure to those metals. In addition, upland and aquatic habitat has been adversely affected by metals (e.g., reduction of cover and food sources). This loss of habitat and the toxic effects of metals have caused and may continue to cause a reduction in the number of animals, impacting the success rates and trip value of hunters and trappers in the assessment area.

Common responses that hunters/trappers have when faced with chemical contamination and any associated changes in resource management and success include hunting/trapping less frequently or not at all, hunting/trapping in less desirable locations, traveling further to hunt/trap, or pursuing a different activity altogether. In order to assess these impacts, the Trustees are evaluating hunting/trapping data and other relevant biological data (e.g., animal densities, habitat data). If existing data are insufficient to quantify injury across the geographic and temporal scope of this assessment the Trustees may implement a survey of hunters and trappers to gather additional information regarding lost services.

5.6 Drinking Water

The deep aquifer wells were used originally by the former Palmer Water Company and are currently used by the Palmerton Municipal Authority. Currently, potable water supplies are sufficient to meet demand. Although the likelihood is considered low, the potential need for increased water supply exists, either due to contamination of the deep aquifer or additional demand. The Trustees are currently reviewing existing groundwater data to evaluate possible service losses to drinking water. If existing data are insufficient to quantify injury across the geographic and temporal scope of this assessment, the Trustees may elect to conduct additional water supply evaluations.

If in the future additional water supplies are required and/or the current supply becomes contaminated, service losses may be incurred. This injury could be quantified by estimating the increased costs associated with providing drinking water from the next best available source (e.g., new well(s), connection with a neighboring supply, or treatment of surface water supply; Kunkle 2004).

This Page Intentionally Left Blank

CHAPTER 6: DAMAGE DETERMINATION

Once injury to natural resources has been determined and quantified, the trustees' next step is to determine damages for those injuries and evaluate appropriate restoration alternatives. Damages are "the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources" (43 CFR §11.14(l)). Restoration is designed to return injured resources to their baseline condition and to compensate for the resource services that were lost during the period of injury. Both damages and restoration are directly linked to the type and quantity of injury, in this case measured as losses in ecological and human use services, incurred by the public due to metals contamination in the assessment area. To determine the appropriate amount of compensation, the Trustees may use one or both of the following approaches (43 CFR §11.80(b)):

- Estimate the cost of restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services those resources provide, and/or

- Estimate the compensable value of the services lost to the public.

These two components are addressed separately below. In addition, the Trustees will develop a Restoration and Compensation Determination Plan that establishes a process for determining damages and appropriate restoration.

6.1 Cost of Restoration, Rehabilitation, Replacement, and/or Acquisition of the Equivalent

As described in the DOI regulations, one measure of damages is the estimated cost of restoring, rehabilitating, or acquiring the equivalent of resources that were injured within the assessment area. *Restoration* or *rehabilitation* means actions undertaken to return an injured resource to its baseline condition (43 CFR §11.14(ll)). *Replacement* or *acquisition of the equivalent* means the substitution for an injured resource with a resource that provides the same or substantially similar services (43 CFR §11.14(ii)).

First, the *amount* of required restoration (rehabilitation, etc.) is determined by scaling the gain in ecological services provided by a restoration project to equal the loss in ecological services due to metals contamination. The trustees will evaluate various scaling factors, measures of ecological services, and equivalency methodologies to determine which is/are the most appropriate for this case.

Second, damages are determined as the *cost* of the required restoration (rehabilitation, etc.). The trustees will use one or a combination of the following methodologies to determine these costs (43 CFR §11.83(b)(2)):

- Comparison methodology,
- Unit methodology,
- Probability methodologies,

- Factor methodology,
- Standard time data methodology,
- Cost- and time-estimating relationships, and/or
- Other cost estimating methodologies (which must be based on standard and accepted cost estimating practices and must be cost-effective (43 CFR §11.83(b)(3))).

In selecting and implementing cost estimating methodologies, the trustees will avoid double counting, or will use techniques that allow any double counting to be estimated and eliminated in the final damage calculation. *Double counting* is when a benefit or cost has been counted more than once in the damage assessment and may result when evaluating damages associated with resources that provide multiple benefits and services.

6.2 Compensable Value

A second measure of damages is based on *compensable value*, the amount of money required to compensate the public for the loss in resource services incurred through the return of those resources and associated services to their baseline conditions (43 CFR §11.83(c)(1)). Compensable value includes the value of both lost public use services (e.g., recreational fishing, timber management), as well as lost nonuse services (e.g., existence and bequest values). Compensable value can be measured by changes in any of the following parameters:

- *Consumer surplus*. The amount individuals are willing to pay for a good or service above and beyond the cost of that good or service. That is, consumer surplus measures the difference between what a person is willing to pay and the amount he/she actually is required to pay (i.e., expenditures). People realize positive net benefits when they are able to obtain goods and services for less than they are willing to pay. Consumer surplus is a measure of that net benefit.

- *Economic rent*. (1) The earnings from a commercially harvested public resource (e.g., timber) minus the cost of the harvest (including a reasonable return on capital). In other words, economic rent for commercially harvested resources is the fee that harvesters could pay to the government and still find harvesting economically feasible. (2) Economic rent accruing to a private party because the Federal or State agency does not charge a fee or price for the use of the resources.

- *Fees or other payments.* Collectable by a Federal or State agency for a private party's use of the natural resources (e.g., hunting license fee).

Once injuries are determined and quantified, as described in preceding sections, the trustees will measure changes in the above parameters (e.g., in consumer surplus) to estimate damages for each injured resource and associated service(s). As this damage assessment progresses, the Trustees will review the methods described in the DOI regulations for determining these values, and expect to use one or a combination of the following to determine compensable value (43 CFR §11.83(c)(2)).

- Market price methodology,
- Appraisal methodology,
- Factor income methodology,
- Travel cost methodology,
- Hedonic pricing methodology,
- Unit value methodology,
- Contingent valuation methodology, and/or
- Other valuation methodologies (which must measure compensable value in accordance with the public's willingness to pay and must be cost-effective, such as conjoint analysis (43 CFR §11.83(c)(3))).

In selecting and implementing valuation methodologies, the trustees will avoid double counting, or use techniques that allow any double counting to be estimated and eliminated in the final damage calculation.

6.3 Damage Determination and Restoration Process

Damage determination and restoration processes are closely linked. While damages are determined as the dollar amount sufficient to compensate for losses due to metals contamination, these dollars are typically applied to restoration projects. Restoration is the goal of an NRDA, providing benefits today and into the future. For example, restoration projects may improve or create aquatic habitats, providing fish with clean spawning habitat and anglers with opportunities to catch fish with reduced metals levels. Similarly, restoration may involve creating conservation areas that are attractive to game and other terrestrial species (e.g., through purchase and management of upland forest).

The determination of appropriate damages and restoration will be summarized in a Restoration and Compensation Determination Plan (RCDP), which will evaluate restoration alternatives, summarize the rationale behind the preferred alternatives, and identify the cost estimating and valuation methodologies that will be used to calculate damages. This RCDP will be distributed to the public and responsible party for review and comment.

This Page Intentionally Left Blank

REFERENCES

ATSDR (Agency for Toxic Substance and Disease Registry) 2004. Toxic Fact Sheets. http://www.atsdr.cdc.gov/toxfaq.html.

Beyer, W.N. 1988. Damage to the Forest Ecosystem on Blue Mountain from Zinc Smelting. Paper presented at Trace Substances in Environmental Health-XXII Symposium, University of Missouri, Columbia.

Beyer, W.N. and G. Storm 1995. Ecotoxicological Damage from Zinc Smelting at Palmerton, Pennsylvania. In: *Handbook of Ecotoxicology*, Hoffman, B.A., G.A. Burton Jr., and J. Cairns, Jr. (eds.). Lewis Publishers, CRC Press, Inc., Boca Raton, FL. 755 pp.

Beyer, W.N., G.W. Miller, and E.J. Cromartie 1984. Contamination of the O_2 soil horizon by zinc smelting and its effect on woodlouse survival. *Journal of Environmental Quality* 13(2): 247-251.

Buchauer M.J. 1973. Contamination of soil and vegetation near a zinc smelter by zinc, cadmium, copper, and lead. Environmental Science and Technology 7:131-135.

CA OEHHA (California Office of Environmental Health Hazard Assessment) 2005. http://www.oehha.ca.gov/.

Carline, R.F. and G.J. Jobsis 1989. Effects of Heavy Metal Contamination on Aquatic Fauna in the Vicinity of the Palmerton, Pennsylvania, Smelters. Final report prepared for the U.S. Fish and Wildlife Service Ecological Services Field Office, State College, PA. August.

Eisler, R. (ed.) 2000. *Handbook of Chemical Risk Assessment. Health Hazards to Humans, Plants, and Animals*. Volume 1. Metals. Lewis Publishers.

Gunson D.E., D.F. Kowalczyk C.R. Shoop, C.J. Ramberg. 1982. Environmental zinc and cadmium pollution associated with generalized osteochondrosis, osteoporosis and nephrocalcinosis in horses. Journal of the American Veterinary Medical Association 180:295-299.

Hawk Mountain 2005. Landscape. http://www.hawkmountain.org/sanctuary/hawk_mountain_landscape.htm

Hawk Mountain 2002. Breeding Bird List. http://www.hawkmountain.org/sanctuary/birds_of_hawk_mountain.htm

Hawk Mountain 2002. Master Biota List. http://www.hawkmountain.org/sanctuary/biodiversity.htm

Henry, D.R. 2004. Personal Communication. Regional Forester, Pennsylvania Bureau of Land Management, Southeast Region.

HRDC (Horsehead Resource Development Company, Inc.) 1987. Remedial Investigation/Feasibility Study for the Palmerton Zinc Site, Palmerton Pennsylvania. Seven volume set.

Jordan M.J. 1975. Effects of zinc smelter emissions and fire on a chestnut-oak woodland. Ecology 56(1)78-91.

Kime, R. and G. Moyer 1986. Aquashicola Creek. Priority Water Body Survey Report. Water Quality Standards Review. Report prepared for Quality Assessment Unit, Division of Water Quality, Bureau of Water Quality Management, Department of Environmental Resources. September.

Kittatinny Project 2002. Fact Sheet on the Blue-Mountain Kittatinny Ridge. http://pa.audubon.org/krhome.html

Kunkle, J. 2004. Personal Communication regarding meeting with Roger Danielson, Borough Manager, and Donald Smith, Manager of the Water Department. May 18. Pennsylvania Department of Environmental Protection.

Kunkle, J. 2005. Personal communication regarding recent sampling results for water hardness in Aquashicola Creek and the Lehigh River. May.

Lehigh Valley Planning Commission 1999. Natural Areas Inventory of Northampton and Lehigh Counties. http://www.lvpc.org/NAISummary/NAIindex.htm

Nash III, T.H. 1975. Influence of effluents from a zinc factory on lichens. *Ecological Monographs* 45(2): 183-198.

NJZ (New Jersey Zinc Company, Inc) 1981. Assessment of Effect of Raw Material and Sludge Storage Areas on Ground Water. Report prepared for Palmer Water Company. November.

NJZ. 1987. Remedial Investigation Report Volume 1. November.

NPS (National Park Service) 2004. Appalachian National Scenic Trail. http://www.nps.gov/appa/index.htm

NPS 1995. Agreement for the Appalachian National Scenic Trail in the Commonwealth of Pennsylvania. 22 pp.

Oyler, J.A. Undated. Evaluation of Sludge-Fly ash Mixtures as Potential Amendments to Facilitate Revegetation of Blue Mountain, Palmerton, Pennsylvania. Report submitted to the USEPA Region III, Philadelphia , PA. 61 pp.

PAS (Pennsylvania Audubon Society) 1999. Important Bird Areas in Pennsylvania: A Guide to Identifying and Conserving Critical Bird Habitat. http://pa.audubon.org/Book/ch2.pdf

PDEP (Pennsylvania Department of Environmental Protection) 1988. Aquashicola Creek, Carbon, Monroe, and Northampton Counties, Special Protection Evaluation Report, Water Quality Standards Review. Quality Assessment Unit, Division of Water Quality, Bureau of Water Quality Management. November.

PGC (Pennsylvania Game Commission) 2004. Forest Wildlife Management Plan State Game Lands 168. Forestry Division, Bureau of Land Management. January.

PGC 2003. Forest Wildlife Management Plan State Game Lands 217. Forestry Division, Bureau of Land Management. January.

REWAI (R.E. Wright Associates, Inc.) 1987. Groundwater Monitoring System Report – Project 8520 for New Jersey Zinc East Plant, Palmerton. February.

Sileo, L. and W.N. Beyer 1985. Heavy metals in white-tailed deer living near a zinc smelter in Pennsylvania. *Journal of Wildlife Diseases* 21(3):289-296.

Sopper, W.E. 1989. Revegetation of a contaminated zinc smelter site. *Landscape and Urban Planning* 17:241-250.

Storm, G.L., G.J. Fosmire, and E.D. Bellis 1994. Persistence of metals in soil and selected vertebrates in the vicinity of the Palmerton Zinc smelters. *Journal of Environmental Quality* 23(3): 508-514.

Trustees (Palmerton Natural Resource Trustee Council) 2003a. Memorandum of Agreement. November. http://www.fws.gov/contaminants/restorationplans/palmerton/palmerton.cfm

Trustees 2003b. Preassessment Screen Determination for the Palmerton Zinc Pile Superfund Site. December. http://www.fws.gov/contaminants/restorationplans/palmerton/palmerton.cfm

USEPA (U.S. Environmental Protection Agency) 2005. Website for the Palmerton Zinc Pile Superfund Site. http://www.epa.gov/reg3hwmd/super/sites/PAD002395887/index.htm

USEPA 2002a. EPA Explanation of Significant Differences: Palmerton Zinc Pile, EPA ID: PAD002395887, OU 02, Palmerton, PA. http://www.epa.gov/reg3hwmd/super/sites/PAD002395887/index.htm

USEPA 2002b. Second five-year review report, Palmerton Zinc Pile Superfund Site, Palmerton, Carbon County, Pennsylvania. 32 pp. + attachments.

USEPA 2002c. List of Drinking Water Contaminants and MCLs. United States Environmental Protection Agency. EPA 816-F-02-013. http://www.epa.gov/safewater/mcl.html#mcls. Accessed May 2004.

USEPA 2001a. EPA Superfund Record of Decision: Palmerton Zinc Pile, EPA ID: PAD002395887, OU 03, Palmerton, PA. http://www.epa.gov/reg3hwmd/super/sites/PAD002395887/index.htm

USEPA 2001b. Final Draft Palmerton Zinc Site Ecological Risk Assessment, Volumes 1-7. February.

USEPA 1997. Site Assessment Technical Assistance Team, Palmerton Zinc OU#4 Trip Report, Palmer Water Company Sampling Event, May, 1997.

USEPA 1993. Hazardous substances source identification study, Palmerton Zinc CERCLA NPL Site, Carbon County, Pennsylvania. Enforcement Confidential Report EPA-330/2-94-029. Prepared by the National Enforcement Investigations Center, Denver, Colorado. Three volume set.

USEPA 1988. EPA Superfund Record of Decision: Palmerton Zinc Pile, EPA ID: PAD002395887, OU 02, Palmerton, PA. http://www.epa.gov/reg3hwmd/super/sites/PAD002395887/index.htm

USEPA 1987a. EPA Superfund Record of Decision: Palmerton Zinc Pile, EPA ID: PAD002395887, OU 01, Palmerton, PA. http://www.epa.gov/reg3hwmd/super/sites/PAD002395887/index.htm

USEPA 1987b. Palmerton Zinc Superfund Site Blue Mountain Project. Summary of RI/FS Results. Prepared by USEPA Region III, Philadelphia, PA. April. 85 pp. + appendices.

USFWS (U.S. Fish and Wildlife Service) 1986. A preliminary survey of contaminants in fish in the vicinity of two zinc smelters at Palmerton, Carbon County, Pennsylvania. State College Field Office Resource Contaminant Assessment Report 86-3. 20 pp + appendices.

Versar, Inc. 2001. Lehigh River 2001 water quality monitoring. Prepared by Versar, Inc., ESM Operations, Columbia, MD for the U.S. Army Corps of Engineers, Philadelphia District.

Wills, S.R. 2002. Aquashicola Creek Lower Towamensing Township, Palmerton Borough, Carbon County. Pennsylvania Department of Environmental Protection, Northeast Regional Office, Water Management Program. June.

APPENDIX A

RESPONSE TO PUBLIC COMMENTS ON THE DRAFT PALMERTON ZINC PILE SUPERFUND SITE NATURAL RESOURCE DAMAGE ASSESSMENT PLAN (JULY 2005)

Response to Public Comments on the Draft Palmerton Zinc Pile Superfund Site Natural Resource Damage Assessment Plan (July 2005)

Comments submitted by the Wildlife Information Center

Comment 1. Land owned by WIC is some of the most severely degraded, being located near the West Plant. Yet this land is not to be evaluated in the Assessment Plan because it is considered privately held. The landowner, WIC, is a private organization, however, PA DCNR helped fund the acquisition and holds an easement on the properties insuring public access under the regulations known as Growing Greener. Therefore, I believe this land should be considered in the public domain and should be evaluated in the assessment.

Response 1. The Trustees understand your concern that Wildlife Information Center (WIC) land has not been specifically mentioned in the Plan. You are correct that this is due to the fact that WIC property is not publicly owned land under management by one of the Federal or State Trustees. Many other private lands have also been potentially affected but ownership is not listed for the same rational as well as to protect privacy. This does not mean that the assessment and restoration activities are limited to publicly owned lands but they are limited to trust resources and the services they provide (i.e., natural resources under Federal or State management for the public). We agree that natural resource impacts on WIC and other private lands need to be evaluated as part of this assessment.

Comment 2. We have contracted with Natural Lands Trust of Media, PA, (with the help of a DCNR grant) to perform an ecological assessment of our refuge lands. if you are interested in using their data in the NRDA process, please contact me.

Response 2. Thank you. Since the objectives of your studies are not necessarily focused on assessing natural resource injuries as described in the Assessment Plan, we cannot guarantee that your information will be used, but we appreciate your willingness to share your data.

Comment 3. Page 5, Background Information, paragraph 2: I am not sure that release of the metals was the cause of defoliation. I suspect is was release of sulfur dioxide from the coal used to smelt the zinc ore that was the primary cause of death of vegetation. The metals have accumulated and are certainly preventing re-growth and have certainly killed most if not all of the soil organisms, including the bacteria and fungi important in decomposition.

Response 3. The Trustees understand that sulfur dioxide may have contributed to the initial defoliation in the area but our focus is on metals since we believe their release is the cause of past and ongoing injuries to natural resources being assessed (1981-future). As indicated in section 2.4, we cannot claim for injuries occurring prior to 1981, but we can claim for ongoing injuries at least through the reasonable expected time of recovery.

Comment 4. Page 5, Section 2.1, paragraph 1: This is a minor technicality, but the Kittatinny actually stretches into New York and includes the Shawangunk Range there. It is over 250 miles long.

Response 4. Suggested detail added.

Comment 5. Page 6, paragraph continuing from previous page: Blue Mountain is a "leading line" for raptor migration, not a "migration corridor." The corridor includes land stretching out from the base of the ridge several miles on either side. These lands are important to resting and feeding raptors during migration. (See D.S. Heintzelman, 1986. Migrations of Hawks. Indiana University Press.)

Response 5. Clarified to indicate that Blue Mountain is a significant “flyway” used by both raptors and songbirds. Thank you for the reference.

Comment 6. Page 6, final paragraph in Section 2.1. While the Lehigh River is managed as a warm water fishery by PA Fish and Boat Commission, it is supporting a trout fishery that is significant locally. The Lehigh River Stocking Association stocks trout, and at lease two commercial guides operate on the river, taking clients there to fish for trout.

Response 6. Suggested detail added.

Comment 7. Page 6, Section 2.2, third bullet: Should also include Lehigh Gap Wildlife Refuge.

Response 7. Yes, the Lehigh Gap Wildlife Refuge falls within the area of concern as described but is not specifically listed since it is not under State or Federal management (see Response 1).

Comment 8. Page 8, Section 2.3, paragraph 1: See comment 3 above concerning role of sulfur dioxide.

Response 8. See Response 3.

Comment 9. Page 11, Section 3.2: WIC land includes numerous seeps and springs. Can they be tested a part of this assessment?

Response 9. Yes, but we believe that such testing needs to be conducted as part of the remedial investigation for OU4 and we will therefore first recommend that EPA require the PRP to so. If unsuccessful, we will plan such a study and ask the PRP to fund it.

Comment 10. Page 17, Section 3.4, second-to-last paragraph: See comment 3 above about role of sulfur dioxide.

Response 10. See Response 3.

Comment 11. Page 21, Section 3.6.3: Several species of birds have returned to the re-vegetated test plot area on the Lehigh Gap Wildlife Refuge and are nesting there, including Eastern Bluebirds, Tree Swallows, and American Kestrels.

Response 11. The Trustees are aware and concerned about birds being attracted to the areas of the mountain that are being revegetated. Unlike the clean-up of Palmerton yards, metal contaminated soils are not being removed from the mountain and so these birds and their young will potentially be exposed to elevated metals in their diet. Such metals exposure can lead to numerous physiological problems, reduced clutch sizes, reduced fledgling success, and premature death. We are also concerned with the significant loss of forested habitat that provided food and shelter to numerous

forest-dwelling species. As described in section 4.1, our overall approach to quantifying ecological injuries focuses on impacts to habitat rather than specific species or biota.

Comment 12. Page 29, Section 4.4: Natural Lands Trust is doing botanical surveys along the entire floodplain. See comment 2 above.

Response 12. Thank you again for your willingness to share data.

Comment 13. Page 32, paragraph continued from previous page: The blue blazed "North Trail," part of the AT, includes a section that drops onto WIC land where the National Park Service owns an easement at the feature known as Devil's Pulpit.

Response 13. Yes, the assessment will include an evaluation of human use injuries (e.g., hiking, trail management, wildlife viewing) associated with impacts to the Appalachian Trail throughout the assessment area. As previously noted, we have chosen to refrain from identifying ownership of lands not in State or Federal management.

Comment 14. Page 32, Section 5.2, paragraph beginning with metals contamination: I strongly object to the statement, the area of AT land "from Lehigh Furnace to Little Gap is denuded due to metals contamination." While that is certainly true for Lehigh Gap to Little Gap and for part of the area just west of Lehigh Gap, there is a several mile long area above Lehigh Gap Wildlife Refuge that is a remarkable scrub/grassland/barrens kind of ecosystem that is the result of burning, perhaps beginning with Native Americans. I have spoken with Palmerton residents who remember that fires were set to enhance the blueberry crop in this area in the 1930s. One of the Natural Lands Trust ecologists feels this area is of conservation significance on a statewide basis.

Response 14. The description is clarified to indicate the entire stretch is not completely devoid of vegetation but is visibly impacted and needs to be included in the assessment. The Trustees will consider all credible lines of evidence when evaluating injuries relative to baseline conditions. Our preliminary evaluation of historical information and the results of our more recent soil sampling indicate that metals have contaminated soils at and above phytotoxic levels, along the ridge between Lehigh Furnace and Lehigh Gap. Similar to other metals contaminated areas down slope to the north and to the east, an evaluation of aerial photos shows a corresponding decline of forested habitat in this area. Historical accounts of extensive logging and the use of fire are not unique to this area and do not explain the more recent loss of forested habitat as observed in aerial photos from 1950 to present.

Comments submitted by Palmerton Citizens for a Clean Environment

Comment 1. We would like to stress the importance of restoration of the Palmerton Valley and the Appalachian Trail, which lies adjacent to the Superfund Site and has been damaged by industrial pollution. Understanding the importance of your mission, we want Palmerton to be at the forefront of your restoration.

Response 1. All feasible restoration options including on- and off-site projects will be considered as part of the restoration planning process. The primary requirement for an acceptable restoration option is that it compensates for an injury quantified in the assessment, including past, interim and anticipated future losses. This is partly achieved by returning the injured resources and services back to baseline level. Considerations include cost, technical feasibility, potential for long term success, proximity to the injured resource, consistency with State and Federal policies and laws, availability of

matching funds or partnerships, natural recovery periods, and the results of response activities associated with remedial actions.

Comment 2. We find it unacceptable that Horsehead Resource and Development Corp. (HRD) plays no role in this complicated endeavor. Unless we hold HRD's hazardous waste industry to the highest environmental regulatory standards, consideration of restoring Palmerton could well be compromised. We would like to know how Viacom can be working with the Trustee Council and HRD is not. Clearly, HRD's responsibility extends beyond the past bankruptcy proceedings.

Response 2. The liability of Horsehead Resource and Development Corporation has been resolved in the bankruptcy process. This Damage Assessment focuses on other potentially responsible parties (PRP's) including Viacom.

Comment 3. Pollution from HRD's industry is an ongoing problem. How will this current dilemma figure in to the final restoration? Will Palmerton be penalized when choosing a location for the restoration?

Response 3. The Natural Resource Damage Assessment process evaluates injuries resulting from the "release" of hazardous substances to the environment and generally does not include federally permitted releases. Consideration of permitted releases and other factors that may influence the long term success of a given restoration option occurs during the restoration planning phase, after injuries have been fully assessed and restoration options identified. Changes concerning permitted releases would be addressed in the context of the statute and regulations pursuant to which the permit was issued (e.g., Clean Water Act, Clean Air Act). See Response 1 regarding restoration location.

Comment submitted by the Philadelphia Trail Club

Comment 1. Two key parking lots for us - among the many problems of the superfund site, which we need very much to be in better shape, have been directly affected in a negative way by the continuing unresolved presence of the superfund site. Further, there has been for years a serious question about whether or not we risk endangering our health by working the soils of the site which are part of the Trail's treadway.

Response 1. The Trustees understand concerns regarding trail management including problems with parking lots, physical hazards, and human health concerns associated with the Superfund Site and that is why we have included "Trail Management" as one of the Human Use injury categories and proposed several studies to address these issues in the Assessment Plan (See Section 5.3). We also believe these issues need to be addressed directly as part of the response and so we will continue to encourage EPA and Viacom to include them in ongoing remedial response activities.

Comment submitted by the Appalachian Trial Conservancy

Comment 1. In addition to experiential losses evident to our members and supporters, it has been a grave challenge to ATC and the PTC in its maintenance and management of this portion of the Trail, including our inability to provide basic treadway maintenance due to the environmental hazards, the extraordinary requirements that we warn the hiking public about the potential (and unseen, or unknowable) soil, vegetation, and water contamination hazards to out-of-state visitors, and the loss, over generation now, to what was once a prime hiking experience.

Response 1. In addition to the trail management concerns described above, the Trustees believe that hikers and other trail users have had diminished recreational experiences as a result of the contamination and associated adverse effects to the environment. Given the national significance and unique nature of this trail, the Trustees have included the evaluation of such losses in the Assessment Plan (See Section 5.2).