Nobis
Engineering a Sustainable Future

Feasibility Study
Executive Summary

Ely Copper Mine Superfund Site
Vershire, Vermont
Remedial Investigation / Feasibility Study
EPA Task Order No. 0024-RI-CO-017L

REMEDIAL ACTION CONTRACT
No. EP-S1-06-03

FOR

US Environmental Protection Agency
Region 1

BY

Nobis Engineering, Inc.

Nobis Project No. 80024

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ACRONYMS

ABA	Acid Base Accounting
ACHP	Advisory Council on Historic Preservation
AMD	Acid Mine Drainage
APE	Area of Potential Effect
ARAR	Applicable or Relevant and Appropriate Requirement
ARD	Acid Rock Drainage
ATV	All Terrain Vehicle
AVS	Acid Volatile Sulfides
BERA	Baseline Ecological Risk Assessment
BMPs	Best Management Practices
CAD	Computer Aided Design
CBRs	Critical Body Residues
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
COPEC	Contaminant of Potential Ecological Concern
CSM	Conceptual Site Model
CTE	Central Tendency Exposure
cy	Cubic Yards
CWA	Clean Water Act
DEC	Vermont Department of Environmental Conservation
EBOR	East Branch of the Ompompanoosuc River
EBT	Ely Brook Tributary
EDD	Estimated Daily Dose
EEQ	Ecological Effect Quotient
ELCR	Excess Lifetime Cancer Risk
EPC	Exposure Point Concentration
EPSCP	Erosion Prevention and Sedimentation Control Plan
EU	Exposure Unit

ACRONYMS (cont.)

FOS	Factor of Safety
FR	Federal Register
FS	Feasibility Study
GPM	Gallons per Minute
GRA	General Response Actions
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	Incremental Lifetime Cancer Risks
IR	Incremental Risk
LDPE	Low Density Polyethylene
LTM	Long Term Monitoring
LWA	Lower Waste Area
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/Kg	Milligram per Kilogram
MOA	Memorandum of Agreement
NAPLs	Non Aqueous Phase Liquids
NRWQC	National Recommended Water Quality Criteria
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHPA	National Historic Preservation Act
Nobis	Nobis Engineering, Inc.
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
NWI	National Wetlands Inventory
O&M	Operations and Maintenance
OMB	Office of Management and Budget
ORB	Ore Roast Bed
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit

ACRONYMS (cont.)

PAL	Public Archaeology Laboratory
PRGs	Preliminary Remediation Goals
PUBH	Palustrine with an unconsolidated bottom
QA/QC	Quality Assurance/Quality Control
RA	Remedial Action
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI	Remedial Investigation
RMEs	Reasonably Maximum Exposures
ROD	Record of Decision
SA	Smelter Area
SC	Source Control
SEM	Simultaneously Extracted Metals
SF	Smoke Flue
SHB	Schoolhouse Brook
SHPO	State Historic Preservation Officer
Site	Ely Copper Mine Superfund Site
SLERA	Screening Level Ecological Risk Assessment
SOW	Statement of Work
SPA	Slag Pile Area
SWPPP	Storm Water Pollution Prevention Plan
TA	Tailings Area
Task Order	Task Order Number 0024-RI-CO-017L
TBC	To-Be-Considered
T&D	Transportation and Disposal
TRVs	Toxicity Reference Values
UCL	Upper Confidence Limit
µg/dL	Micrograms per Deciliter
µg/L	Micrograms per Liter
USEPA	United States Environmental Protection Agency
µg/m^3	Micrograms per Cubic Meter

ACRONYMS (cont.)

URS	URS Corporation
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UWA	Upper Waste Area
VCMC	Vermont Copper Mining Company
VP	Vernal Pool
VSS	Vegetative Support System
VTANR	Vermont Agency of Natural Resources
VTDEC	Vermont Department of Environmental Conservation
VTSWMR	Vermont Solid Waste Management Rules
VTWQS	Vermont Water Quality Standards
WOE	Weight-of-Evidence
XRF	X-ray Fluorescence

ES EXECUTIVE SUMMARY

ES.1 Introduction

This Operable Unit (OU) 1 Feasibility Study (FS) was prepared by Nobis Engineering, Inc. (Nobis) for the United States Environmental Protection Agency (USEPA) under Contract Number EP-S1-06-03, Task Order Number 0024-RI-CO-017L (Task Order). The work was performed in accordance with the September 27, 2007 USEPA Statement of Work (SOW). The Task Order SOW includes the completion of a Remedial Investigation (RI)/FS at the Ely Copper Mine Superfund Site (the "Site") located in Vershire, Vermont. The goal of the RI/FS is to support the selection of a remedy that eliminates, reduces, or controls risks to human health and the environment and can be used to prepare a well-supported Record of Decision (ROD).

The Site is an abandoned copper mine located in Vershire, Orange County, Vermont and encompasses approximately 350 acres, including areas containing an estimated 172,000 tons of waste rock, tailings, ore roast beds, slag heaps, smelter wastes, and over 3,000 linear feet of Underground Mine Workings with shafts and adits opening into the flooded mine. No buildings remain at the Site. Remnant foundations, pads, and stone walls, including a 1,400 foot long smoke flue, demark the location of former Site structures including a former flotation mill and the smelter plant. The Site has been determined to be eligible for listing in the National Register of Historic Places by USEPA in consultation with the State Historic Preservation Officer (SHPO). The location of the Site and RI/FS Study Area is shown in Figure ES-1.

The ore body was discovered in 1813 and explored in the 1830s. Significant mine activities began in 1853 and lasted until 1905. Prior to 1867, ore was shipped to smelters along the east coast for processing; on-site smelting operations began in 1867 and were expanded over time to include a large 24-furnace smelter plant located along the southern edge of the Site. During World War I, a flotation separation mill was constructed and operated for a short period. Table ES-1 presents a history of Site operations.

The Site was added to the USEPA National Priorities List (NPL) in September 2001 (47583 – 47591 Federal Register / Vol. 66, No. 178 / Thursday, September 13, 2001 / Rules and Regulations). The Site is undergoing investigation and clean-up activities pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act, as amended (CERCLA), 42 USC § 9601 *et seq.*, and the National Oil and Hazardous Substances Pollution

Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300. The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) identification number for the Site is VTD988366571. Table ES-2 presents a summary of investigations conducted at the Site.

Purpose and Scope

To facilitate the evaluation and implementation of actions to reduce, eliminate, or control actual or potential human-health and ecological risks, the Site has been divided into two Operable Units (OUs). OUs are discrete actions that comprise incremental steps toward a final remedy. An OU eliminates or mitigates a release, a threat of a release, or an exposure pathway (USEPA, 1988b), and may reflect the final remediation of a defined portion of a site or may be implemented as an interim measure. The two OUs for the Site are described below and shown in Figure ES-2:

- OU1 will include the waste rock, tailings, roast beds, and contaminated soil, along with the surface water and sediment for all areas of the Ely Brook valley (except the Smelter/Slag Area and within any Underground Mine Workings).

- OU2 will include the all of the groundwater impacted by the Site (including the Underground Mine Workings), the sediment of Schoolhouse Brook, and the Smelter/Slag Area.

Addressing source control issues in OU1 first and then evaluating the OU1 remedy's affect on the remaining Site will enable a better understanding of the impacts of the OU1 source control measures on groundwater and on the Smelter/Slag Area discharges into Schoolhouse Brook. This will allow the development of appropriate remedial alternatives for OU2, which, if necessary, will be discussed in a future FS.

The purpose of this FS Report is to identify and evaluate appropriate remedial alternatives for the OU1 areas of the Site posing unacceptable human health or environmental risks as determined from information gathered during the RI, including the Human Health Risk Assessment (HHRA) (Nobis, 2010b and 2010c) and the Baseline Ecological Risk Assessment (BERA) (USEPA, 2010). The FS Report evaluates alternatives based upon the criteria defined in the NCP and CERCLA. As required by the statute, a no-action alternative is considered in the evaluations and a detailed analysis of selected remedies is provided for each area. FS activities include:

- developing remedial action objectives (RAOs);
- developing general response actions (GRAs);
- identifying areas and volumes requiring remedial action (RA);
- identifying and screening of remedial technologies and process options;
- developing and screening of RA alternatives;
- conducting a detailed analysis of retained RA alternatives; and,
- conducting a comparative analysis of retained RA alternatives.

This FS does not select a preferred alternative for OU1, but rather describes the alternatives under consideration. The preferred alternative will be identified in the Proposed Plan and will be subject to public comment. After addressing State and public comments on the proposed alternative, a final remedy selection will be described in a ROD. In addition to the OU1 Remedial Action, an OU2 Early Action is being implemented to restrict public access to overburden and bedrock groundwater contamination and the surface soil within the Smelter/Slag Area.

ES.2 Site Description and History

The Ely Copper Mine Superfund Site is an abandoned copper mine located in Vershire, Orange County, Vermont. The Site encompasses approximately 350 acres along the south slope of Dwight Hill, to the north of Schoolhouse Brook and South Vershire Road. The Site includes features such as waste rock and mine process waste piles, intact and collapsed adits and shafts, remnant foundations of former mine operation buildings, a 1,500-foot-long smoke flue, and over 3,000 linear feet of underground workings. Waste areas include a former ore roast bed (ORB), upper and lower waste rock areas (UWA and LWA, respectively), a tailings area (TA), a former smelter area (SA), a smoke flue (SF), and a slag pile area (SPA), all located within the watershed of Ely Brook (Figure ES-3). Ely Brook joins Schoolhouse Brook at the southern margin of the Site. Schoolhouse Brook flows eastward approximately 1.75 miles to its confluence with the East Branch of the Ompompanoosuc River (EBOR). A major eastern tributary to Ely Brook, Ely Brook tributary (EBT)2, drains from a former reservoir and a series of ponds located east of the mine waste areas.

The Site lies within the Devonian Gile Mountain Formation, in which the primary ore minerals include pyrrhotite, chalcopyrite with minor sphalerite and pyrite (Slack and others, 2001). The Site was added to the Superfund listing in September 2001 due to environmental impacts from acid rock drainage (ARD) on Ely Brook and Schoolhouse Brook. The Site is also eligible for the National Register of Historic Places due to its historical aspects (Hathaway and others, 2001).

The Ely Copper Mine is one of three major historic copper mines located within Besshi-type ore deposits that comprise the Vermont Copper Belt including the Elizabeth, Ely, and Pike Hill Mines within a 20 mile long area from south to north in the belt. The ore body was discovered in 1813 with significant mining activities beginning in 1853 by the Vermont Copper Mining Company (VCMC) and lasting until 1905 (PAL, 2005). Ore roasting began with the initial construction of the smelter in 1867 to reduce the sulfur content of the ore prior to smelting. Mine operations experienced a boom between 1872 and 1880, a period during which Ely Village expanded and the Town of Vershire grew to a population of about 1,900 in contrast to today's population of about 630 people. By 1876, sulfur fumes from the roast beds and smelter had eliminated the vegetation in the valley. A stone slab flue approximately ¼ mile long was built from the smelter up the eastern side of the valley with the intention of reducing fumes in the valley, but the flue reportedly never functioned effectively. By 1879 the smelter building was expanded to 24 furnaces and a length of 700 feet to accommodate ore from the Pike Hill Mines. During this time, the smelter slag pile was expanding south of the building toward Schoolhouse Brook. Between 1883 and the close of the mine in 1905, ownership changed hands several times and production was sporadic. An attempt to rejuvenate copper production in 1900 was unsuccessful due to both the lack of ore at the 3,500-foot downdip limit of the mine and low copper prices. In 1905, equipment was stripped from the Site and buildings were sold, moved, or demolished. In 1917, a flotation mill was constructed in an attempt to recover copper from the mine dumps. The flotation mill operated for only a short period until the end of World War I, at which time the price of copper fell, closing the operation. In 1949-50, attempts were made to recover copper from the mine waste piles and 60,000 tons of waste rock/ore assayed at about 1 percent copper were transported to the Elizabeth Mine for processing. Since 1950, the Site has been used for timber management and recreational activities, including hunting, snowmobile riding, and horseback riding. The Site is often visited by those interested in the remnants of the mining activities or the Site geology. All-Terrain Vehicle (ATV) tracks are observed on several of the waste piles.

ES.3 Site Investigations

Since 1998, a considerable amount of data has been generated as the result of previous investigations conducted at the Site. USEPA has retained the U.S. Army Corps of Engineers (USACE), the U.S. Geological Society (USGS), URS Corporation (URS), and Nobis to perform work at the Site. Additional information has been contributed from studies performed by the State of Vermont. In 2002, the USACE, in cooperation with the USGS, completed a study of spring runoff from the Site to characterize the geochemical diversity of water sources in the Ely Brook Watershed, which included sampling from seeps in mine waste areas, Ely Brook and tributaries, Schoolhouse Brook, and the EBOR. This study documented highly acidic and highly metal-laden runoff from the mine areas (Holmes and others, 2002). Between 1998 and 2007, the USGS conducted sampling surveys and completed a series of studies at the Site, which included sampling and analysis of the various solid mine waste materials and sediment to characterize the materials, assess their acid-generating potential, and assess their potential for leaching metals (Piatak and others, 2004a; 2004b; 2007).

From 2005 through 2008, URS, in conjunction with the USACE and USEPA, completed extensive field studies, including a habitat characterization study of the Site (URS, 2005; 2009). Field investigations included test pits, borings, monitoring well installations, and the collection of surface water and sediment (over 30 locations), surface and subsurface soil (over 150 locations), and groundwater samples (approximately 30 wells) from the Site (URS, 2009). URS evaluated surface and subsurface soil samples from waste areas and transition zones around waste area, including off-site background soil metal concentrations. These data have been incorporated directly into the RI/FS analytical database for the Site.

In 2007, the Vermont Department of Environmental Conservation (VTDEC) completed an aquatic life use attainment assessment of Ely Brook, Schoolhouse Brook, and the EBOR. The assessment included the evaluation of fish and macroinvertebrate community data, which indicated impairment for portions of Schoolhouse Brook and Ely Brook likely related to runoff from the Site (VTDEC, 2007). In 2006 and 2007, the USGS, in conjunction with USEPA, conducted a detailed characterization of surface water, sediment, porewater, and fish and macroinvertebrate communities in Ely Brook, Schoolhouse Brook, and the EBOR in support of the Aquatic BERA (TechLaw, 2008; Seal and others, 2010). These studies included toxicity tests of surface water, sediment, and porewater from each surface water reach.

In 2009, Nobis completed extensive supplemental field investigations to complete the RI. Investigations included sampling of surface/subsurface soil (over 80 samples), groundwater (2 rounds from over 40 wells), surface water (2 rounds over 30 locations, including 4 vernal pools), porewater (7 locations), sediment (16 locations), and biota. Residential drinking water samples were also collected from 6 locations near the Site. Overburden, shallow, and deep bedrock well installations were completed, along with packer testing and borehole geophysical characterization of the deep bedrock at the Site (Nobis, 2010a). Soil sampling included on-site laboratory X-ray fluorescence (XRF) analysis of over 340 soil samples from an extensive network of 26 sample transects. Sediment sampling of the Lower Reach of Ely Brook included detailed evaluation of three sediment transects to assess the vertical distribution of waste rock sediment in the brook. Investigations included the collection of soil and sediment samples for geotechnical analyses to document the physical characteristics of waste materials and support the feasibility study evaluation of remedial options. Biota sampling to support the terrestrial BERA included 8 composite samples of invertebrates and 107 small mammals from 5 transects in select transition zone areas.

ES.4 Contaminant Source Areas

Waste material from over 100 years of mining activities can be found across the entire Site, from the mine entrances high on Dwight Hill to Schoolhouse Brook. The major issue at the Site is acid rock drainage (ARD), which occurs when sulfide mineral-bearing rock and ore are exposed to oxygen and water, thereby creating a low-pH leachate (contaminated water percolating through the impacted soil and infiltrating the groundwater). At low pH, many of the metals that were bound in the ore and native soil become soluble and dissolve into the leachate. The leachate from the Site often contains elevated levels of aluminum, cadmium, cobalt, copper, iron, manganese, and zinc that are likely from the locally mined ore. Aluminum and manganese are also contributed by the leaching of metals in the native soil. In addition to the oxidation of the sulfide-bearing minerals, the cyclic formation and subsequent dissolution of evaporative metal salts on exposed waste ore and tailings also contributes to ARD at the Site. Metal salts form on the surfaces of the tailings and waste ore as metal-containing acidic moisture evaporates. The metals stored in these salts are dissolved and remobilized during subsequent rainfall events. This run-off is eventually conveyed to receiving streams, resulting in an increase in the waterway's metals concentration and load.

Metals associated with ARD at the Site have been detected at elevated concentrations in groundwater, surface water, soil, and sediment. ARD directly affects both groundwater and surface water quality at the Site by lowering the pH and contributing elevated concentrations of metals to these media. This also occurs at the outlet of the adits, where impacted mine waters discharge directly to the ground surface as acid mine drainage (AMD). In addition, the tailings, weathered waste ore, roasted ore, and byproducts generated from the smelting process (i.e., slag) have been transported from the original areas of deposition by erosion and re-distributed nearby, causing elevated concentrations of metals in the soil adjacent to the waste areas. Some of these materials have been conveyed by overland flow, resulting in elevated concentrations of metals in sediment along these Site drainage ways, including: Ely Brook, four tributaries to Ely Brook, Schoolhouse Brook, and the EBOR.

The RI divided the Site into several sub-areas that may be contributing contamination to the surface water, groundwater, or sediment. The sub-areas (shown in Figure ES-3) that fall within OU1 are the UWA; LWA; TA; and ORB. The sub-areas within OU2 are the SA, SF, and SPA. In addition, due to the significant volume of mine waste present in the sediment and banks along Lower Ely Brook, this area is also considered a potential source area. Evaluation of results from each of these areas has led to the following findings.

Operable Unit 1 Source Areas

UWA: The UWA is comprised of a series of terraced, overlapping mine waste rock piles of varying thickness in the upper portion of the Ely Brook valley on the south side of Dwight Hill. The UWA covers an area of approximately 8.5 acres and contains about 73,000 cubic yards of mine waste. The waste piles within the UWA are up to 22 feet thick. The UWA sits just downslope of the Main Adit for the underground workings. A series of shafts and adits (including the Main Adit) are found within and adjacent to the UWA. The primary limits of the UWA were defined by the physical presence of acid generating mine waste. The edges of the UWA were also delineated to include the areas where cobalt, copper, and iron exceed preliminary remediation goals (PRGs) established in the FS. A series of ponds numbered 1 through 5 define the downslope extent of the UWA.

Native soil underlies portions of the UWA, but some of the waste sits directly on bedrock. The groundwater extends into the lower portion of the piles, particularly during spring snowmelt and after periods of substantial rain. Water coming into contact with the mine waste creates an acidic leachate containing high levels of contamination that drains from the UWA into groundwater and several tributaries of Ely Brook (EBT2, EBT3, and EBT4A).

LWA: The LWA occupies approximately 6.4 acres of bare waste rock in the central portion of the Site and contains an estimated 29,000 cubic yards of waste rock. The LWA sits below the UWA and the foundation of the Former Flotation Mill, between the Ore Roast Bed and Ely Brook. Two major Site surface water features, EBT2 and EBT3, traverse the LWA. EBT3 merges into EBT2 prior to Ely Brook and the combined flow represents one of the most significant tributaries to Ely Brook. There are no distinct piles in the LWA. The waste material is relatively thin, typically on the order of 5 ft thick, in contrast to the thicker waste piles in the UWA. The primary limits of the LWA were defined by the physical presence of acid generating mine waste. The edges of the LWA were also delineated to include the areas where cobalt, copper, and iron exceed PRGs.

A relatively thin layer of native soil with variable thickness underlies the LWA. It is possible that some of the waste sits directly on or in close proximity to bedrock. The groundwater extends well into the waste within the LWA. Water coming into contact with the mine waste creates an acidic leachate containing high levels of contamination that drains from the LWA into groundwater and several tributaries of Ely Brook (EBT2, EBT3, and EBT5). These tributaries run across the waste within the LWA.

TA: The Tailings Area encompasses approximately 0.7 acres and contains an estimated volume of 3,600 cubic yards of tailings. The tailings waste are a remnant of the operation of the former floatation mill and are a fairly uniform fine sand/silt material produced from mined ore. The TA is located within the northwest portion of the LWA. There is no well defined tailing pile, but a tributary of Ely Brook (EBT3) has cut a channel that exposes this waste. A relatively continuous layer of glacial till approximately 10 feet thick is interpreted to underlie the Tailings Area, which may limit impact to groundwater beneath the tailings pile. Similar to the LWA, the

Tailings Area is saturated with groundwater and portions of waste source form the watershed of EBT3. Water coming into contact with the tailings creates an acidic leachate containing high levels of contamination that drains from the TA into groundwater and EBT3.

ORB: The ORB was the primary location for the roasting of the ore excavated from the Ely Mine. The ORB covers an area that is approximately 900 feet long and 200 feet wide, abutting the eastern margin of the access road, southeast of the LWA. The ORB is about 8 feet thick, covers about 2.2 acres, and contains approximately 10,300 cubic yards of roasted ore. The western limit of the ORB is demarked by a high stone slab retaining wall. The sparsely vegetated ORB soils are distinguishable from soils in the adjacent LWA by the deep red color of the hematite-rich soil. A small tributary to Ely Brook, EBT1, crosses the roast beds and the access road at a location where the retaining wall has collapsed. An abandoned exploratory shaft is located along the northeast margin of the ORB. The roasted ore in this area still contains significant levels of metals, but the waste material does not produce acidic leachate and appears to be a much less significant source of contamination than the UWA, LWA, and TA.

Ely Brook: The Lower Ely Brook contains significant accumulations of waste material that has eroded from the UWA, LWA, and TA. The waste is up to 3.5 feet thick within the stream channel and portions of the Lower Ely Brook bank. The estimated volume of waste material within the banks of the Lower Ely Brook is 3,900 cubic yards, encompassing an area of 2.5 acres. The waste material within Ely Brook contains elevated concentrations of cobalt, copper, and iron and may be a contributing source to the surface water impacts.

ES.5 Risk Assessments

Human Health Risk Assessment (HHRA) Summary

Nobis prepared the HHRA of the Site for the USEPA. The HHRA presents a description of the risk assessment methods employed for the Site, as well as a summary of the results. The objective of the HHRA was to estimate potential current and future human health risks from the presence of contamination in the soil, groundwater, sediment, and surface water. The HHRA quantitatively evaluates non-cancer health hazards, cancer risks, and lead exposures.

Data from soil, sediment, groundwater, surface water, and fish tissue were evaluated to identify maximum analyte concentrations for comparison to screening level benchmarks to determine human health contaminants of potential concern (COPCs). With regard to soil, the entire Site was combined as a single exposure area because the potential for exposure and contaminant distribution patterns do not indicate any unique areas of potential exposure. For surface water, three exposure areas were considered: the on-site tributaries/Ponds/Ely Brook, Schoolhouse Brook below the Ely Brook confluence and the EBOR below the Schoolhouse Brook confluence. Potential risk from groundwater was evaluated for individual flow units, including, overburden, shallow bedrock, and deep bedrock. Off-site groundwater was evaluated separately using residential well sample results. Fish tissue data were used to assess potential risk in Schoolhouse Brook and the EBOR.

Exposure scenarios are the assumptions used to define the potential use that may bring a person into contact with contamination. For the Ely Mine, the following exposure scenarios were considered:

- The potential risk to a person living on or adjacent to the Site and coming into contact with Site soil or indoor dust that originated as Site soil. The person was assumed to come into contact with the soil or dust for 350 days per year.

- The potential risk to a person installing a drinking water well in the contaminated groundwater at the Ely Mine Site and consuming 2 liters of water every day.

- The potential risk to a person visiting the Site 104 times per year and coming into contact with contaminated soil.

- The potential risk to a person visiting the Site 22 times per year and wading and/or swimming in Ely Brook or Schoolhouse Brook.

- The potential risk to a person whose work activities would require disturbance of the mine waste and inhaling the dust 60 days per year.

The results presented above for the HHRA indicate the following:

For the OU1 media and areas

- Surface and subsurface soils in the OU1 area contain levels of cobalt, copper, and iron that could represent an unacceptable threat to human health for children residing on and near the Site and coming into contact with the contamination 350 days per year.

- Surface and subsurface soil in the OU1 area would not represent an unacceptable threat to human health for adults residing on and near the Site and coming into contact with the contamination 350 days per year.

- Human contact with the soil in the OU1 area under less frequent exposure scenarios (recreational activities) was not considered to represent an unacceptable threat to human health.

- Human contact with sediment and surface water as a result of recreational activities in the OU1 area were also not considered to represent an unacceptable threat to human health.

- An unacceptable risk was not found to be associated with a person working in the waste material in the OU1 area for up to 60 days per year. More frequent contact, however, would result in an unacceptable risk associated with the inhalation of manganese and aluminum dust. The aluminum and manganese concentrations in soil were not significantly different from those measured in background locations.

While OU1 does not address groundwater as a response area, it is recognized that the cleanup of OU1 waste areas may indirectly improve groundwater quality since those waste areas are significant sources of the groundwater contamination.

For the OU2 media and areas

- Overburden and shallow bedrock groundwater at the Site contain contaminants that would represent an unacceptable threat to human health if used as a source of drinking water. The contaminants that are found above levels that are considered acceptable for human ingestion include: aluminum, antimony, cadmium, cobalt, copper, iron, manganese, molybdenum, nickel, zinc.

- Surface and subsurface soils in the OU2 source area (Smelter/Slag Area) contain levels of cobalt, copper, and iron that would represent an unacceptable threat to human health for children residing on and near the Site and coming into contact with the contamination 350 days per year.

- Human contact with the soil in the OU2 area under less frequent exposure scenarios (recreational activities) was not considered to represent an unacceptable threat to human health.

- Human contact with sediment, and surface water as a result of recreational activities in the OU2 area were also not considered to represent an unacceptable threat to human health.

- An unacceptable threat was not found to be associated with a person working in the waste material in the OU2 area for up to 60 days per year. More frequent contact, however, would result in an unacceptable threat associated with the inhalation of manganese and aluminum dust. The aluminum and manganese concentrations in soil were not significant different from background locations.

Aquatic BERA Summary

An aquatic BERA was performed on the aquatic habitats potentially affected by the Site. The major aquatic habitats at the Site consisted of:

- Ely Brook and its tributaries;

- Several small ponds (ponds 1 to 5) which serve as the headwaters for Ely Brook Tributary 2 (EBT2) (note: pond 1, the furthest upstream - and largest - of the five ponds, was used as a reference location because it was found to be unaffected by conditions at the Site);

- Vernal pools;

- Schoolhouse Brook; and
- Ompompanoosuc River.

Results from toxicity tests on sediment, surface water, and porewater along with analysis of the benthic and fish communities provided multiple measurement endpoints to assess potential risk. The following seven types of measurement endpoints were used in the BERA:

- Comparison of the contaminants of potential ecological concern (COPEC) levels in sediment, porewater, and surface water samples to published sediment or surface water benchmarks.
- Assessment of the bioavailability of divalent metals in sediment samples by measuring the Acid Volatile Sulfides (AVS) and Simultaneously Extracted Metals (SEM).
- Performance of toxicity tests in the laboratory by exposing sensitive life stages of aquatic invertebrates and fish to sediment, porewater, and surface water samples from the waterways.
- Performance of toxicity tests in the ponds by exposing wood frog eggs and tadpoles kept in floating cages.
- Comparison of the COPEC levels in whole fish collected from the waterways to literature-derived Critical Body Residues (CBRs).
- Quantification of the structure and function of the benthic invertebrate community and fish community in the waterways.
- Use of food chain modeling to calculate an Estimated Daily Dose (EDD) to insectivorous and piscivorous wildlife receptors from exposure to surface water and aquatic biota (winged aquatic insects and fish); compare these EDDs to Toxicity Reference Values (TRVs) from the literature.
- The results of the Aquatic BERA are summarized below.

Location	Overall Risk Conclusion/Chemicals of Concern
Pond 2	Minor risk detected for water column invertebrates and amphibians due to elevated manganese concentrations in the water. No risk detected for the benthic invertebrate community.
Pond 3	Minor risk detected for benthic invertebrate community, water column invertebrates, and amphibians due to elevated manganese concentrations in the sediment and the water.
Pond 4	Severe risk detected for amphibians and minor risk detected for benthic invertebrate community due to elevated copper concentrations in the sediment.
Pond 5	Severe risk detected for benthic invertebrate community, water column invertebrates, and amphibians due to elevated copper concentrations in the sediment and the water.
Ely Brook and its tributaries	Severe risk detected for benthic invertebrate community and the fish community as a result of ARD.
Schoolhouse Brook	Severe risk detected for benthic invertebrate community and the fish community as a result of ARD being released from the OU1 source areas.

- The Aquatic BERA documented that severe ecological impacts have occurred as a result of the release of ARD with toxic levels of metals from the Site waste areas into the surface water and sediment within the OU1 area including: Ely Brook, the tributaries of Ely Brook, and Ponds 4 and 5. The upstream (reference) areas of the Ely Brook headwaters and Pond 1 supported healthy populations of benthic invertebrates, further documenting that the Site is a significant source of ecological impairment. The measurement endpoint risk characterization is summarized in Tables 1-5 through 1-11 of the FS.

- The Aquatic BERA also documented that severe ecological impacts have occurred as a result of the release of ARD with toxic levels of metals from the OU1 waste areas into OU2 surface water and sediment. Specifically, this finding applies to Schoolhouse Brook. The upstream (reference) areas of Schoolhouse Brook supported healthy populations of benthic invertebrates, further documenting that the Site is the source of observed ecological impairment downstream of the confluence with Ely Brook. OU2 will specifically address any ecological threats associated with the sediment within

Schoolhouse Brook and the Ompompanoosuc River as well as the final restoration of these surface waters.

Terrestrial BERA

The Terrestrial BERA presents the ecological assessment for terrestrial habitats potentially affected by contaminants associated with historical mining operations at the Site. The objective of the Terrestrial BERA was to describe the likelihood, nature, and severity of observed or potential adverse effects to ecological receptors resulting from their exposure to mining-related contaminants currently present at the Site. In addition to evaluating terrestrial risk, the assessment looks at potential risk to the four vernal pools identified within the study area that were not assessed as part of the Aquatic BERA (USEPA, 2010a). Four potential vernal pools/complexes were identified as VP-1 through VP-4.

Sampling and subsequent ecological risk analysis focused on determining the potential for significant adverse ecological effects in the vegetated areas that border the barren surface of the waste piles and TA and any vernal pools located therein. Potential ecological receptors are outlined in the BERA. These include State or Federally–listed threatened bat species, known as the Indiana bat and the Eastern Small-Footed bat, which use the mine openings to hibernate. The target communities and receptors selected to evaluate potential ecological impacts include terrestrial plants, soil invertebrates, herbivorous birds and mammals, invertivorous birds and mammals, carnivorous birds and mammals, and the aquatic and amphibian communities associated with the on-site vernal pools.

The conceptual site model (CSM) includes exposure pathways for plants (direct soil contact), soil invertebrates (ingestion and contact with soil), birds and mammals (soil ingestion and food), and vernal pool species (contact and ingestion with surface water and sediment). Assessment endpoints include the survival, growth, and reproduction of plants, invertebrates, mammals, birds, and aquatic/amphibious vernal pool species. Results from soil, biota (invertebrates and small mammals) and surface water samples were used for comparison to conservative screening benchmarks obtained from a variety of sources as part of a preliminary Screening Level Environmental Risk Assessment (SLERA), including Ecological Soil Screening Levels (EcoSSLs) and PRGs for soil, ambient water quality criteria and other published sources for surface water.

Ecological risks were assessed by comparing media concentrations to benchmark values and modeled exposure concentrations to TRVs. The following table summarizes the findings of this risk analysis.

Receptor Group	Overall Risk Conclusion/Chemicals of Concern for OUI
Terrestrial Plants	The barren areas of the Site represent a significant adverse impact to the plant community. The primary cause of the impact is the acidity of the soil and pore water. There is the potential for adverse impact to individual terrestrial plants as a result of the contaminant concentrations at the Site. The COPCs are copper and, to a lesser extent, zinc. The overall impact on the plant community outside the barren waste areas was not considered significant.
Soil Invertebrates	The barren areas of the Site represent a significant adverse impact to the soil invertebrate community. The primary cause of the impact is the acidity of the soil and pore water. There is the potential for adverse impact to individual soil invertebrates as a result of the contaminant concentrations at the Site. The COPCs are copper and, to a lesser extent, zinc. The overall impact on the soil invertebrate community outside the barren waste areas was not considered significant.
Herbivorous Birds	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Invertivorous Birds	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Carnivorous Birds	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Herbivorous Mammals	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Invertivorous Mammals	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.
Carnivorous Mammals	The Terrestrial BERA concluded that significant ecological impacts to this receptor were unlikely.

The only significant terrestrial ecological threat in the OU1 area is the impairment of the plant and soil invertebrate communities in the barren areas of the Site. Although concentrations of metals detected in the vegetated (non-barren) areas at the Site were higher than plant and soil invertebrate benchmarks, field observations suggest that the toxicity of the Site material is substantially reduced when the waste is incorporated into a natural soil. Areas along the fringe of the barren waste areas have concentrations of metals comparable to the barren waste areas yet these areas support a plant community and soil invertebrates. Other factors, such as the highly acidic porewater and acid salts within the waste along with the absence of any organic matter to support vegetation are likely to be more significant factors in the absence of vegetation on the barren areas. When a soil horizon forms and provides organic matter, the plant community appears to be able to exist. As a result, a clear chemical-specific threat to the plant or soil invertebrate community is not identified for OU1 of the Site. The general Terrestrial BERA conclusion for OU1 is that the Site conditions, primarily the acidic waste material and associated acid salts and pore water have created barren areas which represent a local, yet significant, ecological harm to the plant and soil invertebrate community resulting in a loss of the critical ecological support functions including nutrient cycling, habitat, food, and soil stabilization to limit erosion. The barren areas of the Site are generally consistent with the source areas shown in Figure ES-3.

No significant ecological risk was identified for the other terrestrial receptors within the OU1 area. The hazard quotients were generally low for the mammal and bird receptors. In addition, the biota sampling suggested that most metals (particularly selenium and zinc) were not accumulating in tissue. Only copper was detected at concentrations that were statistically different from reference biota tissue samples, although individual samples suggested that some accumulation of aluminum and iron may occur. OU2 will address the ecological risk associated with the vernal pools and the Smelter/Slag area as well as any ecological risk associated with the underground mining workings.

ES.6 Development of Remedial Action Objectives

Remedial Action Objectives (RAOs) consist of medium-specific (e.g., water, soil), quantitative goals defining the extent of remediation required to protect human health and the environment. They specify contaminants of concern (COCs), exposure routes and receptors, and PRGs. In the case of groundwater, they also include a restoration time frame. RAOs are used as the framework for developing remedial alternatives. To develop RAOs, it is first necessary to identify applicable or relevant and appropriate requirements (ARARs) and PRGs.

Preliminary Remediation Goals

PRGs are long-term numerical goals used during analysis and selection of remedial alternatives. PRGs should comply with ARARs and result in residual risks consistent with NCP requirements for protection of human health and the environment. Therefore, PRGs are based both on risk-based concentrations and on ARARs. Eventually, PRGs become the basis for final remediation goals for the selected remedy. PRGs developed for protection of human health and ecological receptors are listed in Table ES-3.

Remedial Action Objectives

The RAOs for OU1 are summarized as follows:

- Control the release of ARD and acid mine drainage from the waste rock and tailings source areas (UWA, LWA, TA, and ORB) to allow Ely Brook to achieve the numerical and biological criteria for a Class B surface water in Vermont and to achieve Class B numerical criteria in Ponds 4 and 5.

- Protect Human Health by preventing direct contact with or incidental ingestion of soil within the OU1 source areas containing:
  - copper concentrations above 629 mg/Kg;
  - cobalt concentrations above 24 mg/Kg; or
  - iron concentrations above 44,800 mg/Kg.

- Restore the sediment quality of Ely Brook and its tributaries and Ponds 4 and 5 to concentrations below the PRG for copper and achieve biological integrity for these surface water bodies as demonstrated through compliance with Vermont Water Quality Criteria (VTWQC), NRWQC, and biological measures of recovery. Recovery will be measured by benthic and fish metrics achieving populations comparable with upstream and/or reference values and a finding of the sediment being non-toxic to aquatic organisms in toxicity tests.

- Restore the surface water quality of Ely Brook and its tributaries, and Ponds 4 and 5 to achieve biological integrity for these surface water bodies as demonstrated through compliance with VTWQC, NRWQC, and biological measures of recovery. Recovery will be measured by benthic and fish metrics achieving populations comparable with upstream and/or reference values and a finding of the surface water being non-toxic to aquatic organisms in toxicity tests.

- Restore the acid-impacted barren areas containing mine waste to create a functional ecological habitat with respect to the plant and soil invertebrate communities.

Areas and Volumes of Media Exceeding PRGs

Media identified for remedial action as part of OU1 include source area soil/waste material found in the UWA, LWA, TA, and the ORB. In addition, contaminated sediment is located in Ely Brook, Ely Brook Tributaries, and Ponds 4 and 5. Surface water that exceeds PRGs is not considered a waste media since RAs would address the root cause of the surface water impairment (ARD from waste rock and tailings) rather than being directly applied to the surface water itself. Site-wide groundwater is part of OU2. The areas and volumes of the source areas and sediment are summarized in Table ES-4 and below:

- The UWA extends over an approximately 8.5-acre area, and includes an estimated 73,000 cubic yards (cy) of mine waste. These volumes do not include the Lower Adit development rock pile. No adverse impacts have been observed from this development rock pile and the lithology of this waste rock is believed to be non-reactive. Therefore, it is not anticipated to be a source of metals or acidity. However, pre-design investigations should be performed to ensure that unidentified waste sources do not underlie this development rock pile. If the development rock is found to be acid generating, it will be removed along with the other waste rock in the UWA. It may also reside above acid generating waste rock and require relocation to access that material.

- Based on the observed vertical and lateral extent of waste rock and levels of cobalt, copper, and iron above PRGs the LWA area subject to the Remedial Action covers an approximately 6.4-acre area and includes an estimated 29,000 cubic yards (cy) of contaminated material.

- Based on the observed vertical and lateral extent of waste rock and levels of cobalt, copper, and iron above PRGs the TA area subject to the Remedial Action covers an approximately 0.7-acre area and includes an estimated 3,600 cubic yards (cy) of contaminated material. The tailings are a finer-grained soil than the course-grained and cobble waste rock observed in the remainder of the LWA. The tailings are classified as by the State of Vermont a beneficiated waste which has different closure requirements than non-beneficiated waste in accordance with the Solid Waste Management Rules.

- The ORB extends over a 2.2 acre area and includes an estimated 10,330 cy of waste rock. The extent of this waste area is defined by cobalt, copper, and iron soil concentrations exceeding the PRGs. Waste material in this area includes remnant layers of partially-roasted ore, which were left there after closure of the mine operation. The ORB material is classified by the State of Vermont as a beneficiated waste which has different closure requirements than non-beneficiated waste in accordance with the Solid Waste Management Rules.

Ely Brook and Tributaries

Ely Brook, its tributaries (EBT1, EBT2, EBT3, and EBT4) and Ponds 4 and 5 all contain sediment that exceeds the sediment PRG for copper. The areas and volumes of sediment for these three components are discussed separately below.

Ely Brook: As previously stated, the Ely Brook Headwaters are believed to be unimpacted by mine activities as evidenced by the lack of elevated metals concentrations in sediment and surface water samples collected in the reach. Therefore, the Ely Brook Headwaters are used as background or reference location. The RI and the Aquatic BERA documented that the sediments of the rest of Ely Brook exceed the PRG for copper and could be contributing metals to the surface water. For the purpose of estimating the volume of impacted sediment, the entirety of each of the remaining zones in the rest of Ely Brook is considered to exceed the copper PRG and, therefore, to require a response action. The area and volume for each reach is presented in Table ES-4 and summarized in the table below.

Reaches	Defined Location	Length (ft)	Estimated Volume of Impacted Sediments (cy)
Ely Brook Headwaters	north and upstream of old road crossing	1,500	N/A – reference
Upper Ely Brook	from EBT-2 up to old road crossing	1,700	378
Middle Ely Brook	EBT-2 to between SD-61 and SD-62	660	580
Lower Ely Brook	between SD-61 and SD-62 and includes the delta located at the confluence with Schoolhouse Brook	1,200	3,950

It should be noted that the sediment deposited in the deltaic fan at the confluence with Schoolhouse Brook is believed to be a significant source of metals and acidity to Schoolhouse Brook. Because this sediment originated from Ely Brook, is laterally contiguous with the Ely Brook impacted sediment zone, and is most feasibly addressed in conjunction with sediment removal alternatives that extend to the termination of the Ely Brook, this sediment volume will be included in the Lower Ely Brook source area as part of OU1.

Ely Brook Tributaries: Ely Brook has four designated tributaries (EBT1 through EBT4):

- EBT1 is the surface water drainage originating from the ORB and the waste rock in the Site access road;
- EBT2 is the surface water drainage originating from Ponds 4 and 5 and the LWA;
- EBT3 is the surface water drainage originating from the UWA, TA, and LWA; and
- EBT4 is the surface water drainage originating from the UWA.

The area and volume for Ely Brook's four designated tributaries (EBT1 through EBT4) are presented in Table ES-4. These tributaries receive water and waste rock or tailing sediments from the waste source areas described in the sections above. It is assumed that the entire reach of the tributaries contains sediments that exceed the copper PRG, and will therefore require being addressed by the remedial action. The estimated total volume of impacted sediments within the Ely tributaries is 3,221 cy.

Ponds 4 and 5

The RI and the Aquatic BERA documented that the sediments of Ponds 4 and 5 exceed the sediment PRG for copper and are contributing to the adverse impacts to the ecological receptors. The estimated surface area of Ponds 4 and 5 are approximately 4,800 ft^2 (0.1 acres). Due to the small size of the ponds and the small volume of the drainage connecting the pond complex, the depth of contamination is believed to be shallow. Based on the sediment data, the estimated volume of impacted sediments in Ponds 4 and 5 is 378 cy.

ES.7 General Response Actions

GRAs are broad categories consisting of remedial technologies and process options that can be selected individually or in combination in order to meet the RAOs for OU1. GRAs are included in the FS process to give a range of responses for consideration for site remediation. A complete list of these categories can be found in Table ES-5. The selected OU1 GRAs are:

- No Action
- Limited Action
- Containment
- Removal and Disposal/Discharge
- In-Situ Treatment
- Ex-Situ Treatment

Categories of remedial technologies and specific process options were identified based on a review of literature, vendor information, performance data, and experience in developing other FSs under CERCLA. The screening process assesses each technology or process option for its effectiveness, implementability with regard to site conditions, known and suspected contaminants, and affected environmental media; and relative cost. The effectiveness evaluation focuses on: (1) whether the technology is capable of handling the estimated areas or volumes of media and meeting the contaminant reduction goals identified in the RAOs; (2) the effectiveness of the technology in protecting human health and the environment during the construction and implementation phase; and (3) how proven and reliable the technology is with respect to contaminants and conditions at the site. Implementability encompasses both the technical and administrative feasibility of implementing a technology. Tables ES-6 and ES-7 display the screening of the applicable GRAs for waste rock/impacted soils and sediment, respectively.

Technologies and process options judged ineffective or not implementable were eliminated from further consideration. The RI did not identify any principal threat wastes at the Site. In addition, because the source of contamination is a large volume of low level mine waste, technologies that would require treatment of the entire volume of mine was were not retained after the identification and initial screening of alternatives. The technologies retained at the end of the screening represent an inventory of technologies that are considered most suitable for remediation of soil and sediment in OU1.

Due to the nature of the OU1 waste material (mine waste), only a limited range of options were identified based on the general response actions and process options that passed the technology screening. Furthermore, only one technology (excavation/dredging) was retained to address the contaminated sediment in Ely Brook, its tributaries, and Ponds 4 and 5. As a result, the RA for addressing the sediments is incorporated into the alternatives that address, soil, waste rock and tailings. The four source control (SC) remedial alternatives (including No Action) that have been identified to address OU1 RAOs for sediment, soil, waste rock, and tailings are listed below.

- Alternative SC1 – No Action Alternative
- Alternative SC2 – Waste containment in the Lower Waste Area Cell and in the Ore Roast Bed of the tailings from the TA within a capped closure on the ORB.
- Alternative SC3 – Waste containment in the West Cell and in the Ore Roast Bed
- Alternative SC4 – Off-site disposal and waste containment in the Ore Roast Bed

The following subsections describe the alternatives developed for OU1 source areas and sediments.

Alternative SC1 – No Action

Alternative SC1, the No Action alternative, does not include RA components to reduce, control, or eliminate potential risks from exposure to contaminants in source-area soil. No action will be taken to reduce ARD generation or the migration of ARD-impacted groundwater or seeps to Ely Brook or its tributaries and Ponds 4 and 5 where it may contribute to surface water exceedances of NRWQC and exceedances of sediment PRGs. Alternative SC1 would not implement an environmental monitoring program to assess long-term changes in contaminant concentrations in soil in order to protect human health and the environment. Alternative SC1 would include statutorily-required five-year reviews. CERCLA requires that the No Action alternative be evaluated to establish a baseline for comparison to other remedial alternatives. Alternative SC1 will not be evaluated according to screening criteria, and will pass through screening to be evaluated during detailed analysis (USEPA, 1988b).

A detailed analysis of Alternative SC1 is included in Section 4.1 of the FS Report.

Alternative SC2 – Waste Containment in the LWA Cell and in the Ore Roast Bed

Alternative SC2 would involve the excavation of the UWA and LWA, Ely Brook and its tributaries, and Ponds 4 and 5, consolidation of the material into a containment cell located in the area of the LWA (Figure ES-4) (LWA Cell), constructing surface water diversions to redirect the surface water around the LWA Cell, installation of a low permeability cover system to contain and isolate the waste rock, installation of a continuous full-bottom containment liner below the waste and installation of a horizontal underdrain system to maintain the groundwater elevation to a level below the waste and liner (cross-section of potential cell depicted on Figure ES-5).

Several tributaries to Ely Brook are located within the UWA and LWA; these tributaries will be excavated as a source of surface water contamination and consolidated with the waste rock in the containment cell. The sediments located in Ponds 4 and 5, Middle Ely Brook and Lower Ely Brook exceeding the copper PRG will be excavated and disposed in the LWA Cell. The sediments in Upper Ely Brook will be removed by either flushing the sediments into the lower reaches prior to the removal of sediment from these areas or via vacuum extraction. Monitoring of Upper Ely Brook will be performed to assess whether all contaminated sediment was successfully removed. Temporary diversions or damming of Ely Brook and Ponds 4 and 5 would be used to enable dry working conditions. After excavation/dredging, restoration would be performed for Ely Brook. Middle Ely Brook would be restored as a rip-rap armored channel; Lower Ely Brook would be restored as a natural channel; and Ponds 4 and 5 as either a rip-rap armored channel from Pond 3 downstream to Ely Brook near the confluence with EBT2 or restored to native aquatic habitat as part of a wetland mitigation.

Alternative SC2 also includes excavation of the TA and layering of the tailings on the ORB, construction of a low-permeability cover system over the material, and construction of surface water diversions to redirect the surface water from the areas upgradient of the ORB around the cover system. A cross-section of the ORB cell is depicted on Figure ES-6.

Restoration of the excavated areas will consist of grading the slopes to allow for adequate surface water drainage and minimize soil erosion. Additional components include institutional controls, environmental monitoring, and five-year reviews.

This alternative would consist of the following key components:

- Pre-design investigations and studies;
- If on-site material is used for the containment cell, timber clearing and grading of an approximate 15-acre area west of Ely Brook to obtain soil for the containment cell;
- Excavation of the soil material and restoration of the disturbed areas;
- Excavation and consolidation of waste rock, soil, and sediment exceeding PRGs from the UWA, LWA, Ely Brook, and Ponds 4 and 5, within a containment cell in a subarea of the LWA;
- Construction of a lined cover system for the containment cell in the LWA with surface water diversion measures;
- Installation of a continuous full-bottom containment liner and horizontal underdrain beneath the containment cell in the LWA to maintain separation between the waste material and surface water/groundwater;
- Excavation of the TA and placement of the tailings on the ORB;
- Construction of a low-permeability cover system over the ORB/tailings material with surface water diversion;
- Institutional controls to protect the response actions, including protection of the cover system, surface water diversions, and restoration areas;
- Installation of monitoring wells;

- Long-term operation and maintenance;
- Environmental monitoring;
- Restoration of waterways, wetlands, and wildlife habitat, as required;
- Institutional control inspections; and
- Five-year reviews.

The containment of the waste rock and soil exceeding PRGs in the LWA using a lined cover system and a horizontal underdrain system will minimize the potential for these waste materials to come in contact with surface water and/or groundwater, thereby minimizing the potential for ARD to occur. These activities will reduce human contact with metals above the PRGs, improve surface water and groundwater quality by reducing the sources of contamination, and comply with ARARs.

The capping of the tailings and ORB will reduce human contact with metals above the PRGs. The tailings and ORB do not contribute a significant impact to the groundwater or surface water. The excavation of source material will, in addition to controlling direct exposure risks, reduce leaching and erosion that contribute to exceedances of federal and state water quality standards in Ely Brook and its tributaries sediment and surface water.

A detailed analysis of Alternative SC2 is included in Section 4.2 of the FS Report.

Alternative SC3 – Waste Containment in the West Cell and in the Ore Roast Bed

Alternative SC3 includes excavation of the UWA and LWA and consolidation into a containment cell located in an on-site area to the west of Ely Brook (Figure ES-7) (West Cell); clearing and grading the work area along with a sufficient lay-down area; construction of surface water diversions to redirect the surface water from Ponds 4 and 5 and seeps/runoff around the cell; and installation of a low-permeability cover system to contain and isolate the waste rock (cross-section of potential cell depicted on Figure ES-8).

Several tributaries to Ely Brook are located within the UWA and LWA; these tributaries will be excavated as a source of surface water contamination and consolidated with the waste rock in the containment cell. The sediments located in Ponds 4 and 5, Middle Ely Brook and Lower Ely Brook exceeding the PRGs will be excavated and disposed of in the containment cell. The sediments in Upper Ely Brook will be removed by either flushing the sediments into the lower reaches prior to the removal of sediment from these areas or via vacuum extraction. Monitoring of Upper Ely Brook will be performed to assess whether all contaminated sediment was successfully removed. Temporary diversions or damming of Ely Brook and Ponds 4 and 5 would be used to enable dry working conditions. After excavation/dredging, restoration would be performed for Ely Brook. Middle Ely Brook would be restored as a rip-rap armored channel; Lower Ely Brook would be restored as a natural channel; and Ponds 4 and 5 as either a rip-rap armored channel from Pond 3 downstream to Ely Brook near the confluence with EBT2 or restored to native aquatic habitat as part of a wetland mitigation.

Alternative SC3 also includes excavation of the TA and layering of the tailings on the ORB, construction of a low-permeability cover system over the material, and construction of surface water diversions to redirect the surface water areas upgradient of the ORB around the cover system. A cross-section of the ORB cell is depicted on Figure ES-6.

Restoration of the excavated areas will consist of grading the slopes to allow for adequate surface water drainage and minimize soil erosion. Additional components include institutional controls, environmental monitoring, and five-year reviews.

This alternative would consist of the following key components:

- Pre-design investigations and studies;
- Timber clearing and grading of cell area and lay-down area west of Ely Brook;
- Excavation and consolidation of waste rock, soil, and sediment exceeding PRGs from the UWA, LWA., Ely Brook, Ponds 4 and Pond 5, within a containment cell west of Ely Brook;
- Construction of a cover system for the containment cell west of Ely Brook with surface water diversion measures;
- Excavation of the TA and placement of the tailings on the ORB;

- Construction of a low-permeability cover system over the ORB/tailings material with surface water diversion;
- Institutional controls to protect the response actions: including protection of the cover system, surface water diversions, and restoration areas;
- Installation of monitoring wells;
- Long-term operation and maintenance;
- Environmental monitoring;
- Restoration of waterways, wetlands, and wildlife habitat, as required;
- Institutional control inspections; and
- Five-year reviews.

The containment of the waste rock and soil exceeding PRGs in a cell west of Ely Brook using a lined cover system will minimize the potential for the waste material to come in contact with surface water and/or groundwater, thereby minimizing the potential for ARD to occur. These activities will reduce human contact with metals above the PRGs, improve surface water and groundwater quality by reducing the sources of contamination, and comply with ARARs.

The capping of the tailings and ORB will reduce human contact with metals above the PRGs. The tailings and ORB do not contribute a significant impact to the groundwater or surface water. The excavation of source material will, in addition to controlling direct exposure risks, reduce leaching and erosion that contribute to exceedances of federal and state water quality standards in Ely Brook and its tributaries sediment and surface water.

A detailed analysis of Alternative SC3 is included in Section 4.3 of the FS Report.

Alternative SC4 – Off-Site Disposal and Waste Containment in the Ore Roast Bed

Alternative SC4 includes excavation of waste rock and soils that exceed PRGs from the UWA and LWA with off-site disposal of the material and construction of surface water diversions to redirect the surface water from Ponds 4 and 5 (Figure ES-9). Several tributaries that act as a source of surface water contamination to Ely Brook are located within the UWA and LWA. These tributaries will be excavated and consolidated with the waste rock transported for off-site disposal. The sediments located in Ponds 4 and 5, Middle Ely Brook and Lower Ely Brook that exceed PRGs will be excavated and disposed of off-site with the waste rock. The sediments in

Upper Ely Brook will be removed by either flushing the sediments into the lower reaches prior to the removal of sediment from these areas or via vacuum extraction. Monitoring of Upper Ely Brook will be performed to assess whether all contaminated sediment was successfully removed. Temporary diversions or damming of Ely Brook and Ponds 4 and 5 would be used to enable dry working conditions. After excavation/dredging, restoration would be performed for Ely Brook. Middle Ely Brook would be restored as a rip-rap armored channel; Lower Ely Brook would be restored as a natural channel; and Ponds 4 and 5 as either a rip-rap armored channel from Pond 3 downstream to Ely Brook near the confluence with EBT2 or restored to native aquatic habitat as part of a wetland mitigation.

Alternative SC4 also includes excavation of the TA and layering of the tailings on the ORB, construction of a low permeability cover system over the material, and construction of surface water diversions to redirect the surface water areas upgradient of the ORB around the cover system. A cross-section of the ORB cell is depicted on Figure ES-6.

Restoration of the excavated areas will consist of grading the slopes to allow for adequate surface water drainage and minimize soil erosion. Additional components include institutional controls, environmental monitoring, and five-year reviews.

This alternative would consist of the following key components:

- Pre-design investigations and studies;
- Excavation and off-site disposal of waste rock, soil, and sediment exceeding PRGs from the UWA, LWA, Ely Brook, and Pond 4 and Pond 5;
- Excavation of the TA and placement of the tailings on the ORB;
- Construction of a low-permeability cover system over the ORB/tailings material with surface water diversion;
- Institutional controls to protect the response actions: including protection of the cover system, surface water diversions, and restoration areas;
- Installation of monitoring wells;
- Long-term operation and maintenance;
- Environmental monitoring;
- Restoration of waterways, wetlands, and wildlife habitat, as required;

- Institutional control inspections; and
- Five-year reviews

The removal of the waste rock and soil exceeding PRGs will minimize the potential for the waste material to come in contact with surface water and/or groundwater, thereby minimizing the potential for ARD to occur. These activities will reduce human contact with metals above the PRGs, improve surface water and groundwater quality by reducing the sources of contamination, and comply with ARARs. The capping of the tailings and ORB will reduce human contact with metals above the PRGs. The tailings and ORB do not contribute a significant impact to the groundwater or surface water. The excavation of source material will, in addition to controlling direct exposure risks, reduce leaching and erosion that contribute to exceedances of federal and state water quality standards in Ely Brook and its tributaries sediment and surface water.

A detailed analysis of Alternative SC4 is included in Section 4.4 of the FS Report.

ES.8 Evaluation of Alternatives

The detailed analysis included in the FS is intended to provide decision makers with information on specific statutory requirements for RAs that must be addressed in the ROD (USEPA, 1988b). The comparative analysis compares the remedial alternatives with respect to the evaluation criteria used during the detailed analysis of alternatives. The purposes of the comparative analysis are to identify the advantages and disadvantages of alternatives relative to one another, and to assist in the eventual selection of a preferred remedial alternative for OU1 that will be included in the OU1 Proposed Plan for public comment and documented in the OU1 ROD.

The NCP outlines the approach for performing the comparative analysis of remedial alternatives. The proposed remedy must reflect the scope and purpose of the actions undertaken and how these actions relate to other RAs and the long-term response at the site. Identification of the preferred alternative and final selection of a remedy are based on an evaluation of the major tradeoffs among alternatives in terms of the nine evaluation criteria. USEPA categorizes the evaluation criteria into three groups: threshold, balancing, and modifying. Each criteria group is discussed in the following subsections.

Threshold Criteria

USEPA designated two threshold criteria: (1) overall protection of human health and the environment, and (2) compliance with ARARs. An alternative must meet both criteria to be eligible for selection as the preferred site remedy.

Primary Balancing Criteria

The five primary balancing criteria are long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. These balancing criteria provide a preliminary assessment of the extent to which permanent solutions and treatment can be used practicably and in a cost-effective manner.

An alternative that is protective of human health and the environment, is ARAR-compliant, and affords the best balance among these criteria is identified as the preferred alternative in the Proposed Plan. The balancing emphasizes long-term effectiveness and reduction of toxicity, mobility, or volume through treatment.

Modifying Criteria

State and community acceptance are factored into a final balancing that determines the preferred remedy and the extent of permanent solutions and treatment practicable for the site. Formal state regulatory agency comments will not be received until after the agencies have reviewed the FS and public comments to the Proposed Plan. Community input will be factored into the remedy selection process following the public comment period on the Proposed Plan.

ES.9 Comparative Analysis of Alternatives

Based on the results of the detailed analysis of alternatives, it was determined that each of the waste rock alternatives (SC2, SC3, and SC4) was technically feasible and has been brought forward for the comparative analysis.

Overall Protection of Human Health and the Environment

According to CERCLA, this criterion must be met for a remedial alternative to be chosen as a final site remedy. Alternative SC1, the No Action Alternative, would not eliminate, reduce, or control source areas or potential future exposure to contaminants exceeding PRGs and would not meet RAOs. Therefore, this alternative is not protective of human health and the environment and cannot be chosen as a final remedy.

Alternatives SC2, SC3, and SC4 would each be protective of human health and the environment. Each of the alternatives would eliminate the direct contact and incidental ingestion risks from cobalt, copper and iron within the waste rock, tailing, and sediment areas through removal or capping of these materials.

The removal of the UWA and LWA source material and containment in either the LWA Cell (SC2) or the West Cell (SC3) or off-site disposal (SC4) would remove and/or control the most significant sources of sediment and surface water contamination by preventing the formation of ARD and the erosion of mine waste. Restoration of the areas formerly occupied by the waste material would also eliminate the barren soil that was toxic to plants and soil invertebrates.

Capping of the tailings within the ORB would prevent this material from acting as a source of sediment and surface water contamination. Also, removal of acutely toxic sediments from Ely Brook, its tributaries, and Ponds 4 and 5 and consolidating them in the LWA Cell (SC2) or the West Cell (SC3) or transporting them off site for disposal (SC4) would eliminate that threat to the ecological system of OU1. Each of the alternatives would implement institutional controls to prevent site use that could damage the components of the cleanup.

Alternatives SC2, SC3, and SC4 are very similar in the degree to which they achieve protection of human health and the environment. SC3 would be more protective than SC2 because the waste material would be isolated in a containment cell that is specifically engineered to prevent direct contact and ARD generation for the site specific waste. The disposal location chosen under SC4 could have a less protective cover system because the waste material is not a regulated solid waste. The location of the West Cell makes SC3 more protective than SC2 since SC2 would create a LWA Cell in a location that is more susceptible to infiltration by groundwater and surface waters from the adjacent waterway. In addition, a LWA cell would potentially be susceptible to uncontrolled discharges from the Underground Mine Workings (OU2). Each of the alternatives includes those components that result in direct and indirect impacts to wetlands and aquatic habitat. SC4 would have a lower short-term environmental impact to wetlands because it would not require clearing for staging areas, borrow areas, or for construction of the West Cell (SC3) or LWA Cell (SC2). SC4 would, however, have a substantially greater overall environmental impact as there are no disposal facilities in close proximity to the Site. The nearest licensed solid waste facility in VT is 50 miles away, resulting in a 100-mile round trip for trucks to bring material from the Site to the landfill. These short term impacts associated with the additional truck traffic and generation of greenhouse gases reduce the overall protectiveness of SC4. If the waste material required substantial processing (due to size restrictions or pre-treatment requirements to reduce acid generating potential) additional cost and short-term impacts would arise. SC2 and SC3 are considered equally protective with respect to the environment as a whole because SC2 would result in a smaller footprint of disturbance than SC3 in the event that on-site materials are not used, although SC2 would result in a 63 percent increase in trucking requirements over SC3, resulting in a much higher carbon footprint. Furthermore, if on-site materials are utilized, SC2 would require an estimated 15 acres of forest clearing, while SC3 would only require 12 acres, all of which is in the footprint of the West Cell and staging area.

The relative ranking of protectiveness is SC3 > SC4 > SC2.

Compliance with ARARs

CERCLA requires that a selected alternative must also meet a second threshold criterion of compliance with ARARs, or a waiver must be obtained if the criterion cannot be met. According to CERCLA, this criterion must be met for a remedial alternative to be chosen as a final remedy.

Location-Specific ARARs. Alternative SC1 – No Action does not include any actions, therefore this alternative does not trigger location-specific ARARs.

Alternatives SC2, SC3, and SC4 would be designed and implemented to comply with regulations related to wetlands, historical preservation, land use and development, stream flow, fish and wildlife habitat, endangered species, floodplains, and wetlands. Each of the alternatives includes components that result in unavoidable direct and indirect impacts to both wetlands and historic resources, but these impacts can be mitigated. USEPA has determined that SC3 is the least environmentally damaging practicable alternative for protecting wetland resources as called for under Section 404 of the federal Clean Water Act and is therefore more ARAR compliant than SC2 and SC4. The extents of the impacts are shown on Figure ES-10. This finding was made because SC3 will permanently contain Site contamination in Site uplands where long-term impacts to wetland resources will be minimized in comparison with SC2 which would locate the LWA Cell adjacent to Site waterways in an area with a high groundwater table. While SC4 permanently removes a large volume of contamination from the Site the operation to ship such a large volume of waste is less practicable than SC3's on-site option.

EPA will need to consult with federal and state wildlife officials to determine what measures may be required to mitigate for impacts to endangered bat habitat on Site. All other identified location-specific ARARs can be satisfied by all the alternatives. The relative ranking of location-specific ARAR compliance is SC3 >SC4>SC2 (i.e., SC3 is more compliant than SC4 which is more compliant than SC2).

Chemical-Specific ARARs. Alternative SC1 would not attain protective concentrations for Site contaminants in soil or sediment and would not comply with chemical-specific ARARs and standards to be considered (TBCs).

SC2, SC3, and SC4 would each result in effective containment or removal of the waste rock, sediment, and tailings sources, resulting in restoration of OU1 surface water to PRGs following implementation. Each would achieve equal compliance with chemical-specific ARARs and TBCs, therefore, the relative ranking of chemical-specific ARAR compliance is SC4 = SC3 = SC2.

Action-Specific ARARs. Because Alternative SC1 does not include any actions, the alternative does not trigger action-specific ARARs.

Alternatives SC2 and SC3 would construct a containment cell for the waste rock (which is not regulated as solid waste in Vermont) and sediments and therefore meet relevant and appropriate mine closure and risk-based standards. SC2 can achieve these standards only if implementability issues with citing the LWA contaminant cell in an area of high groundwater adjacent to Site waterways can be addressed. Alternative SC4 will meet these standards by removing all of the material and disposing of it off-site. All three alternatives will consolidate and permanently cap tailings and ORB in the ORB Cell in compliance with Vermont Solid Waste standards. Alternatives SC2, SC3, and SC4 are equally compliant with respect to action-specific ARARs regarding long-term monitoring of the waste management areas that would include federal and state drinking/groundwater standards for monitoring groundwater, as well as federal and State surface water quality standards for monitoring Site waterways. The remediation of OU1 sediments under all three alternatives would meet TBC standards under USEPA contaminated sediment guidance. The three alternatives would also meet State erosion control TBC guidance standards. Therefore, the relative ranking of action-specific ARAR compliance is SC4 = SC3 = >SC2.

Long-Term Effectiveness and Permanence

This criterion evaluates the magnitude of residual risk and the reliability of controls after response objectives have been met. Alternative SC1 would not eliminate, reduce, or control source areas or potential future exposure to contaminants exceeding PRGs and would not provide long-term effectiveness at protecting human health and the environment.

Alternatives SC2, SC3, and SC4 would each provide similar actions to control exposure risk for the waste rock and sediments in OU1. These actions would provide good long-term effectiveness and permanence. Alternatives SC2, SC3, and SC4 each take actions to cap the tailings on the ORB, excavate the source areas, and either consolidate waste materials in containment cells (SC2 and SC3) or dispose of them off-site (SC4), thereby controlling the generation of ARD at these source areas. For Alternative SC2, excavated material would be removed and isolated in the LWA Cell. For Alternative SC3, excavated material would be removed and isolated by consolidation and capping in the West Cell.

Alternatives SC2, SC3, and SC4 would reduce ecological risk from exposure to contaminated sediments exceeding PRGs by excavating/dredging the reaches of Ely Brook and Ponds 4 and 5 and then isolating the excavated sediments in the containment cells or at an off-site location.

Consolidation of source material in the LWA as part of Alternative SC2 is considered a long-term solution. However, because the LWA Cell footprint is located within the low point of the Ely

Brook drainage area, below the existing water table, significant engineering controls will be required to divert surface water and groundwater discharge from the cell. The requirement to construct an underdrain that isolates waste from groundwater and surface water may require additional long-term maintenance and repairs. Because this closure cell design is atypical and non-ideal, it creates greater uncertainty regarding the long-term effectiveness and permanence relative to SC3 and SC4. Long-term maintenance and repair of the SC2 underdrain system is expected to be more problematic than maintenance of the SC3 cell, which is more effectively isolated from surface water and groundwater.

In comparison, Alternative SC3 would be constructed in an area isolated from low-lying wet areas and would utilize standard design and construction components. Based on its reliance on proven technology, SC3 is considered to be more implementable and have greater long-term effectiveness and permanence than Alternative SC2.

Alternative SC4 includes excavating the waste material and transporting it to an off-site location for permanent disposal. Since Alternative SC4 does not rely on an on-site engineering control for the waste rock and sediments it is considered to have slightly more long-term effectiveness and permanence than SC3, which is more effective and permanent than SC2, provided the off-site facility places the unregulated material beneath a cover system of equal performance to the cover system to be installed for SC2 or SC3. If a less substantial cover system is used to cover the waste at the off-site facility, then SC2 and SC3 would have greater long-term effectiveness.

The relative ranking of long-term effectiveness, therefore, is SC3 = > SC34 > SC2, due to the long-term effectiveness of disposing of the waste off-site rather than on-site.

Reduction of Toxicity, Mobility, and Volume through Treatment

This criterion evaluates whether the alternatives meet the statutory preference for treatment under CERCLA. The criterion evaluates the reduction of toxicity, mobility, or volume of contaminants, and the type and quantity of treatment residuals.

Alternative SC1 does not contain any components to reduce the toxicity, mobility, or volume of contaminants through treatment. Alternatives SC2, SC3, and SC4 all may have limited treatment components pertaining to treatment of dewatering liquid and the potential use of limestone in settling ponds, drainage channels, or in streams to reduce the toxicity and mobility of ARD. SC2 and SC3 may include added treatment processes for leachate generated from the LWA and West Cells, respectively. SC4 may include limited stabilization of contaminated sediments prior to off-site shipment.

The relative ranking of the alternatives at reducing the toxicity, mobility, or volume of contaminants through treatment is SC3 = SC2 > SC4.

Short-Term Effectiveness

CERCLA requires that potential adverse short-term effects to workers, the surrounding community, and the environment be considered during implementation of an RA and until response objectives have been met. Under this criterion, the time period to achieve protectiveness is also evaluated. Alternative SC1 does not lead to any exposure risks and, therefore, results in no short-term effects; however, it never achieves protectiveness of human health or the environment and therefore is not effective in the short-term.

Each of the alternatives would use on-site materials and resources to reduce short-term risks to the community from construction traffic to and from the Site. In the event that sufficient on-site sources for earthen materials are not identified, SC2 and SC3 would need to rely on imported materials. The construction of SC2 would require an estimated 93,000 cy of stone, borrow, and topsoil, resulting in approximately 5,150 truck loads. The construction of SC3 would require an estimated 52,000 cy of stone, borrow, and topsoil, resulting in approximately 2,901 truck loads, significantly less than the trucking required for SC2. As a result, SC2 would have a larger short-term environmental footprint than SC3.

In the event that sufficient on-site sources for earthen materials are identified, SC2 and SC3 would generate earthen materials from previously undisturbed areas. Based on an estimated yield of 7,000 cy per acre, the construction of SC2 could potentially require 15 acres of land to be cleared, while the construction of SC3 would require 12 acres, all of which may potentially be within the footprint of the SC3 cell construction and staging area. As a result, SC2 would have a larger short-term environmental footprint than SC3.

Under both alternatives SC2 and SC3, the areas where waste is removed will be reclaimed to the extent practical. Some areas may be left as exposed rock, whereas areas with clean soil remaining after waste removal will be restored to establish native vegetation, including wetland habitat, which will dramatically decrease the environmental footprint of the Site when compared to current conditions. The surface of the containment cells will also be vegetated.

For the other common components of SC2 and SC3, there would also be similar short-term impacts resulting from truck traffic importing the necessary materials to the Site for the remediation activities, including the restoration of Ely Brook and the Ponds 4 and 5 Area, as well as the construction of containment cell cover systems.

Alternative SC4 would include significantly higher short-term impacts related to the estimated 7,400 to 9,500 truck loads required to transport the waste material to an off-site facility. Some of these would be offset by the significantly fewer loads coming to the Site with needed materials for construction of containment cells; however, the ORB cap and stream channel restoration work included in SC4 will require material deliveries. In total, assuming that all needed borrow materials can be found on site, SC2 and SC3 result in an estimated 5,333 fewer truck trips on local roads. Due to the distance to the off-site disposal facility, SC4 would have a substantially greater overall environmental impact as there are no disposal facilities in close proximity to the Site. The nearest licensed solid waste facility in Vermont is 50 miles away, resulting in a 100-mile round trip for trucks to bring material from the Site to the landfill. If the waste material required substantial processing (due to size restrictions or pre-treatment requirements to reduce acid generating potential) additional cost and short-term impacts would arise.

SC2 would also require that LWA waste rock be removed and placed in a temporary stockpile area. This is necessary for the construction of the underdrain system, as well as to provide some dewatering of these wastes prior to placement in the closure cell. This stockpile area would be located in an area previously altered to minimize short-term impacts to wetlands and terrestrial habitats. Although temporary, the construction of the LWA relocation stockpiles would require some features typical of the final closure cells, such as surface water diversions, groundwater interceptor trenches, leachate collection systems, and covers to provide protection from erosion and stormwater discharge.

Alternatives SC2, SC3, and SC4 would all result in construction-related concerns (e.g., blasting, noise, and dust) and would result in some short-term effects to the community from truck traffic to deliver equipment and materials.

Both SC2 and SC3 would result in short-term impacts to known wetland areas and aquatic habitats (Ely Brook and Ponds 4 and 5). Some permanent loss of these areas may occur depending on the need for engineered structures to protect the cover systems. The areas that are not subject to permanent loss are expected to fully recover and achieve a higher level of function and value post-cleanup with the removal of the site contaminants. There would be short-term impacts to Ely Brook, Ponds 4 and 5, and areas subject to dredging or excavation as part of SC2, SC3, and SC4. Besides the wetland areas destroyed to excavate the waste material, no other unaltered wetlands areas would be impacted due to activities associated with Alternative SC4.

At this time it has not been determined how each alternative may impact endangered bat habitat. USEPA will consult with federal and state wildlife authorities to determine if any of the components of the proposed alternatives poses significant negative impacts on endangered bats at the Site.

For Alternatives SC2, SC3, and SC4, the time period to achieve the PRGs is estimated to be 2 to 4 years after the source control and sediment activities are completed.

Because SC2 creates a larger environmental footprint under both an off-site material import and an on-site material generation scenario, SC3 ranks higher than SC2 with respect to short-term effectiveness. Based on the overall impacts to the community and increased traffic hazards resulting from the significant truck loads required to transport waste off-site, both SC2 and SC3 rank higher than SC4 with respect to short-term effectiveness. SC2 and SC3 are equal in terms of short-term impacts and in time needed to achieve protection and SC4 results in significant short-term impacts to the local community regarding heavy truck traffic on local roads.

The relative ranking of the alternatives with respect to short-term effectiveness is SC3 > SC2 > SC4.

Implementability

This criterion evaluates each alternative's ease of construction and operation, and availability of services, equipment, and materials to construct and operate the alternative. Also evaluated is the ease of undertaking additional RAs and administrative feasibility.

Alternative SC1 does not include any actions, other than Five-Year Reviews, and, therefore, would be technically easy to implement. No permits would be required, and administrative feasibility would be high.

Services and equipment are available to implement Alternatives SC2, SC3, and SC4. Waste removal from the UWA, LWA, Ely Brook and tributaries, and the Ponds 4 and 5 Area, as well as the construction of the tailings cover over the ORB is similar for each alternative.

SC2 is considered less implementable than SC3 and SC4 based on its location in the center and low point of the Ely Brook drainage. The LWA Cell (SC2) relies on a location partially within the groundwater table at the lowest point in a steep-sided topographic drainage. This setting presents distinct engineering challenges for the construction of an effective waste containment cell whose primary objective is to separate waste rock and tailings from interacting with water. The construction the LWA Cell on a high-transmissivity underdrain and drainage barrier is more complicated engineering design and has a greater dependence on the successful performance of the maintenance activities.

The LWA Cell footprint is also the current location of the LWA waste rock. Therefore the LWA waste will need to be excavated and relocated twice. LWA would also require the construction of a temporary staging area that is constructed with a liner and leachate collection system to prevent residual saturation in the waste and to prevent sediments from draining to groundwater and surface water. Lastly, long-term maintenance and repair of the SC2 underdrain system is expected to be more problematic than maintenance of the SC3 cell, which is more effectively isolated from surface water and groundwater.

In comparison, the construction of the West Cell (SC3) relies on proven methods and technologies and could be sequenced in a manner that would eliminate the need for a temporary lay-down area and leachate collection system for waste. The West Cell's location on the side-slope of the Ely Brook drainage would also allow for surface water diversions that are sized for significantly smaller flows than would be required for SC2. Therefore, SC3 is considered to be more implementable than SC2.

For the implementation of SC4, South Vershire Road would require improvements to safely handle the heavy truck traffic. In addition, nearly 1,000 waste characterization samples would be required to meet the disposal facility requirements. Despite these difficulties, SC4 is considered easily implementable from a technical perspective because it does not include the design and construction of a geosynthetic cap.

The administrative feasibility of Alternatives SC2 and SC3 is equally high since neither requires off-site permits or approvals. The administrative process to obtain institutional controls to protect the remedy components (caps, stream restoration, monitoring wells) for SC2, SC3, and SC4 are readily implementable. SC4 could experience substantial implementability issues with respect to the off-site disposal of the waste material. There is limited capacity at many regional facilities within a reasonable haul distance. If the facility with sufficient capacity were a substantial distance from the Site, the cost could be significantly higher. Also, there could be substantial delays in the implementation of SC4 associated with obtaining approval for the off-site disposal.

While each of the alternatives is implementable, the relative ranking of the alternatives for implementability is SC3 > SC4 > SC2.

Cost

The following table summarizes capital, annual O&M, present worth for 30 years at 7 percent discount rate, and total estimated non-discounted costs for the evaluated alternatives.

Cost Category	SC1	SC2	SC3	SC4
Capital Costs	$0	$18,402,286	$16,446,057	$29,754,186
Annual O&M	$8,050	$74,907	$74,907	$27,753
Total Non-Discounted Cost	$241,000	$20,713,786	$18,757,557	$30,586,786
Total Present Worth (30 yrs @ 7 percent)	$113,015	$19,428,508	$17,472,278	$30,123,830

Comparative Analysis Summary

Table ES-8 summarizes the comparative analysis of alternatives. A detailed comparative analysis of the alternatives is included in Section 5.0 of the FS Report.

ES.10 OU2 Early Action

USEPA has identified the need for an early cleanup action for the OU2 area. Specifically, since the finalization of the OU2 RI/FS and selection of an OU2 cleanup action is dependent upon the completion of the OU1 Remedial Action, many years may pass before an OU2 cleanup can be implemented. The Site HHRA identified the future consumption of contaminated groundwater and the direct contact and incidental ingestion of soil contaminated with cobalt, copper, and iron as potential threats to human health. To address this threat to human health, USEPA will implement an Early Action to prevent groundwater use within the portions of the Site where groundwater is not suitable for human consumption. The Early Action will also prevent residential development of the Smelter/Slag Area.

The RAOs for the Early Action are:

- Prevent exposure to soil or waste with concentrations of cobalt, copper, and iron above the Site specific cleanup levels listed in Table 2-4 of this FS for future residential use within the Site; and

- Prevent ingestion of bedrock groundwater in excess of federal safe drinking water act Maximum Contaminant Levels (MCLs); Maximum Contaminant Level Goals (MCLGs); VTGWPS; or USEPA risk standards within portions of the Site.

The design for the Early Action will identify the extent of the Ely Copper Mine Site where groundwater that exceeds MCLs, MCLGs, VTGWPS, or risk based standards in the absence of these. Figure ES-11 shows the extent of the area of the Site that would be subject to institutional controls using the existing Site data.

The Early Action will include the placement of land use restrictions that run with the land to effectively prevent future residential use or installation of water supply wells within the portions of the Site where such use could result in exposure to contamination or adversely impact the response actions. Restrictive covenants are the primary mechanism to achieve this objective with local and/or state ordinances or zoning to supplement the property restriction.

Because the only RAOs are to prevent the groundwater or residential use of certain portions of the Site and not restore groundwater or contain/remove contaminated soil, no other technologies or alternatives were considered, other than No Action. The OU2 FS will develop and analyze technologies with respect to any groundwater restoration, migration control, or soil remediation determined to be necessary for OU2. A very simplified nine criteria analysis was performed in Section 6 of the OU1 FS for No Action and Institutional Controls for an Early Action for OU2.

USEPA has determined that a cleanup action is appropriate for OU2 at the Site. The early cleanup action provides the best balance of the NCP criteria to ensure protection of human health prior to the implementation of the OU2 response action. The Early Action early cleanup may be the only cleanup action for OU2 or may be the first component of additional cleanup actions that will be evaluated in the OU2 FS and selected in a future OU2 ROD.

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Table ES-1
Summary of Site Operations
Ely Copper Mine Superfund Site
Vershire, Vermont

Year of Investigation	Era of Operation	Operation Description
1813	Discovery	Gossan discovered by Richardson Family, used for dye.
1820s-1861	Upper Workings and Development Rock	Includes Tyson 1834/Pollard1854 Adit, Shaft II, 1850s/1860s Pollard Shaft and Adit
1820s-1861	Upper Waste Pile 4	Low grade ore
1830s	Vershire Copper Manufacturing Co.	Isaac Tyson, Jr. sporadically worked the deposit
1840s	Sporadic Prospecting	Pliny Dwight controlled the land
1853-1883	Vermont Copper Mining Company	Began large scale working of the deposit led by Thomas Pollard
mid-1850s-1918	Copper Mine Production	Peak production from 1870s-1880s. 30-40 million pounds total production
1850s-1860s	Deep Adit	Collapsed entrance, development rock pile remains
1850s-1880s	Washhouse	Schist slab foundation remains in Lower Waste Pile Area
1859	Rittler Map/Report	Documentation for Vermont Copper Mining Company (VCMC) of mine related features and associated buildings.
1861-1905	Main Adit (1861 Adit)	Main haulageway
1861-1905	Upper Waste Piles 6, 7, 8, and 9	Low grade ore, 1949-50 loading platform, 1861 Adit spur road
1864-1883	Smith Ely Era	Smith Ely became president of VCMC
1867-1905	Ore Roast Beds	Schist slab retaining wall, 900 ft of oxidized low grade ore, collapsed shaft
1867-1905	Smelter Building	Tramway embankment, retaining wall, furnace bases, bldg nearly 1,000 ft long, refined pig copper.
1867-1905	Slag Pile	Smelter/Slag pot skull layers remain
1870s-1880s	Burleigh Shaft	Shaft entrance remains partially collapsed.
1877	Smoke Flue	Schist slab flue, stack footing remain
1881-1905	Main Shaft	Primary shaft hoist access
1882	Vermont Copper Company of NY	Francis Cazin and Ely -Goddard took control of the mine
1882-pre-1902	Reservoir (Pond 1)	Earthen/rubble dam on the east branch of Ely Brook. Possibly Westinghouse Era
1883	The "Ely War"	Vermont Copper Company worker revolt and company collapse
Late 1800s	Shaft No 4	Collapsed entrance, development rock pile remains
1883-1899	Mine Decline	Mine ownership changed hands multiple times
1900-1905	Westinghouse Era	Modernization of smelting process, little production
1905	End of Underground Mining	Site buildings and equipment were sold, and property was stripped
1917-1918	World War I Era Flotation Mill	Foundations, walls, floor slabs remain
1917-1918	Ely-Copperfield Association of NY, NY	Flotation Mill constructed to reprocess 19,000 tons of mine waste piles. Mill shut down at end of WWI
1942-1950	World War II Era	Assay of mine dumps. 1949-50, 60,000 tons of waste ore transported to Elizabeth Mine yielding 1.2 million pounds of copper
mid-1950s	Appalachian Sulphides, Inc	Prospect drill holes completed

Table ES-2
Summary of Site Investigations
Ely Copper Mine Superfund Site
Vershire, Vermont

Year of Investigation	Principle Investigator	Investigation Description	Sampling Summary
2001	Slack and others	Geology and geochemistry of ore and rocks of Vermont Copper Belt	
2002	USGS and USACE	Geochemical diversity of water sources in the Ely Brook Watershed	surface water sampling from seeps from mine waste areas, Ely Brook and tributaries, Schoolhouse Brook, and the Ompompanoosuc River
2004 and 2007	USGS		various solid mine waste materials and sediment, geochemistry of the slag material deposited along South Vershire Road
2005 to 2008	URS and USACE	Habitat characterization	terrestrial habitats, potential wetland areas, potential terrestrial receptors
			test pits and borings in waste areas
			monitoring well installation
			surface water samples
			sediment samples
			surface and subsurface soil samples
			groundwater samples
			residential samples
2007	VTDEC	Aquatic Life Use Attainment Assessment	evaluation of fish and macroinvertebrate data
2008	Techlaw	Aquatic Baseline Ecological Risk Assessment	surface water samples
			sediment samples
			porewater samples
2009	Nobis	Remedial Investigation	terrestrial habitats, potential wetland areas, potential terrestrial receptors
			test pits and borings in waste areas
			monitoring well installation
			surface water samples
			sediment samples
			surface and subsurface soil samples
			groundwater samples
			residential samples

Notes:
USGS = United States Geological Survey
USACE = United States Army Corp of Engineers
VTDEC = Vermont Department of Environmental Conservation

Table ES-3
Preliminary Remediation Goals
Ely Copper Mine Superfund Site
Vershire, Vermont

Analyte	OU1 Maximum Detected Concentration	Average Background Concentration	Preliminary Remediation Goal	Basis for cleanup level
Soil (mg/Kg)				
Cobalt	4,330	6.6	**24**	HHRA risk-based standard (NC) [1]
Copper	65,700	15	**629**	HHRA risk-based standard (NC)
Iron	190,000	13,852	**44,800**	HHRA risk-based standard (NC)
Sediment (mg/Kg)				
Copper	11,000	5.6	**149**	Aquatic BERA risk-based standard
Surface Water (µg/L)				
Aluminum	120,000	82	**87**	NRWQC [2]
Cadmium	55.8	ND (0.24) [6]	**1.10**	VTWQC [3, 4]
Chromium	130	1.2	**11**	VTWQC
Copper	88,500	2.4	**8.6**	Site-Specific [5]
Iron	199,000	102	**1,000**	NRWQC
Lead	17	0.089	**3.2**	VTWQC
Mercury	0.2	ND (0.2)	**0.012**	VTWQC
Nickel	456	0.61	**52**	NRWQC [4]
Selenium	27	ND (1.0)	**5**	VTWQC
Silver	4.2	ND (2.2)	**3.2**	NRWQC [4]
Zinc	8,192	150	**106**	VTWQC
Sulfide	1,300	ND (100)	**2**	NRWQC
pH	2.8[7]	7.41	**6.5-8.5**	VTWQC

Notes:
1. NC = non-cancer based level, hazard index = 1
2. NRWQC = National Recommended Water Quality Criteria. 2009.
3. VTWQC = Vermont Water Quality Criteria. Jan 2008.
4. Interim clean-up level adjusted for hardness based on VTWQC Appendix C or NRWQC note E. assumes hardness = 100 mg/L.
5. Recommended aquatic BERA site-specific interim clean-up level adjusted for hardness = 9 µg/L x CF
   CF = 0.96 (EPA National Recommended Water Quality Criteria: Appendix A. 2009.)
6. ND = non-detect with the average detection limit shown in parentheses.
7. Value displayed for pH reflects minimum detected OU1 surface water value.

Table ES-4
Estimated Areas and Volumes of Waste Rock, Tailings, and Sediment
Ely Copper Mine Superfund Site
Vershire, Vermont

OU1 Waste Rock, Tailing, and Soil					
	Average Thickness (ft)	**Area (ft^2)**	**Area (acres)**	**Volume (ft^3)**	**Volume (yd^3)**
Upper Waste Area (UWA)	varies	287,500	7.8	1,873,800	69,400
UWA soil above cleanup levels outside limits of mine waste	varies	30,300	0.7	90,900	3,363
Lower Waste Area (LWA)	varies	255,290	5.9	702,000	26,000
LWA soil above cleanup levels outside limits of mine waste	varies	23,600	0.5	70,800	2,620
Tailing Area (TA)	varies	28,990	0.7	97,200	3,600
Ore Roast Bed (ORB)	varies	96,970	2.2	278,910	10,330
Development Rock within UWA	varies	45,530	1.05	327,807	12,141
OU1 Sediment					
	Average Thickness (ft)	**Length (ft)**	**Width (ft)**	**Volume (ft^3)**	**Volume (yd^3)**
Upper Ely Brook	0.5	1,700	6	5,100	190
Ponds 4 and 5	3.0	60	80	10,200	378
Middle Ely Brook	2.0	660	12	15,660	580
Lower Ely Brook	2.0	1,200	12	106,650	3,950
OU1 Surface Water Channels in UWA and LWA					
	Average Thickness (ft)	**Length (ft)**	**Width (ft)**	**Volume (ft^3)**	**Volume (yd^3)**
EBT1	2	500	12	12,000	445
EBT2	2	530	12	12,720	471
EBT3	2	773	12	43,680	1,618
EBT4	2	650	12	18,552	687
OU2 Areas					
	Average Thickness (ft)	**Area (ft^2)**	**Area (acres)**	**Volume (ft^3)**	**Volume (yd^3)**
Smelter Area	varies	165,515	3.8	840,240	31,120
Slag Area	varies	185,130	4.2	675,000	25,000
Schoolhouse Brook Hot Spots	1.0	100	0.002	1,100	41

Notes:

1. OU1 Waste Rock and Tailings and OU2 Waste Rock values calculated with AutoCAD. The irregular shape of the piles does not allow for specific thickness values to be presented.
2. Sediment thickness are assumed and should be considered estimates. Actual depths will be confirmed during pre-design studies.

Table ES-5
Applicable Treatment Technologies
Ely Copper Mine Superfund Site
Vershire, Vermont

General Technology	Waste Rock and Tailings	Sediment
No-Action	x	x
Institutional Controls	x	
Monitored Natural Recovery		x
Surface Controls	x	
Capping Systems	x	x
Excavation/Dredging	x	x
Land Disposal	x	x
Ex-Situ Physical or Chemical Treatment	x	x
In-Situ Physical or Chemical Treatment	x	x

Notes:
"x" indicates that the General Technology is applicable to the media listed and will be selected for alternative screening.

Table ES-6
Screening of Potential Treatment Options for Waste Rock and Tailings
Ely Copper Mine Superfund Site
Vershire, Vermont

General Response Action	Technology	Process Option	Description	Effectiveness	Cost	Implementability	Retained For Further Consideration	Notes
No Action	No Action	No action	The "No Action" GRA is required in accordance with CERCLA and NCP to serve as a baseline comparison for other GRA technologies. The "No Action" alternative includes only scheduled 5-Year Reviews to assess the alternative effectiveness and compliance with OU1 PRGs. It does not include any active or passive treatment of media, institutional controls, or monitoring.	The alternative does not address the RAOs developed for OU1.	**Low** Include periodic monitoring and 5-Year Reviews	This technology would be implementable.	**Yes** (Required by CERCLA/NCP)	(Required by CERCLA/NCP)
Limited Action	Institutional Controls	Land use restrictions	Land use restrictions would be used to prevent certain use and activities such as residential building or recreational use. The restrictions would be included in the chain of title/deed for the property and would continue into the future regardless of change in ownership or zoning in the vicinity of the Site.	The alternative does not address the RAOs developed for the OU1, and although the Land Use Restriction is in place, the technology does not physically prevent the exposure to human receptors. However, the technology could be used in conjunction with other technologies in a larger system.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	Although this process option would not achieve the remedial action objectives, it may be included as part of a more comprehensive alternative
		Access controls	Engineered controls include restricting access to the OU1 area but does include treating the waste material with any physical or chemical processes. Fencing, signage, and security patrols could be utilized. Fencing would minimize human and animal access and warning signs would alert people to the specific OU1 hazards located within the fence. Security patrols would deter vandalism and unauthorized access to the OU1 and would notify EPA of breaches in the controls.	The alternative does not address the RAOs developed for OU1, but it would be effective in reducing the access to the OU1 area. OU1 is relatively large, however, and the fence would have to extend to around the entire property with gates located at all access points. Due to the remoteness of OU1, it would be difficult to completely prevent vandalism and unauthorized access by humans and/or animals.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	Although this process option would not achieve the remedial action objectives, it may be included as part of a more comprehensive alternative
Containment	Surface Controls	Grading	Grading of the existing ground surface/waste can be used to improve slope stability and run-off and reduce erosion of the waste piles, and to divert surface water away from the impacted material.	The alternative does not address the RAOs developed for OU1. It would be effective in minimizing erosion and precipitation percolated through the impacted material into the aquifer; however, portions of the waste piles are seasonally within the overburden aquifer; therefore, impacts from the waste on the aquifer would not be addressed.	**Moderate** Capital costs **Low** O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	Although this process option would not achieve the remedial action objectives, it may be included as part of a more comprehensive alternative
		Revegetation	Revegetation includes planting in order to stabilize the impacted soils and to reduce erosion of the soils. The root systems will hold surface soils in place while the aboveground portions of the plants disrupts the flow and removes the energy from overland surface water allowing for the plants to take and use the water. The plants may also serve some utility as filtering devices, both physical and chemical, through straining and biological processes.	The alternative does not address the RAOs developed for OU1; however, it would be an effective alternative in conjunction with a more active alternative. Revegetation is commonly used with a consolidation and capping system to stabilize the soils and reduce run-off of the cap.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	Although this process option would not achieve the remedial action objectives, it may be included as part of a more comprehensive alternative
	Capping System	Close in place	Grading the existing waste and constructing an engineered cap to conform with low-permeability cover system requirements. Surface water diversions will be constructed as needed to eliminate potential infiltration. Prior to capping, the waste material will be dried to reduce leachate, if necessary.	This alternative would be effective in preventing human contact; however, it would not remove and isolate the contaminated material from the overburden groundwater aquifer. Waste/groundwater contact would perpetuate the impacts to the groundwater aquifer and surface water downgradient of the waste. Institutional controls and a monitoring program would be required to maintain the effectiveness of the cell.	**Moderate** Capital costs **Moderate** O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	This process option was eliminated because there are similar process option approaches that could achieve the remedial action objectives without the need for long-term treatment.
		On-site consolidation and containment cell construction in the LWA	Excavate the Upper and Lower Waste Piles and consolidate the waste material into a constructed cell within the current WMU. The engineered cap will conform with low-permeability cover system requirements and includes a bottom liner to prevent groundwater infiltration into the waste. Underdrains and surface water diversions will be constructed as needed to eliminate potential infiltration. Prior to capping, the waste material will be dried to reduce leachate. if necessary.	This alternative would be effective in preventing human contact and would remove and isolate the contaminated material from the overburden groundwater aquifer, therefore, allowing the groundwater pH to adjust to a more neutral level and reducing the metals mobility. Institutional controls and a monitoring program would be required to maintain the effectiveness of the cell.	**High** Capital Costs	This technology would be implementable.	**Yes**	
		On-site consolidation and containment cell construction west of Ely Brook	Excavate the Upper and Lower Waste Piles and consolidate the waste material into a constructed cell located to the west of Ely Brook and outside of the current WMU. The engineered cap will conform with low-permeability cover system requirements. Underdrains and surface water diversions will be constructed as needed to eliminate potential infiltration. Prior to capping, the waste material will be dried to reduce leachate, if necessary.		**Moderate** O&M costs			

Table ES-6
Screening of Potential Treatment Options for Waste Rock and Tailings
Ely Copper Mine Superfund Site
Vershire, Vermont

General Response Action	Technology	Process Option	Description	Effectiveness	Cost	Implementability	Retained For Further Consideration	Notes
Removal	Excavation and Disposal	On-site disposal of treated excavation water	Treat leachate water from waste material and excavation dewatering through settling and discharge to on-site waterways. Additional treatment could include bag filters and chemical amendments depending on analytical results.	This alternative would be effective in treating the water to achieve performance goals prior to discharge to the on-site waterways through settling, amendments, and/or dilution with clean diverted surface water.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	
		Off-Site disposal	Excavate the Upper and Lower Waste Piles and the Tailings pile and transport waste to a off-site location for disposal at an approved disposal facility. The alternative includes restoration of the natural grade and vegetation.	This alternative would be effective in preventing human contact and would remove and isolate the contaminated material from the overburden groundwater aquifer, therefore, allowing the groundwater pH to adjust to a more neutral level and reducing the metals mobility.	**High** Capital costs **Low** O&M costs	This technology would be implementable.	**Yes**	
Treatment	In-situ	Injection of an alkaline stabilizer	Perform a series of soil borings completed as injection wells. An alkaline stabilizer is injected reducing the soluble metals present to their lowest valence state. This reduces or eliminates their mobility and solubility and reduces their impact on groundwater and surface water.	Difficult to achieve adequate mixing and coverage without very large quantity of material. Long-term effectiveness for oxidized waste is unknown. Surface contact threats would not be mitigated.	**High** Capital costs **Moderate** O&M costs	This technology would be implementable.	**No**	Although the technology would be implementable, it would be difficult and likely not very effective; therefore, it is not retained for further consideration.
	Ex-Situ	Excavation and mixing with chemicals to neutralize or passivate	Excavate the waste material and mix with passivation/neutralization chemicals to bring the pH of the soils and groundwater more neutral and to reduce the reactivity of the metals. The excavated and amended soil would be replaced in the original locations.	Passivation technologies are more applicable to fresh un-oxidized waste. Neutralization would require substantial quantities of material and would not eliminate surface contact with waste. Also, long-term degradation of an alkaline addition would be a concern.	**High** Capital costs **Moderate** O&M costs	This technology would be implementable.	**No**	Although the technology would be implementable, it would be difficult and likely not very effective; therefore, it is not retained for further consideration.
		Treatment of groundwater and stormwater from excavations	Treat leachate water from waste material and excavation dewatering through settling and discharge to on-site waterways. Additional treatment could include bag filters and chemical amendments depending on analytical results.	This alternative would be effective in treating the water to achieve performance goals prior to discharge to the on-site waterways through settling, amendments, and/or dilution with clean diverted surface water.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	

Notes:
GRA = General Remedial Action
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
NCP = National Contingency Plan
RAO = Remedial Action Objective

Table ES-7
Screening of Potential Treatment Options for Sediment
Ely Copper Mine Superfund Site
Vershire, Vermont
Page 1 of 2

General Response Action	Technology	Process Option	Description	Effectiveness	Cost	Implementability	Retained For Further Consideration	Notes
No Action	No Action	No Action	The "No Action" GRA is required in accordance with CERCLA and NCP to serve as a baseline comparison for other GRA technologies. The "No Action" alternative includes scheduled 5-Year Reviews to assess the alternative effectiveness and compliance with OU1 PRGs. It does not include any active or passive treatment of media, institutional controls, or monitoring.	The alternative does not address the RAOs developed for OU1.	**Low** Includes 5-Year Reviews	This technology would be implementable.	**Yes** (Required by CERCLA/NCP)	(Required by CERCLA/NCP)
Limited Action	Institutional Controls	Land Use Restrictions	Land use restrictions would be used to prevent certain use and activities such as recreational use. The restrictions would be included in the chain of title/deed for the property and would continue into the future regardless of change in ownership or zoning in the vicinity of the Site.	The alternative does not address the RAOs developed for OU1, and although the Land Use Restriction is in place, the technology does not physically prevent the exposure to human receptors. However, the technology could be used in conjunction with other technologies in a larger system.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	Although this process option would not achieve the remedial action objectives, it may be included as part of a more comprehensive alternative
		Access Controls	Engineered controls include restricting access to the OU1 area but does include treating the waste material with any physical or chemical processes. Fencing, signage, and security patrols could be utilized. Fencing would minimize human and animal access and warning signs would alert people to the specific OU1 hazards located within the fence. Security patrols would deter vandalism and unauthorized access to OU1 area and would notify EPA of breaches in the controls.	The alternative does not address the RAOs developed for the OU1 area, but it would be effective in reducing the access to the OU1 area. The OU1 area is relatively large, however, and the fence would have to extend to around the entire property with gates located at all access points. Due to the remoteness of the OU1 area, it would be difficult to completely prevent vandalism and unauthorized access by humans and/or animals.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	Although this process option would not achieve the remedial action objectives, it may be included as part of a more comprehensive alternative
	Monitored Natural Recovery	Sediment Sampling	Relies on sediment transport processes to disperse the contaminated sediment downstream, thereby reducing OU1 exposure risks.	In Ely Brook this process option may address inaccessible areas of contaminated sediment that is not removed by other process options.	**Moderate** Low **Low** O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	
Containment	Capping System	In-Place Cap Construction	Capping of the impacted sediments with clean material in the existing stream bed. The clean materials would be laid down in a 1 foot thick layer to protect the surface water from contacting the impacted sediment. The capping material would be graded to match the existing the runs, riffles, and pools of the current streambed.	This alternative would be effective in preventing human contact and would separate the surface water from the impacted sediment; however, Ely Brook is a gaining stream and impacted groundwater will percolate through the cap material, potentially creating another impacted mass.	**Moderate** capital costs **Low** O&M costs	This technology would be implementable.	**No**	It would be possible to build a sub-aqueous cap over the contaminated sediments and maintain the stream hydrology. Ely Brook flow is often less than 1 foot in depth. The steep gradient would cause erosion of the cover system. The stream habitat is also dependent on exposed boulders and gravel for the benthic community.
	Excavation and Disposal	On-Site Consolidation into a Containment Cell	Excavate the sediments above cleanup levels in Ponds 4 and 5, Ely Brook and its tributaries, and consolidate the waste material into a on-site constructed cell.	This alternative would be effective in preventing human contact and would remove and isolate the contaminated material from the surface water, therefore, allowing the surface water pH to adjust to a more neutral level and reducing the metals mobility. Institutional controls and a monitoring program would be required to maintain the effectiveness of the cell.	**High** capital costs **Moderate** O&M costs	This technology would be implementable	**Yes** (as component in larger system)	
		On-Site Discharge of Treated Dewatering Liquid	Discharge of treated dewatering liquid to on-site waterways.	This alternative would be effective in treating the water to achieve performance goals prior to discharge to the on-site waterways through settling, amendments, and/or dilution with clean diverted surface water.	**Low** Capital and O&M costs	This technology would be implementable	**Yes** (as component in larger system)	
Removal		Off-Site Disposal	Excavate the sediments above cleanup levels in Ponds 4 and 5, Ely Brook and its tributaries, and transport the material to an off-site disposal facility. Disposal of treatment media off-site.	This alternative would be effective in preventing human contact and would remove and isolate the contaminated material from the overburden groundwater aquifer, therefore, allowing the groundwater pH to adjust to a more neutral level and reducing the metals mobility.	**High** capital costs **Low** O&M costs	This technology would be implementable	**Yes** (as component in larger system)	

Table ES-7
Screening of Potential Treatment Options for Sediment
Ely Copper Mine Superfund Site
Vershire, Vermont

General Response Action	Technology	Process Option	Description	Effectiveness	Cost	Implementability	Retained For Further Consideration	Notes
Treatment	In-Situ Chemical Treatment	Adding Limestone	Add limestone to waterways to neutralize pH.	This alternative may be effective in concert with other process options.	**Low** Capital and O&M costs	This technology would be implementable	**Yes** (as component in larger system)	
	Ex-Situ Physical Treatment	Dewatering	Removing water from sediment prior to disposal by open-air drying.	This alternative may be effective in concert with other process options.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	
		Treatment of Dewatering Liquid	Filtration through bag filters to remove sediment.	This alternative may be effective in concert with other process options.	**Low** Capital and O&M costs	This technology would be implementable.	**Yes** (as component in larger system)	

Notes:
GRA = General Remedial Action
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
NCP = National Contingency Plan
RAO = Remedial Action Objective

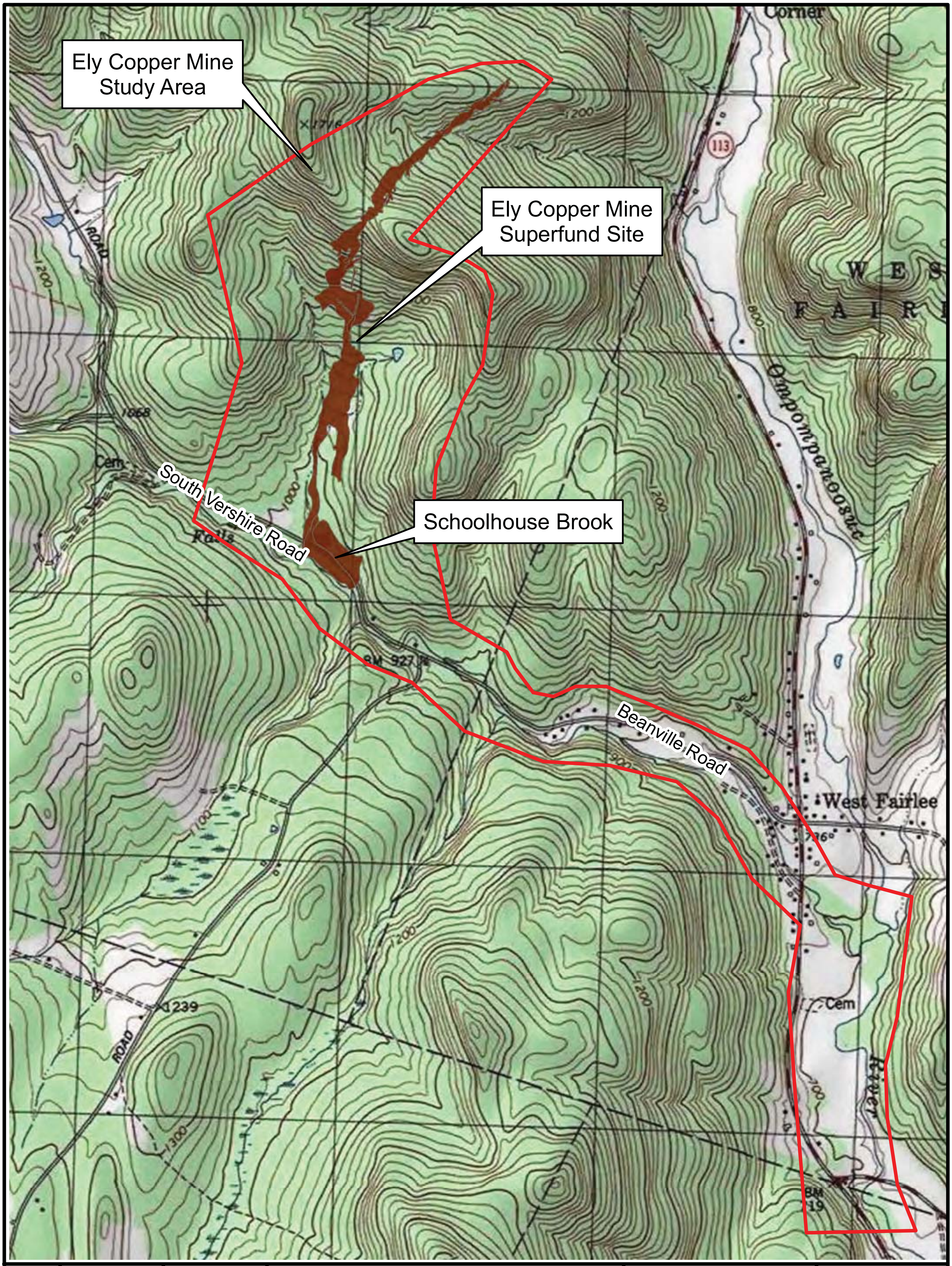
Table ES-8
Comparison Analysis of Alternatives
Ely Copper Mine Superfund Site
Vershire, Vermont

Evaluation Criteria	Alternative SC1	Alternative SC2	Alternative SC3	Alternative SC4
Overall Protection of Human Health and the Environment	Does not meet the criterion. Would not eliminate, reduce, or control source areas or potential future exposure to contaminants exceeding PRGs and would not meet remedial action objectives.	Good Would eliminate the ecological risks from copper and other metals within the waste rock, tailing, and sediment areas and from ARD generated from the sediments and waste rock through consolidation and capping of these materials in the LWA Containment Cell. Human health risks posed by the tailings will be addressed by consolidation and capping of these materials at the ore roast bed containment cell. The location of the LWA Containment Cell will require additional engineering controls and O&M to remain protective.	Better Would be protective of human health and the environment. Would eliminate the ecological risks from copper within the sediment areas and from ARD generated from the sediments and waste rock through consolidation and capping of these materials in the West Containment Cell. Human health risks posed by the tailings will be addressed by consolidation and capping of these materials at the ore roast bed containment cell. SC3 is slightly more protective than SC2 because of the greater long-term effectiveness afforded by placing the material in a location that is more effectively isolated from groundwater and Ely Brook.	Good Would be protective of human health and the environment. Would eliminate the ecological risks from copper within the sediment areas and from ARD generated from the sediments and waste rock through removal and offsite disposal. Human health risks posed by the tailings will be addressed by consolidation and capping of these materials at the ore roast bed containment cell. SC4 is slightly more protective than SC2 because of the waste material is either removed from the OU1 area or is capped at the ore roast beds where it is more effectively isolated from groundwater and Ely Brook.
Compliance with ARARs	Does not meet the criterion. Would not attain protective concentrations for copper in soil or sediment and would not attain ecological risk-based standards based on chemical-specific ARARs and TBCs.	Good Would be designed to attain ARARs pertaining to management of mine waste and copper and protection of wetlands. Source control actions would be designed to protect groundwater and surface water quality. The LWA containment Cell would be located in more environmentally sensitive resource areas that would require additional engineering controls and O&M to remain compliant.	Best Would be designed to attain ARARs pertaining to management of mine waste and copper and protection of wetlands. Source control actions would be designed to protect groundwater and surface water quality. SC3 is the least environmentally damaging practicable alternative under the Federal Clean Water Act, Sec. 404 for protecting wetland resources within the Site. On site containment of contaminated materials at the West Containment Cell poses less impacts to protected resources under State facility siting standards than off-site disposal through SC4.	Good Would be designed to attain ARARs pertaining to management of mine waste and copper and protection of wetlands. Source control actions would be designed to protect groundwater and surface water quality. However, the off-site disposal of large volumes of materials poses significant impacted to protective resources under State facility siting standards.

Table ES-8
Comparison Analysis of Alternatives
Ely Copper Mine Superfund Site
Vershire, Vermont

Evaluation Criteria	Alternative SC1	Alternative SC2	Alternative SC3	Alternative SC4
Long-term Effectiveness and Permanence	Does not meet the criterion Would not eliminate, reduce, or control source areas or potential future exposure to contaminants exceeding PRGs and would not provide long-term effectiveness at protecting human health and the environment.	Good Would isolated the acid generating material that contains cobalt, copper, and iron above PRGs in either the ORB cell (tailings) or the LWA cell for the waste rock. This would have a high degree of long-term effectiveness and permanence provided the cover systems and underdrain are maintained. The reliance upon a most engineering and maintenance intensive groundwater control system reduces the overall effectiveness relative to SC3 which would not rely of the underdrain.	Better Would isolated the acid generating material that contains cobalt, copper, and iron above PRGs in either the ORB cell (tailings) or the West cell for the waste rock. This would have a high degree of long-term effectiveness and permanence provided the cover systems are maintained. Less maintenance would be required to maintain the SC3 West Cell than the SC2 LWA cell resulting in greater long-term effectiveness and permanence for SC3. SC3 also will dispose of the ARD generating waste rock in a location designed to isolate the waste and prevent ARD, whereas the integrity of the off-site disposal of the non-regulated waste rock is uncertain.	Better Would take actions to cap the Tailings Area in the ORB and excavate and dispose of the source areas off-site, thereby controlling the generation of ARD at these source areas. Waste rock and sediment is permanently removed from OU1; therefore, permanence of the alternative could be better than SC2 and SC3. The Long-Term Effectiveness may not be greater since the material is not regulated and may not be disposed in a manner that protects the new disposal location. SC3 is less permanent but has the highest degree of long-term effectiveness due to the ability to select the location for disposal and control the design for the long-term cover system.
Reduction of Toxicity, Mobility, and Volume through Treatment	SC1 would not use treatment to accomplish the reduction of toxicity, mobility, and volume.	SC2 would potentially only use limited treatment to accomplish the reduction of toxicity, mobility, and volume of water produced from dewatering operations or leachate from containment cells that may require treatment prior to discharge.	SC3 would potentially only use treatment to accomplish the reduction of toxicity, mobility, and volume of water produced from dewatering operations or leachate from containment cells that may require treatment prior to discharge.	SC4 would potentially only use treatment to accomplish the reduction of toxicity, mobility, and volume of water produced from dewatering operations that may require treatment prior to discharge.
Short-term Effectiveness	Poor Does not lead to any exposure risks and, therefore, results in no short-term effects; however, it never achieves protectiveness of human health or the environment.	Better Substantially higher requirement for borrow materials to cap the LWA Containment Cell results in either more truck traffic to import materials, or a larger area of clearing for on-site generation when compared to SC3. The time period to achieve the remedial action objectives for each media is estimated to be 2 to 4 years.	Best Would utilize on-site materials eliminating several thousand truck trips on local roads, result in construction related concerns (e.g., blasting, noise, and dust), results in a smaller environmental footprint than SC2, the time period to achieve the remedial action objectives for each media is estimated to be 2 to 4 years. Also significantly less truck trips would be required than for disposing of all of the ARD producing waste rock and sediment off-site under SC4.	Good Significant short-term improvements to local roads and on-site haulage and access roads would be required to address the high volume of truck traffic that would be required under this alternative. Would require several thousand truck trips on local roads, result in construction related concerns and hazards. The time period to achieve the remedial action objectives for each media is estimated to be 2 to 4 years.

Evaluation Criteria	Alternative SC1	Alternative SC2	Alternative SC3	Alternative SC4
Implementability	Implementable. Does not include any actions, other than Five-Year Reviews, and, therefore, would be technically easy to implement.	Good Services and equipment are available, construction of the Tailings Area cover over the ORB is similar for Alternatives SC2, SC3 and SC4. Eighteen acres of on-site borrow would be need to be excavated to obtain material. Construction of the LVA Containment Cell considered less implementable based on its location in the center and low point of the Ely Brook drainage and will require more O&M because of the required underdrain. May require unproven methods or technologies.	Best Services and equipment are available, construction of the Tailings Area cover over the ORB is similar for Alternatives SC2, SC3, and SC4. Less of an area of on-site borrow would be needed than SC2 because borrow could be dug in the same area as where the West Containment Cell will be built and the total requirement for material is less than SC2. The West Containment Cell is considered more implementable based on its standard design and contriction and location higher and west of Ely Brook drainage and potentially above the water table. SC3 is considered more implementable than SC4 because it does not require the large volume of truck use to remove contaminated material from the Site and does not include the uncertainty associated with securing a location for the off-site disposal of 110,000 cubic yards of mine waste.	Better Services and equipment are available, construction of the Tailings Area cover over the ORB is similar for Alternatives SC2, SC3, and SC4. Only limited on-site borrow would be needed to cap the ore roast bed containment cell. There may be significant implementability issues maintaining local roadways from the impact of transporting up to 110,000 cy of waste material off-site on local roads along with the uncertainty associated with securing a location for the off-site disposal of the material.
Cost	Excellent $113,015 - Total Present Worth (30 yrs)	Good $19,428,508 - Total Present Worth (30 yrs)	Better $17,472,278 - Total Present Worth (30 yrs)	Poor $30,123,830 - Total Present Worth (30 yrs)



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Drawn By: JRS | Checked By: AJB
June 24, 2011 | Revision No. 00

APPROXIMATE SCALE
0 400 800 1,600 Feet

Quadrangle Location

USGS TOPOGRAPHIC MAP
VERSHIRE, VERMONT
1981; (Photo-inspected 1983)

FIGURE ES-1
Site Locus
Ely Copper Mine
Vershire, Vermont

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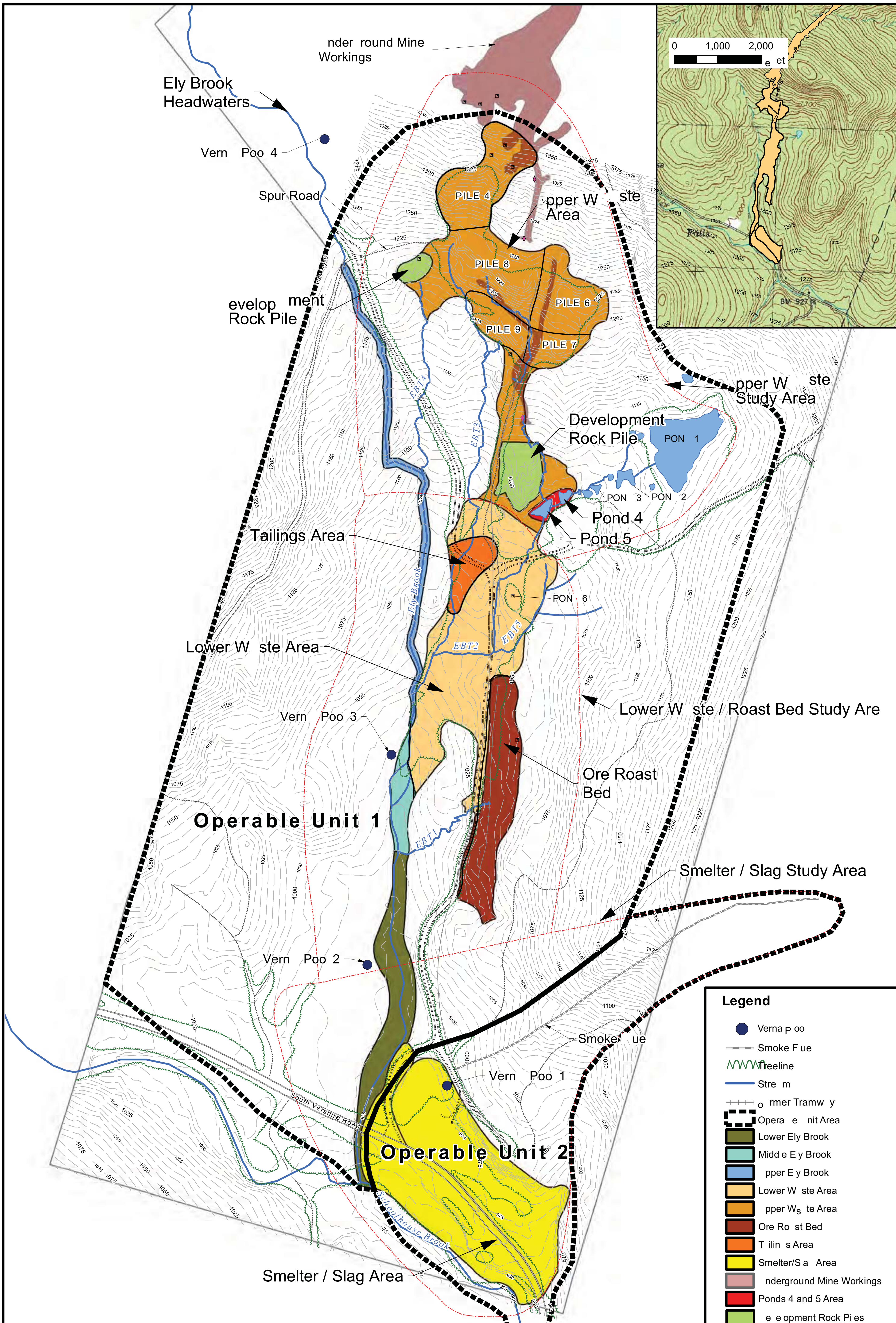

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rawn By: J RS	Checked By AJB
June 7, 2011	Re ision No 0 0

APPROXIMATE SCALE
0 150 300 600
eet

NOTE E e tions shown are feet above mean sea evel (T AMSL).

GURE ES 2

Site Sketch
E y Copper Mine
Vershire, Vermont

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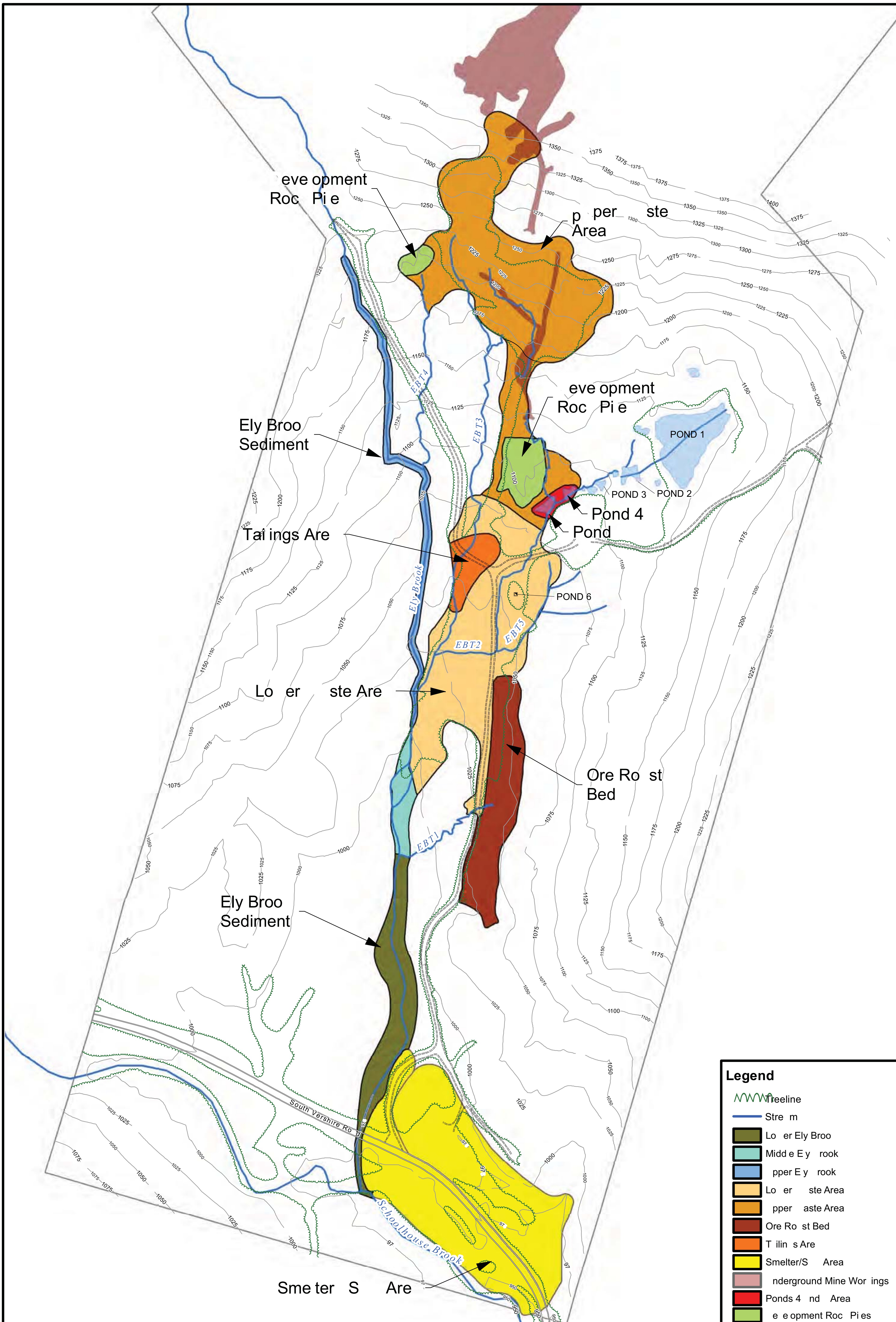

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r n y J RS	Checked y AJ
June , 2011	Re ision No 0 0

APPROXIMATE SCALE
0 150 300 600 eet

NOTE E e tions shown re feet ove mean evel (T AMSL)
sea

GURE ES 3
Site Source Are s
E y Copper Mine
Vershire, Vermont

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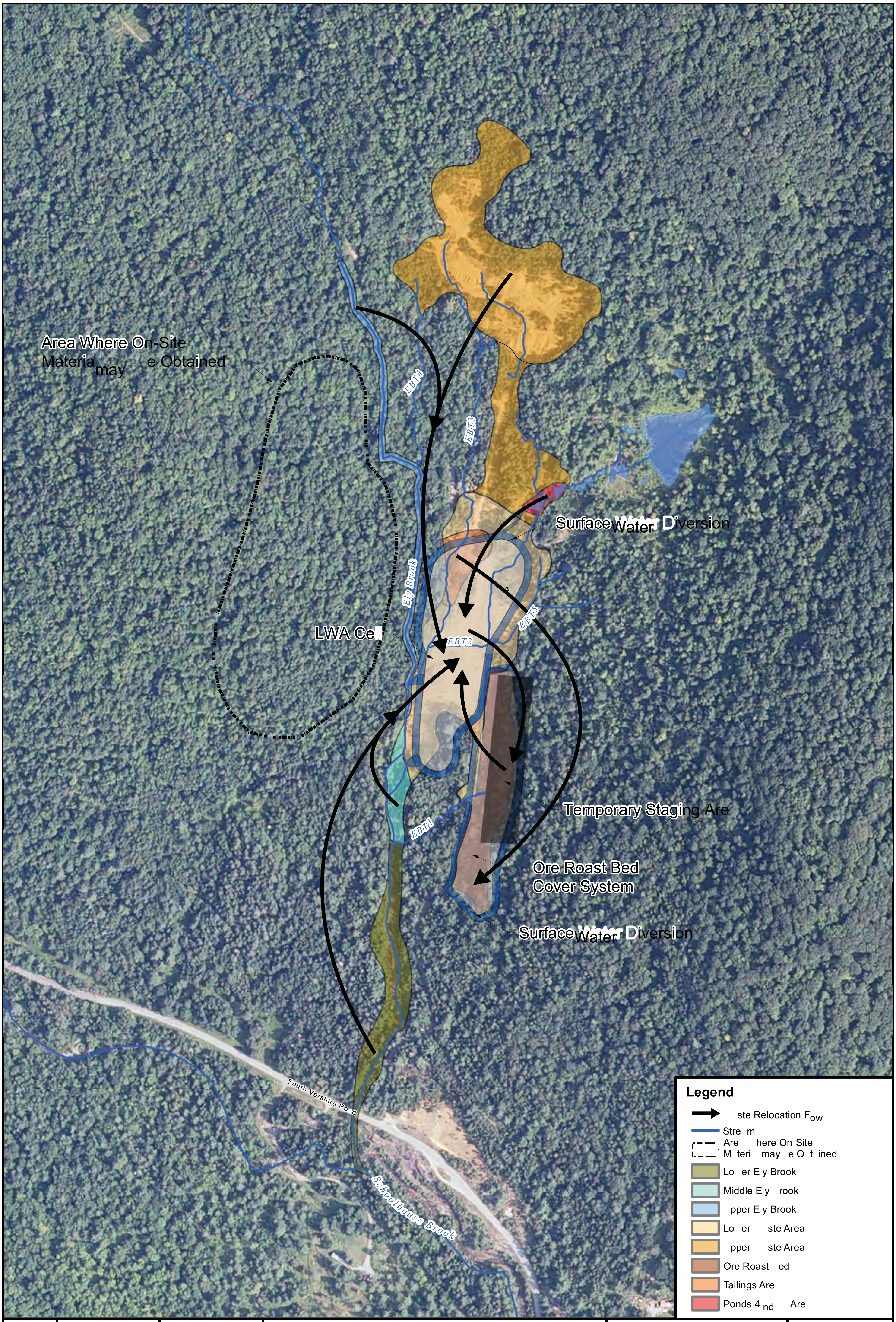

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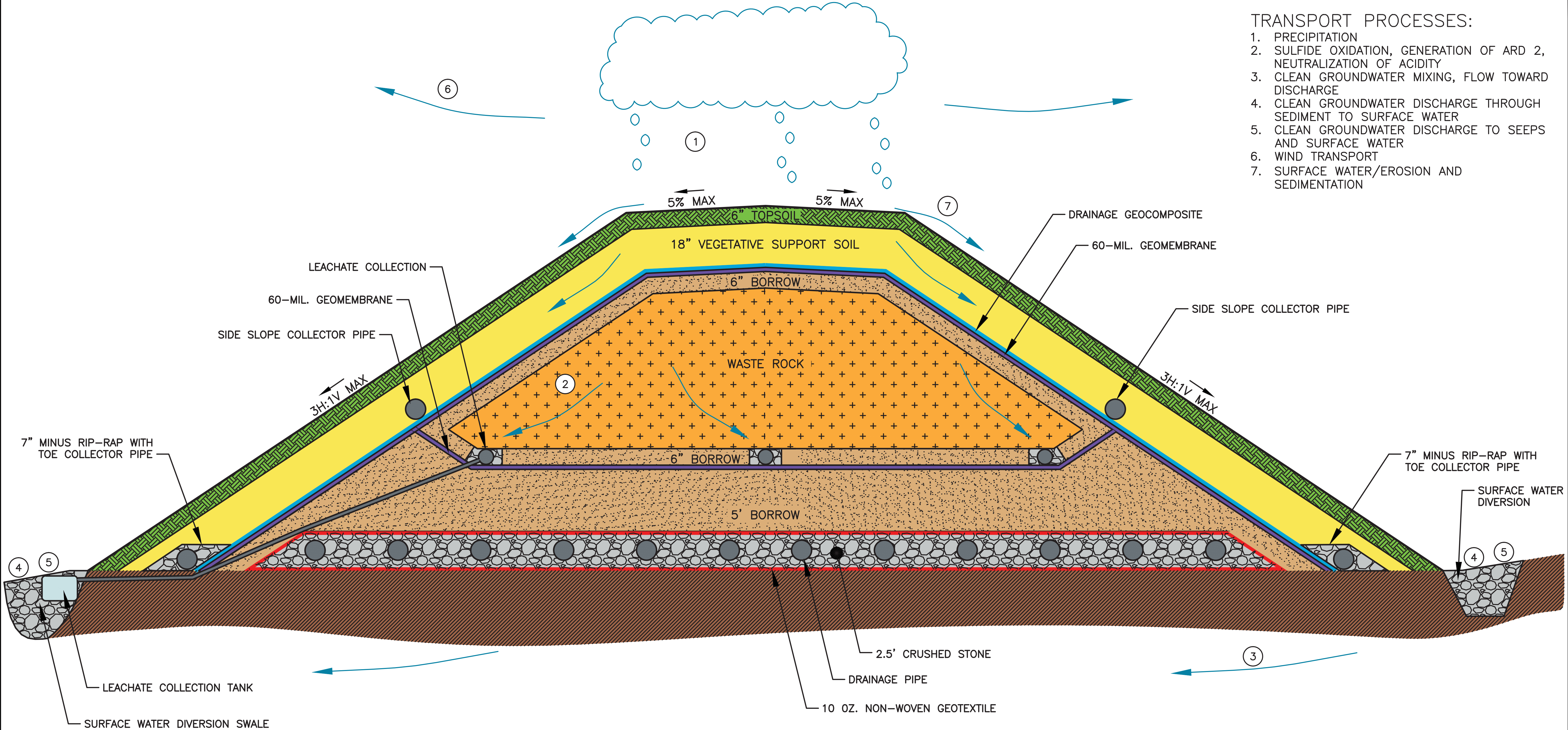
	June 24, 2011	Re ision No. 00	A ternati e Remedy Map Altern ti e SC2 E y Copper Mine Vershire, Vermont	Engineering a Sustainable Future Nobis En ineerin , nc 18 Chenel ri e Concord, NH 03301 (603) 224 4182
	APPROXIMATE SCALE 0 150 300 600 eet			

TRANSPORT PROCESSES:
1. PRECIPITATION
2. SULFIDE OXIDATION, GENERATION OF ARD 2, NEUTRALIZATION OF ACIDITY
3. CLEAN GROUNDWATER MIXING, FLOW TOWARD DISCHARGE
4. CLEAN GROUNDWATER DISCHARGE THROUGH SEDIMENT TO SURFACE WATER
5. CLEAN GROUNDWATER DISCHARGE TO SEEPS AND SURFACE WATER
6. WIND TRANSPORT
7. SURFACE WATER/EROSION AND SEDIMENTATION



METAL RETENTION MECHANISMS:
A. FORMATION OF METAL OXIDES INSIDE WASTE ROCK PILES
B. PRECIPITATION MECHANISMS OPERATING WITHIN WASTE ROCK PILE
C. MINERAL PRECIPITATES IN SURFACEWATER/SEEP DISCHARGE AREAS
D. METALS IN GROUNDWATER; DISCHARGED TO AND RETAINED BY SEDIMENTS
E. METALS RETAINED IN "MINE WASTE" LAYER SEDIMENT

NOT TO SCALE

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IGURE ES-

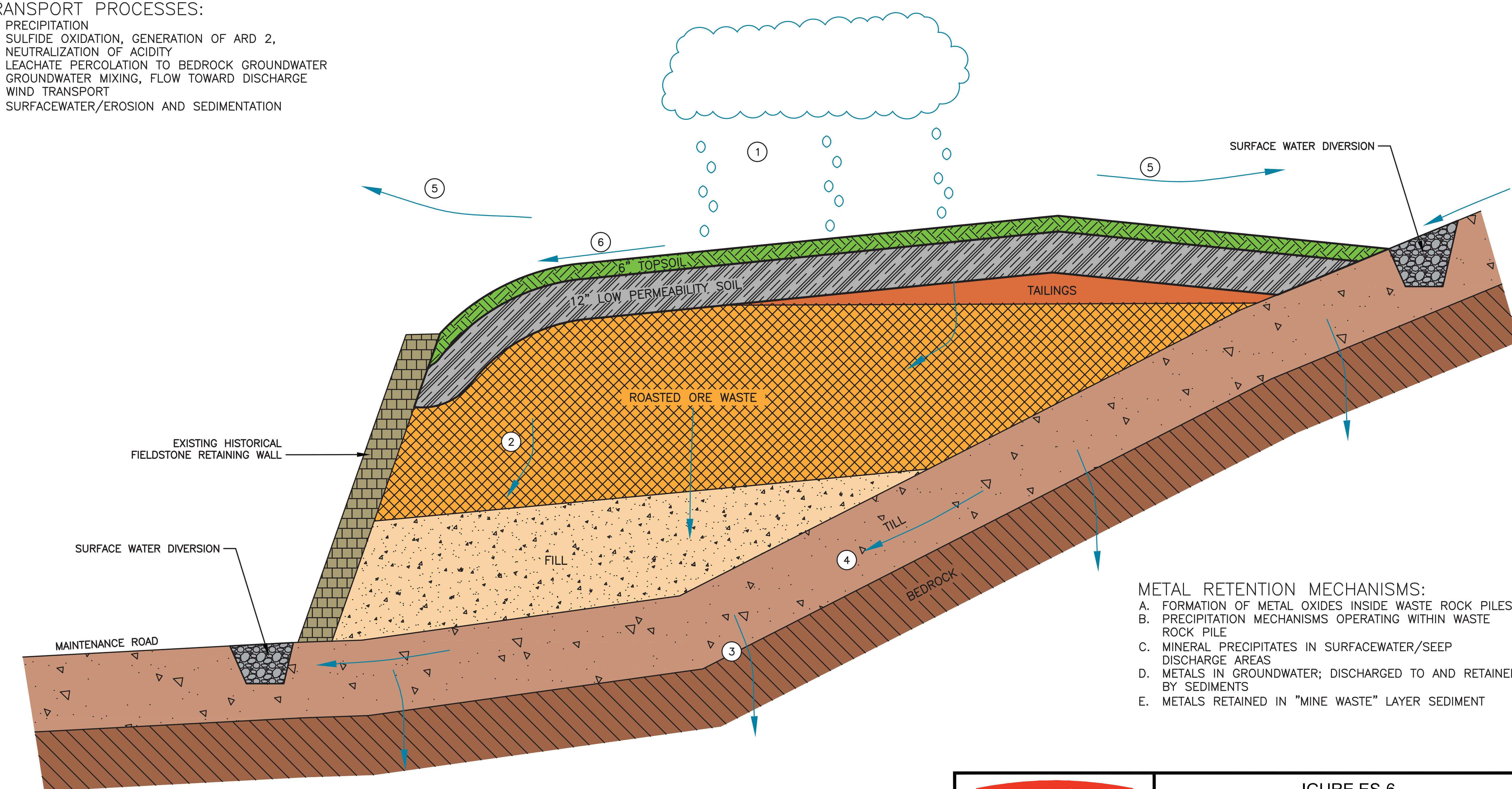
LWA CELL SYSTEM PROCESS MODEL

ELY COPPER MINE
VERSHIRE, VERMONT

DRAWN BY:	ML	APPROVED BY:	AB
PROJECT:	80024.12		JUNE 24, 2011

TRANSPORT PROCESSES:

1. PRECIPITATION
2. SULFIDE OXIDATION, GENERATION OF ARD 2, NEUTRALIZATION OF ACIDITY
3. LEACHATE PERCOLATION TO BEDROCK GROUNDWATER
4. GROUNDWATER MIXING, FLOW TOWARD DISCHARGE
5. WIND TRANSPORT
6. SURFACEWATER/EROSION AND SEDIMENTATION



METAL RETENTION MECHANISMS:

A. FORMATION OF METAL OXIDES INSIDE WASTE ROCK PILES
B. PRECIPITATION MECHANISMS OPERATING WITHIN WASTE ROCK PILE
C. MINERAL PRECIPITATES IN SURFACEWATER/SEEP DISCHARGE AREAS
D. METALS IN GROUNDWATER; DISCHARGED TO AND RETAINED BY SEDIMENTS
E. METALS RETAINED IN "MINE WASTE" LAYER SEDIMENT

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IGURE ES-6

ORB CAP SYSTEM PROCESS MODEL

ELY COPPER MINE
VERSHIRE, VERMONT

DRAWN BY:	ML	APPROVED BY:	AJB
PROJECT:	80024.12	JUNE 24, 2011	

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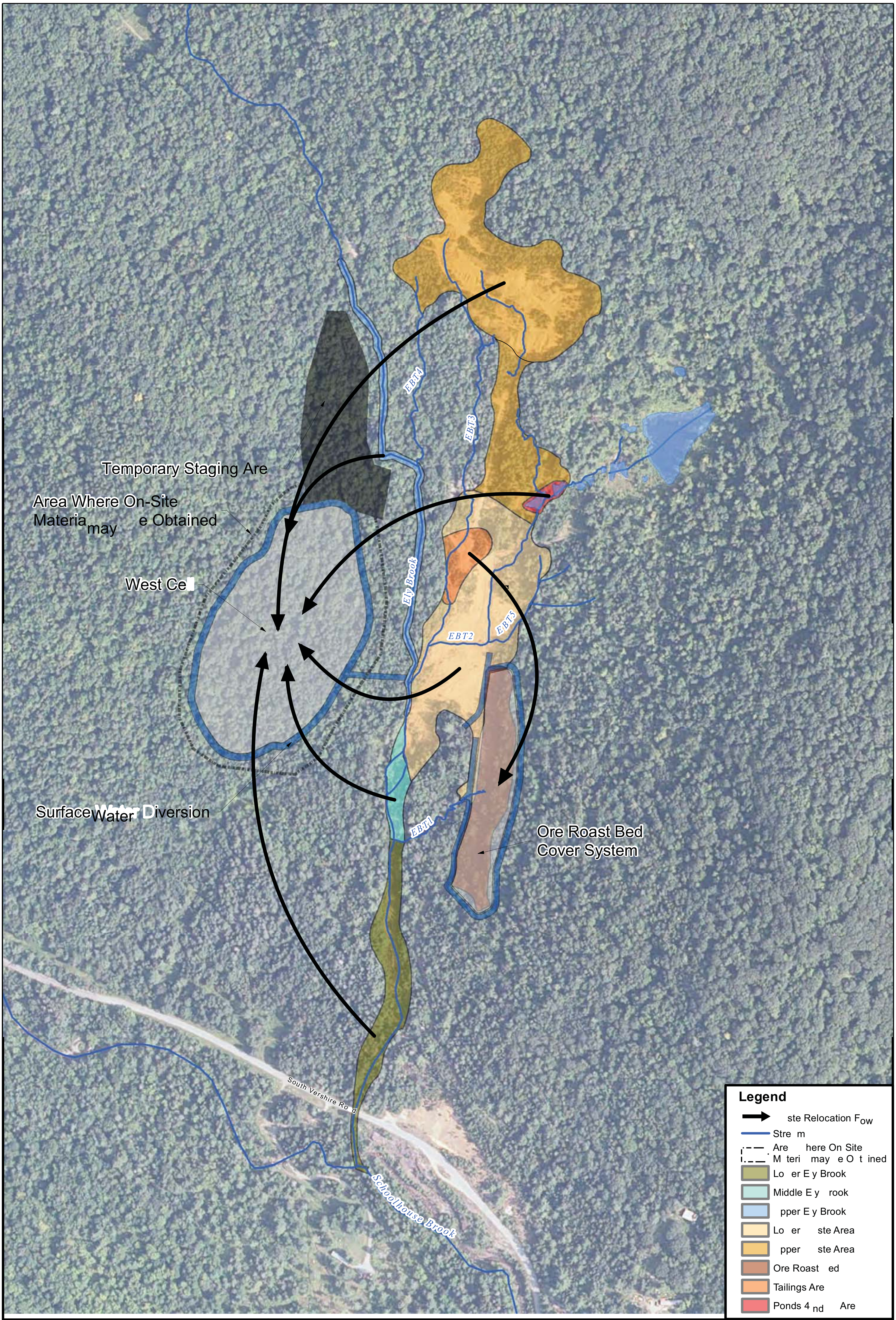

r n y JRS	Checked y AJ
June 24, 2011	Re ision No. 00

APPROXIMATE SCALE
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GURE ES

A ternati e Remedy Map
Altern ti e SC3
E y Copper Mine
Vershire, Vermont

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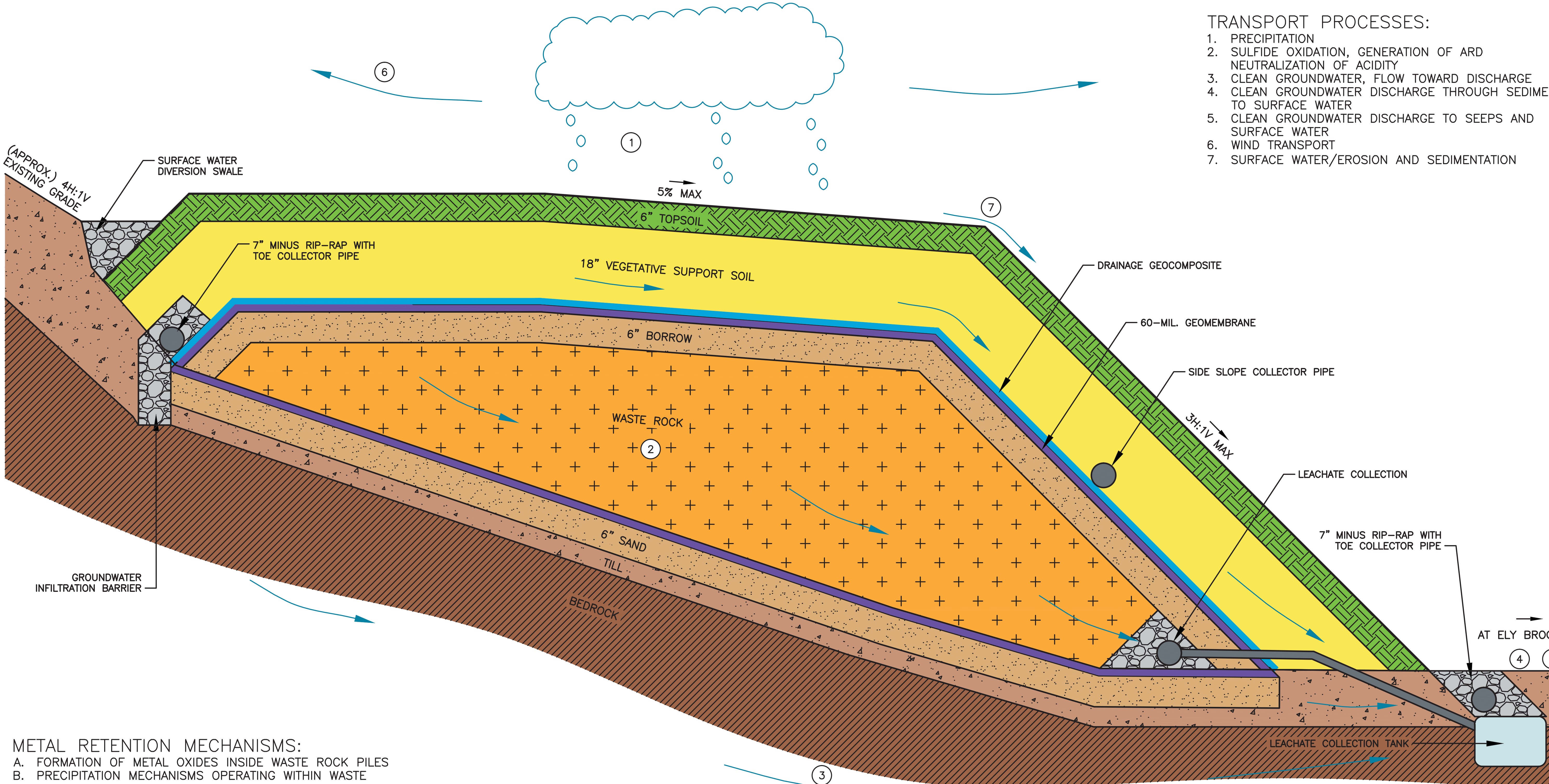
TRANSPORT PROCESSES:

1. PRECIPITATION
2. SULFIDE OXIDATION, GENERATION OF ARD NEUTRALIZATION OF ACIDITY
3. CLEAN GROUNDWATER, FLOW TOWARD DISCHARGE
4. CLEAN GROUNDWATER DISCHARGE THROUGH SEDIMENT TO SURFACE WATER
5. CLEAN GROUNDWATER DISCHARGE TO SEEPS AND SURFACE WATER
6. WIND TRANSPORT
7. SURFACE WATER/EROSION AND SEDIMENTATION



METAL RETENTION MECHANISMS:

A. FORMATION OF METAL OXIDES INSIDE WASTE ROCK PILES
B. PRECIPITATION MECHANISMS OPERATING WITHIN WASTE ROCK PILE
C. MINERAL PRECIPITATES IN SURFACEWATER/SEEP DISCHARGE AREAS
D. METALS IN GROUNDWATER; DISCHARGED TO AND RETAINED BY SEDIMENTS
E. METALS RETAINED IN "MINE WASTE" LAYER SEDIMENT

NOT TO SCALE

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IGURE ES-8

WEST CELL SYSTEM PROCESS MODEL

ELY COPPER MINE
VERSHIRE, VERMONT

DRAWN BY: ML	APPROVED BY: AJB
PROJECT: 80024.12	JUNE 24, 2011

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r n y JRS	Checked y AJ
June 24, 2011	Re ision No. 00

APPROXIMATE SCALE
0 150 300 600
eet

GURE ES 9
A ternati e Remedy Map
Altern ti e SC4
E y Copper Mine
Vershire, Vermont

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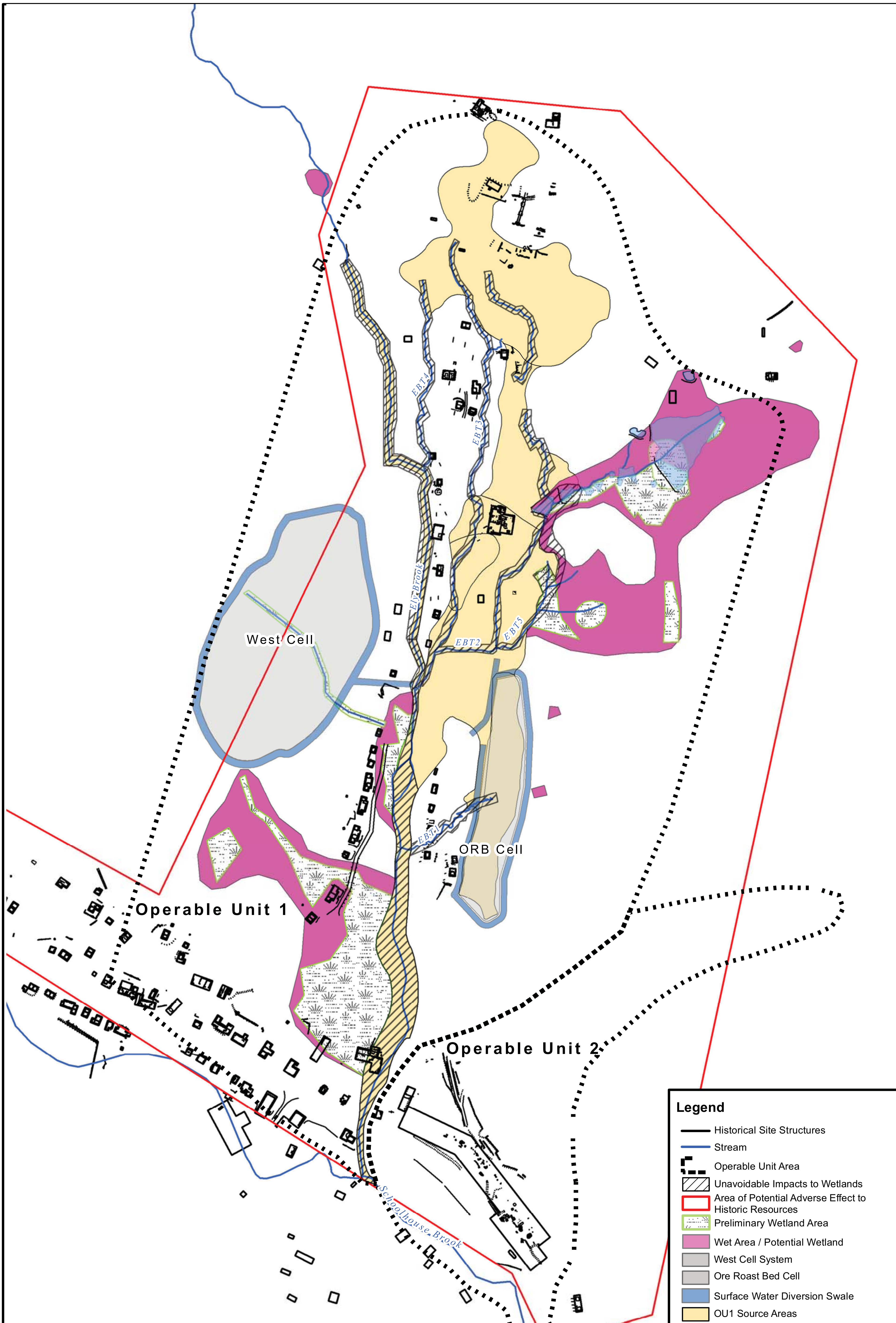

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Drawn By: JRS	Checked By: AJB
June 24, 2011	Revision No. 00

APPROXIMATE SCALE
0 150 300 600 Feet

FIGURE ES-10
SC3 Area of Potential Impact
Ely Copper Mine
Vershire, Vermont

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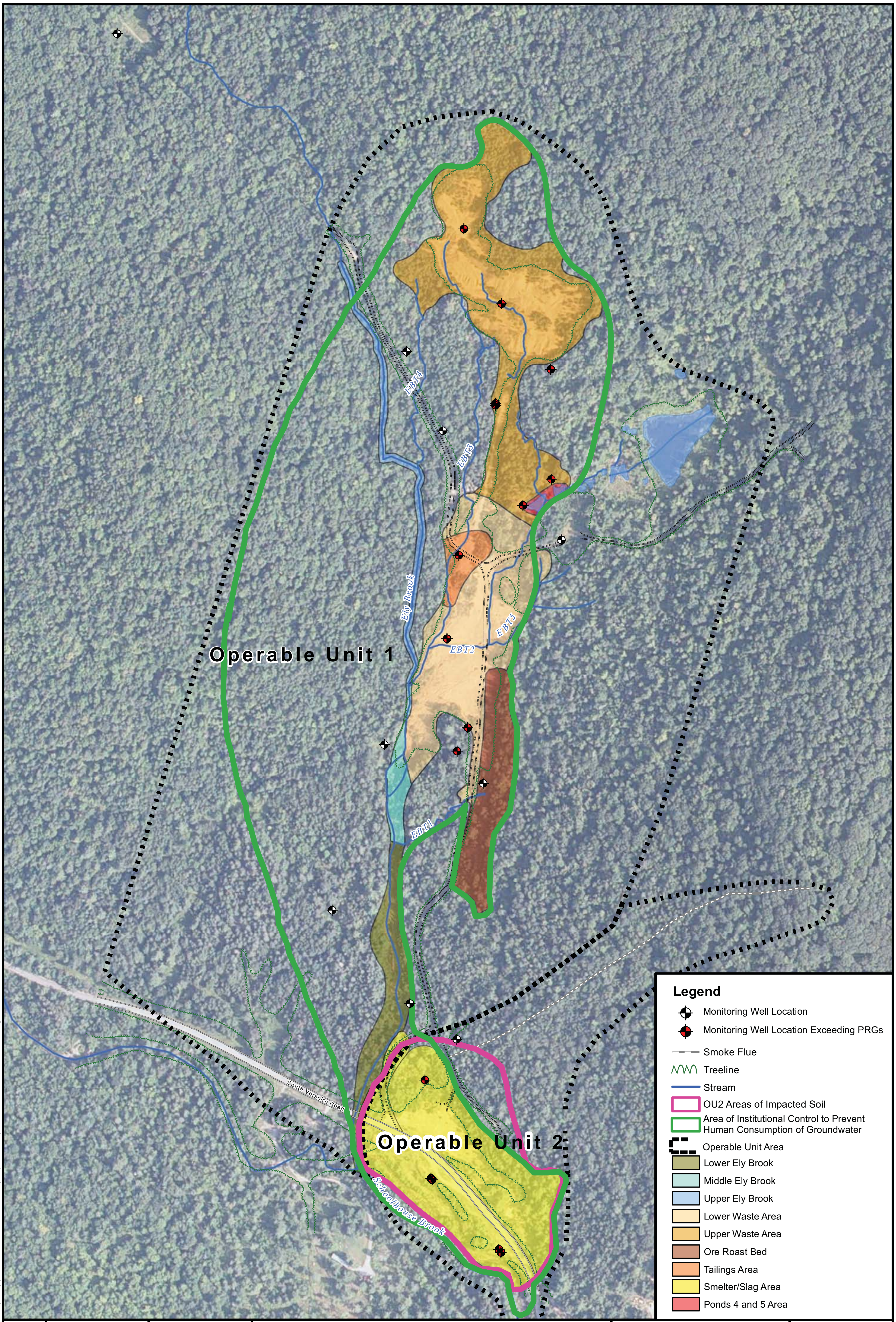

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Drawn By: J RS	Checked By: AJB
June 24, 2011	Revision No. 00

NOTE:
Limit of Groundwater Exceedances based on Total/Dissolved Metal Exceedances From 2009 Groundwater Sampling by Nobis Engineering, Inc.
Soil Impact areas are based on sample results in exceedance of the site soil PRGs

FIGURE ES-11

OU2 Early Action
Ely Copper Mine
Vershire, Vermont

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FIGURES